PCCP INTERSECTIONS

DESIGN AND CONSTRUCTION IN WASHINGTON STATE

May 2001

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TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 503.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
PCCP Intersections Design and Construction in Washington State	May 2001
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Jeff S. Uhlmeyer	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Washington State Transportation Center (TRAC) University of Washington, Box 354802 University District Building; 1107 NE 45th Street, Suite 535 Seattle, Washington 98105-4631	11. CONTRACT OR GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Research Office Washington State Department of Transportation Transportation Building, MS 47370 Olympia, Washington 98504-7370 Keith Anderson, Project Manager, 360-709-5405	Final report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The primary objective of this study was to summarize information related to the use of portland cement concrete pavement (PCCP) for urban intersection construction in Washington State. PCCP construction has been used in Washington State since the early 1900s, but only since 1994 has the Washington State Department of Transportation (WSDOT) begun reconstructing a selection of urban intersections with PCCP. Statewide, fifteen PCCP intersections have been constructed on state highways, and more will be built in the future. PCCP intersections eliminate the significant rutting problems that sometimes occur with asphalt-surfaced roadways. This report includes lessons learned about PCCP intersection construction costs, life cycle costs, traffic control/staging, design and construction considerations, and quality control issues.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Concrete intersections, urban intersections, concrete pavement, concrete construction, pavement rutting, traffic control, fast track paving, accelerated construction, life cycle cost analysis (LCCA)	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None		

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ACKNOWLEDGMENTS

Special thanks are extended to the many individuals who made this effort possible. Review comments were provided by Chris Courtney, Larry Eik, Gion Gibson, John Morris, Linda Pierce, Andy Schenk, Virgil Schmidt, and Nadarajah "Siva" Sivaneswaran of WSDOT; Robert Segehtti and Steve Wittstock of ACME Materials and Construction; Joe Mahoney of the University of Washington; Barry Greene of Spokane County Public Works, and Tom Nelson, Jim Powell, and Jim Tobin of the Northwest Chapter of the American Concrete Pavement Association. Thanks also to WSDOT Office engineers Paul Jensen, Rick Jordan, and Michelle Plaggerman, who supplied contract data to make cost and contract comparisons possible. Thanks to Mark Allen, Jerry Franklin, Roger Herrmann, and Mike Pea of the Eastern Region and Moe Davari, Jim Munro, Jeff Peters, and Alex Sanguino of the South Central Region for sharing their experiences during the design and construction of PCCP intersections. Thanks to Chuck Kinne, Jim Lovejoy, and Kim Willoughby, who provided service at the WSDOT Materials Lab while this report was being written. Finally, thanks to Mark Bozanich from Photogrammetry for cartography work, Jay Terry from IT Support for scanning photos, and Amy O'Brien from the Washington State Transportation Center (TRAC) for editing this report.

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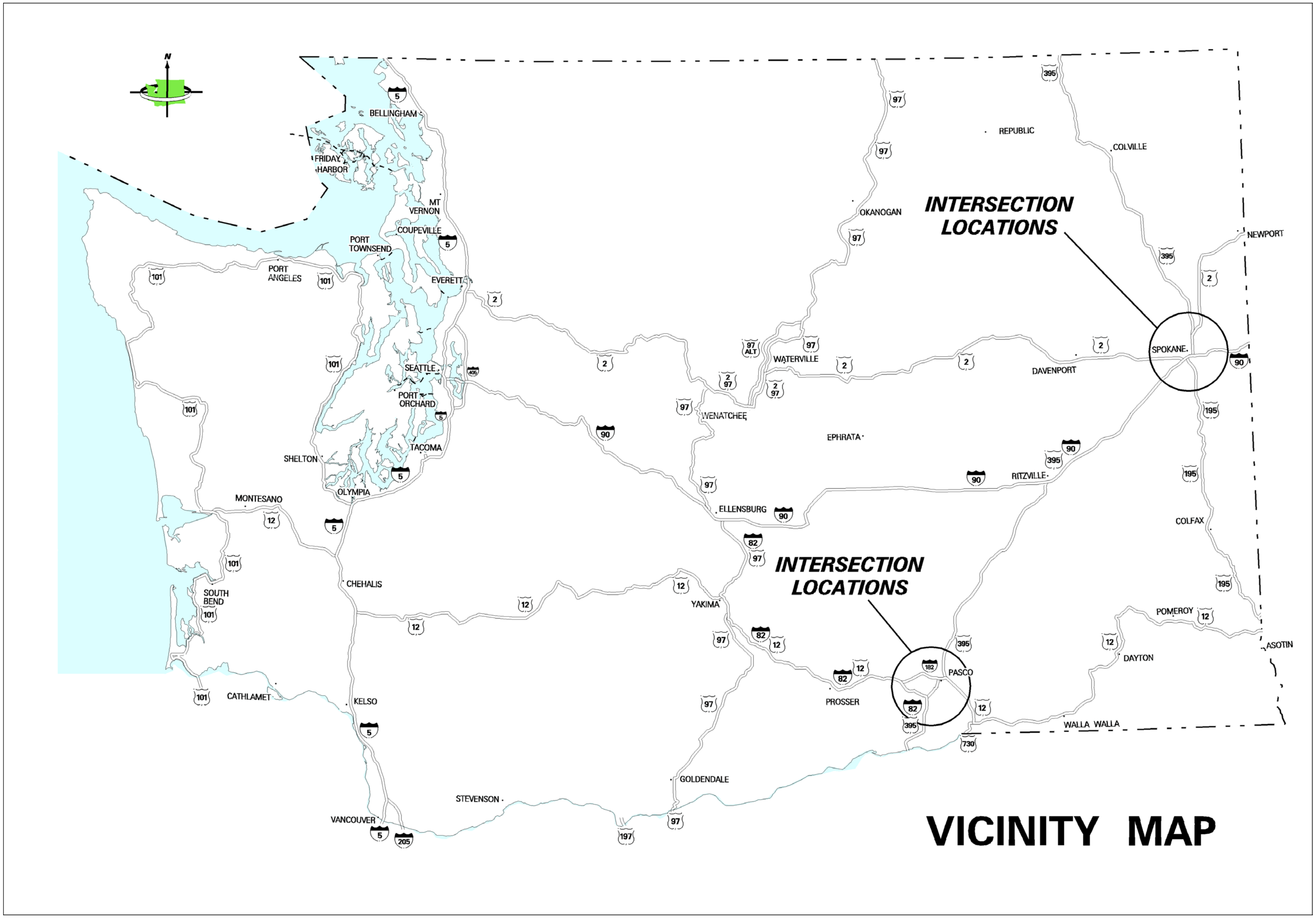
OBJECTIVE

The primary objective of this study is to summarize information related to the use of portland cement concrete pavement (PCCP) for urban intersection construction in Washington State. PCCP construction has been used in Washington State since the early 1900s, but only since 1994 has the Washington State Department of Transportation (WSDOT) begun reconstructing a selection of urban intersections with PCCP. Statewide, fifteen PCCP intersections have been constructed, partially or completely, on state highways, and more will be built in the future. PCCP intersections eliminate the significant rutting problems that sometimes occur with asphalt-surfaced roadways. Interest by WSDOT, local agencies, other states, and contractors has been substantial, and valuable lessons have been learned in the design and construction of these intersections. This report includes lessons learned, PCCP intersection costs, life cycle costs, traffic control/staging, design and construction considerations, and quality control issues. Recommendations and conclusions, based on WSDOT's experience, are included.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INTRODUCTION

In 1994, WSDOT began replacing selected flexible pavement intersections with PCCP. These originally built asphalt concrete pavement (ACP) intersections were severely rutted and distressed by loads from slow moving vehicles and warm temperatures. Statewide, rut depths of 2 inches or more occasionally occurred. Rehabilitation to restore the intersection to an acceptable level sometimes recurred at intervals of eight years or less. In some cases ruts as deep as 4 inches or greater occurred within two years of paving, and immediate rehabilitation was necessary.

Photos 1 through 5 show intersection rutting experienced east and west of the Cascade Mountains in Washington State.

Photo 1. Rutting experienced by heavy truck volumes in Spokane near I-90 at the Broadway Avenue and Thierman Street Intersection.

Photo 2. Severe rutting on SR 395 at 27th Avenue in Kennewick.

Photo 3. Rutting in Western Washington at Portland Avenue and Puyallup Avenue in Tacoma.

Photo 4. Asphalt rutting at Tacoma Mall Boulevard and 48th Street in Tacoma.

Photo 5. Severe rutting where asphalt was rotomilled between lanes to lessen ruts on SR 395 at the West Kennewick Avenue intersection in Kennewick.

Though WSDOT has considerable experience with cement concrete pavements, a unique feature was the replacement of existing flexible pavement with rigid pavement at intersections on urban arterials. Within WSDOT, the Eastern and South Central regions have been proactive in rehabilitating urban intersections with PCCP. Table 1 lists the fifteen intersection locations where PCCP has been used on WSDOT highways as of October 2000. Photos 6 and 7 show the rutted ACP and reconstructed PCCP intersection on SR 395 at 27^{th} Avenue in Kennewick. Photos 8 to 10 show additional views of reconstructed intersections in Eastern Washington.

Table 1. Locations of PCCP Intersections built by WSDOT.

SR	Intersection	Region	Year Constructed
27	Pines Road and Sprague Avenue	Eastern	1994
90	Broadway Avenue and Thierman Street	Eastern	1996
90	Sprague Avenue and Fancher Street[2]	Eastern	1997
97	Dolar Way Intersection[1]	South Central	1997
2	Division Street and Francis Avenue	Eastern	1997
291	Francis Avenue with Maple and Ash Streets	Eastern	1997
27	Pines Road and Broadway Avenue	Eastern	1998
395	SR 395 and 7^{th}, 10th, 19^{th} and 27^{th} Avenues	South Central	1998
2	Division Street and Third Avenue[2]	Eastern	1998
395	SR 395 and Yelm Street, Clearwater and West Kennewick Avenues	South Central	2000

[1] Partial reconstruction, replaced two approach legs only.
[2] Partial reconstruction, replaced one approach leg only.

Photo 6. Asphalt approach leg on SR 395 at 27th Avenue in Kennewick.

Photo 7. Reconstructed PCCP approach leg on SR 395 at 27th Avenue in Kennewick.

Photo 8. SR 27, Pines Road and Broadway Avenue reconstructed PCCP intersection.

Photo 9. Southbound PCCP approach leg on SR 27, Pines Road and Broadway Avenue in Spokane.

Photo 10. SR 2, Division Street and Francis Avenue PCCP intersection.

An advantage with PCCP is the 40-year design life the PCCP provides with minimal or no rehabilitation required. The construction user costs and disruption to traffic that are necessary with future ACP overlays during its 40-year design life are eliminated when PCCP is used. The major disadvantage with PCCP intersections is the initial construction cost. However, a life cycle cost analysis of PCCP intersections versus ACP reconstruction and future inlays shows that PCCP intersection construction competes with and can be less expensive than rebuilding with ACP. A life cycle cost analysis for PCCP intersections versus ACP options will be discussed in a following section.

WSDOT EXPERIENCE

Several municipalities in the State of Washington, including the City of Spokane, City of Seattle, and Spokane County, have completed successful PCCP intersection projects. The PCCP intersection projects for the City of Spokane and Spokane County were selected primarily to eliminate chronic rutting problems; PCCP intersections within the City of Seattle were a result of its PCCP construction program on many arterials.

Prior to the first PCCP intersection reconstruction, WSDOT had considered PCCP at urban intersections for some time as a solution to eliminate asphalt rutting. However, because budget constraints have often dictated the choice of construction, ACP was often the choice, largely due to its lower initial cost. Life cycle cost analyses between ACP and PCCP reconstruction typically were not done.

An additional reason for not considering PCCP reconstruction was related to constructabilty and concerns about accommodating high traffic flows through urban intersections. Rehabilitating urban intersections with ACP requires rotomilling and inlaying with ACP to remove wheel rutting. This work can typically be done at night, in a short period, and with minor inconvenience to the public. Rehabilitating intersections with PCCP, on the other hand, involves the complete disruption of the intersection, as construction for specific areas sometimes must be staged over several days. The concern within WSDOT was that the inconvenience to the uses was too great to construct urban intersections with PCCP. One Eastern Region concrete contractor commented that even if a concrete intersection contract were awarded, the construction fears related to traffic control would result in very high unit prices.

Since 1994, however, WSDOT has shown that PCCP intersections are constructible, and the early concerns have been overcome. The Pines Road and Sprague Avenue intersection on SR 27 and the Broadway Avenue and Thierman Street intersection adjacent to SR 90 were selected to be rebuilt with PCCP despite the less expensive ACP rehabilitation to rotomill and inlay with ACP.

Nearly 1,600 heavy trucks use Pines Road daily. Both approach legs on Pines Road were down hill, and 3-inch ruts formed within two years following rehabilitation with ACP. The Broadway Avenue and Thierman Street intersection was reconstructed adjacent to a truck stop where daily truck counts numbered approximately 2,800 on Broadway Avenue. After two years, the ruts in the ACP on Broadway Avenue were 4 to 5 inches deep. Rutting may have been due to a number of factors, including insufficient structural depth and or unstable mix.

The Eastern Region was faced with either more inlay or overlay cycles with ACP at short intervals or reconstructing with PCCP and eliminating rutting potential. Selecting to reconstruct with PCCP provided a valuable learning tool and allowed additional PCCP intersection projects to progress relatively problem free. As will be discussed in this report, reconstructing with PCCP can be cost effective in comparison to ACP alternatives.

Table 2 lists, for comparison purposes, the average daily traffic (ADT), percentage of trucks, and the corresponding 40-year equivalent single axle loads (ESALs) for the seven intersections that will be reviewed in this report. Note that ADT and the percentage of trucks do not necessarily indicate whether an intersection will or will not have an ACP rutting problem. Factors that can affect rutting include the starting and stopping of trucks, roadway grade, climate and mix properties combined with the ADT, truck percentage, and ESALs.

Table 2. Average daily traffic (1997 traffic year) and associated ESALs for WSDOT's intersections.

SR	Intersection	Major Leg		Minor Leg		Major Leg 40 Year Equivalent Single Axle Loads (ESALs)
		Average Daily Traffic	Percent Trucks (%)	Average Daily Traffic	Percent Trucks (%)	
27	Pines Road and Sprague Avenue	24,596	6.5	24,596[1]	6.5	20,000,000
90	Broadway Avenue and Thierman Street	17,000	17.0	2,500	30.0	30,000,000
2	Division Street and Francis Avenue	36,726	2.6	31,768	2.8	10,000,000
291	Francis Avenue with Maple and Ash Streets	31,768	2.8	15,884	2.0	9,000,000
27	Pines Road and Broadway Avenue	25,608	6.5	12,804	6.5	20,000,000
395	SR 395 and 19th Avenue	13,370	19.0	10,000	5.0	53,000,000
2	Division Street and Third Avenue	12,000	2.8	6,000	2.0	16,000,000

[1] Pines Road and Sprague Avenue carry equivalent traffic volumes.

Photos 11 through 16 show aerial photographs of the following WSDOT PCCP intersections:

- SR 2, Division Street and Francis Avenue
- SR 291, Francis Avenue with Maple and Ash Streets
- SR 27, Pines Road and Broadway Avenue
- SR 2, Division Street and Third Avenue
- SR 395, SR 395 and West Kennewick Avenue
- SR 395, SR 395 with West Kennewick and Clearwater Avenues.

These photos provide a "birds eye" view of the extent of intersection rehabilitation in Washington State.

Photo 11. SR 2, Division Street and Francis Avenue PCCP intersection in Spokane (Photo courtesy AirPhoto Spokane, Spokane, Washington).

Photo 12. SR 291, Francis Avenue with Maple and Ash Streets in Spokane (Photo courtesy AirPhoto Spokane, Spokane, Washington)

Photo 13. SR 27, Pines Road and Broadway Avenue in Spokane (Photo courtesy AirPhoto Spokane, Spokane, Washington).

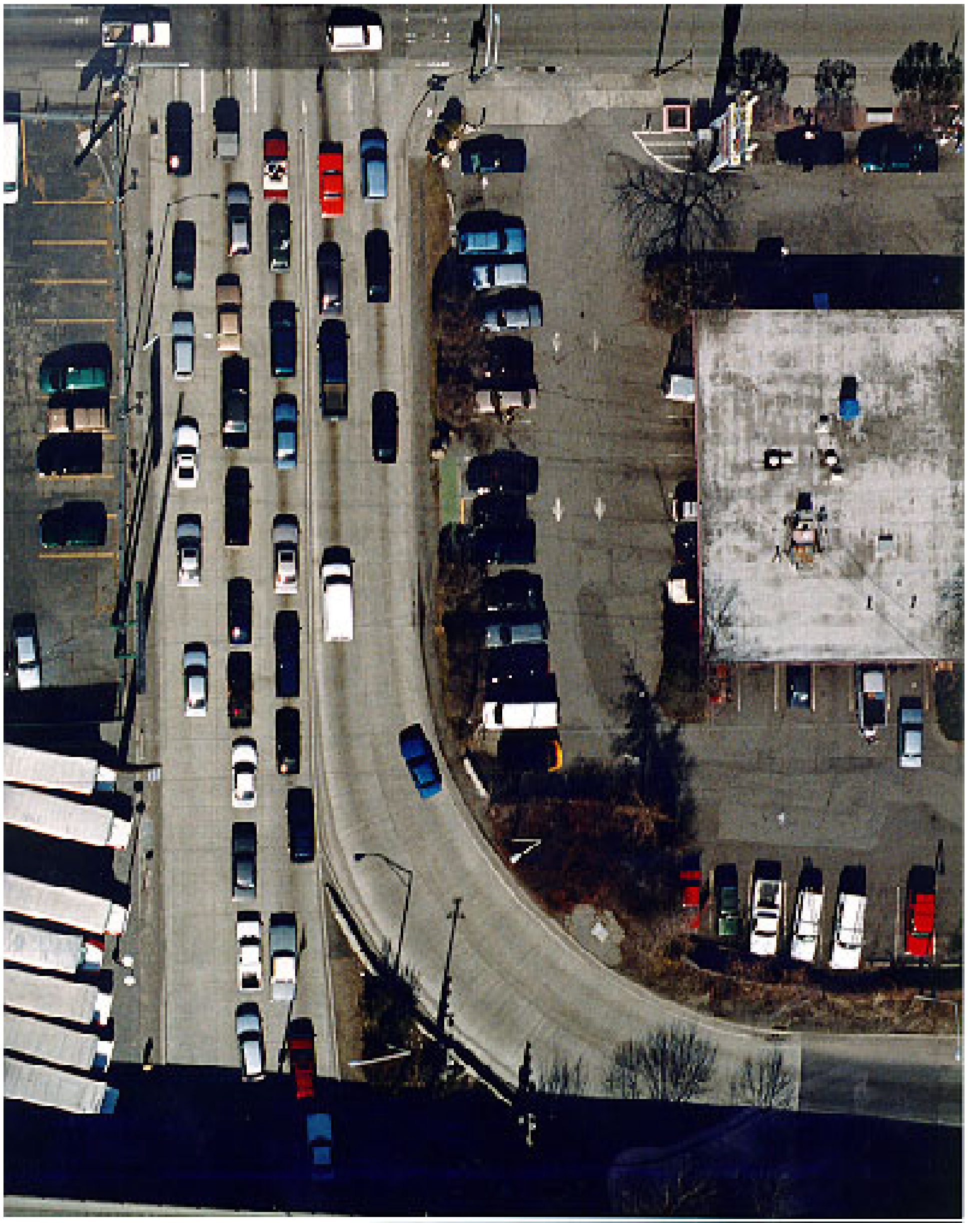

Photo 14. SR 2, Division Street and Third Avenue in Spokane (Photo courtesy AirPhoto Spokane, Spokane, Washington).

Photo 15. SR 395 and West Kennewick Avenue in Kennewick, Washington.

Photo 16. SR 395 with West Kennewick Avenue and Clearwater Avenue in Kennewick, Washington.

CONSTRUCTION COSTS

To investigate costs for PCCP intersections, one project from the South Central Region and six from the Eastern Region were analyzed. Three of the seven intersections were complete PCCP projects, while four were included on larger ACP resurfacing projects. The complete PCCP intersection projects were simpler to analyze, as all costs on the project were directly tied to the contract. The PCCP intersection costs on the ACP resurfacing projects were developed by isolating pay groups or summarizing construction pay notes. The effect was to establish accurate costs for PCCP reconstruction.

Once the PCCP costs were summarized, calculations were made to estimate the costs of a comparable reconstructed intersection with ACP. The PCCP thickness used to rebuild the intersections ranged from 9 to 12 inches. The comparable flexible AASHTO design ranged from 8.5 to 9.6 inches of ACP over approximately 10 inches of CSBC to meet frost depth design criteria. The total existing pavement structure (ACP and aggregate base) for the PCCP intersections reviewed in this study ranged from 15 to 18 inches thick. The price used for ACP was based on unit bid prices that would be expected for the ACP quantity represented. All other items for the PCCP or ACP reconstruction remained the same.

Finally, cost estimates for future inlays were computed on the basis of a typical 2.4-inch depth, the area for the PCCP reconstruction, and unit bid prices that would be expected for the ACP quantity represented.

A summary of PCCP or asphalt concrete intersection reconstruction costs, as well as future inlay costs, is shown in Table 3. These costs include labor, materials, preliminary and construction engineering, change orders, and taxes. Individual estimates for PCCP or ACP reconstruction or ACP inlays for each intersection can be seen in Appendix A.

Table 3. Initial ACP and PCCP construction costs and future ACP inlay costs.

SR	Year Constructed	Intersection	Initial PCCP Cost ($)	Initial ACP Cost ($)	Future Inlay Cost ($)
27	1994	Pines Rd. and Sprague Ave.	531,300	403,900	72,900
90	1996	Broadway Ave. and Thierman St.	982,200	728,600	95,900
2	1997	Division St. and Francis Ave.	675,100	519,000	151,200
291	1997	Francis St./Maple and Ash St.	466,200	361,800	91,900
27	1998	Pines Rd. and Broadway Ave.	455,500	349,800	89,700
395	1998	SR 395 and 19th Ave.[1]	546,400	441,600	91,900
2	1998	Division St. and Third Ave.	208,500	164,700	27,700

[3] Project included four intersections. Cost estimate is for SR 395 and 19th Avenue only.

The initial PCCP intersection costs ranged from $455,500 to $982,200, whereas the initial ACP intersection costs ranged from $349,800 to $728,600. The Third Avenue and Division Street initial PCCP and ACP construction, and inlay costs were substantially less; however, only the northbound approach leg of this intersection, on Division Street to Third Avenue, was constructed. Since the construction costs for the Division Street and Third Avenue leg do not reflect full intersection reconstruction, the costs were left out of the ranges for the initial PCCP, and ACP construction, or inlay costs listed above.

The spread in the PCCP reconstruction costs resulted primarily from the size and variability in unit bid prices for each intersection. Table 4 shows the size in square yards for each intersection and the cost per square yard for initial PCCP and ACP construction costs. In general, initial PCCP intersection construction ranged from $66 to $148 per square yard. ACP intersection costs ranged from $51 to $109 per square yard. The PCCP reconstruction costs were less when intersections were reconstructed as part of a larger resurfacing project.

Table 4. PCCP and ACP initial construction intersection costs per square yard.

SR	Year	Intersection	Quantity (yd^2)	Initial PCCP Const. Cost[1] ($\$/yd^2$)	Initial ACP Const. Cost[1] ($\$/yd^2$)
27	1994	Sprague Ave. and Pines Rd.	4,116	129[2]	98
90	1996	Broadway Ave. and Thierman St.	6,657	148[2]	109
2	1997	Division St. and Francis Ave.	10,289	66	51
291	1997	Francis with Maple and Ash St.	6,053	77	60
27	1998	Broadway Ave. and Pines Rd.	5,751	79	61
395	1998	SR 395 and 19th Ave.	6,365	82[3]	65
2	1998	Division St. and Third Ave.	1,959	106	84

[1] Square yard costs include labor, materials, preliminary and construction engineering, and taxes.
[2] Intersection constructed as an individual intersection project.
[3] Project included four intersections. Quantity shown is for SR 395 and 19th Avenue only.

Individual unit bid prices for major items are shown in tables 5 through 8. Table 5 compares cement concrete pavement prices for PCCP thicknesses of 9, 10, and 12 inches. The concrete for all the intersections required opening to traffic within 24 hours and used approximately 705 pounds of Type III cement per cubic yard. The cement concrete pavement price included both placing and finishing the PCCP. The average bid price for the five projects with a 10-inch section was $38.83 per square yard. The 12-inch-thick intersection at SR 395 and 19th Avenue was slightly higher at $42.22 per square yard, and the SR 291 intersection at Francis Avenue with Maple and Ash Streets, with a 9-inch section, was less at $34.28 per square yard.

Table 5. Cement concrete pavement unit bid prices.

SR	Intersection	PCCP Thickness (inch)	Quantity (yd^2)	Unit Price ($)
27	Pines Rd. and Sprague Ave.	10	4,116	43.00
90	Broadway Ave. and Thierman St.	10	6,657	40.00
2	Division St. and Francis Ave.	10	10,289	34.70
291	Francis Ave./ Maple and Ash St.	9	6,053	34.28
27	Pines Rd. and Broadway Ave.	10	5,751	37.63
395	SR 395 and 19th Ave.	12	6,365	42.22
2	Division St. and Third Ave.	10	1,959	41.81

Crushed surfacing base course unit bid prices are shown in Table 6. The crushed surfacing was used during reconstruction to provide the necessary grade or to provide a shim of material for leveling purposes. The existing crushed surfacing was generally in good condition. The average unit bid price was $16.28 per ton.

Roadway excavation unit bid prices are shown in Table 7. Six of the seven intersections specified roadway excavation in the contract plans. However, the actual removal method for many of the intersections was planing/rotomilling. The average unit bid price of roadway excavation was $11.40 per cubic yard. On SR 395, at 19th Avenue the contract included planing bituminous pavement as a contract item. The unit bid price for planing bituminous pavement on SR 395 was $2.97 per square yard, which equates to a cubic yard price of $9.05.

Table 6. Crushed surfacing base course unit bid prices.

SR	Intersection	Quantity (Ton)	Unit Price ($)
27	Pines Rd. and Sprague Ave.	1,155	16.00
90	Broadway Ave. and Thierman St.	1,189	20.00
2	Division St. and Francis Ave.	2,200	15.42
291	Francis Ave./ Maple and Ash St.	1,306	15.42
27	Pines Rd. and Broadway Ave.	1,480	16.32
395	SR 395 and 19th Ave.	---[1]	---[1]
2	Division St. and Third Ave.	791	14.52

[1] Crushed surfacing base course was not used on this contract.

Table 7. Roadway excavation unit bid prices.

SR	Intersection	Quantity (yd^3)	Unit Price ($)
27	Pines Rd. and Sprague Ave.	2,086	16.00
90	Broadway Ave. and Thierman St.	2,823	10.00
2	Division St. and Francis Ave.	5,382	8.41
291	Francis Ave./ Maple and Ash St.	4,400	8.41
27	Pines Rd. and Broadway Ave.	2,387	11.46
395	SR 395 and 19th Ave.	---[1]	---[1]
2	Division St. and Third Ave.	519	14.14

[1] Roadway excavation was not included on this contract. Rotomilling was specified for removal of the existing asphalt pavement.

ACP pavement unit bid prices for the different classes of asphalt used on the intersections are shown in Table 8. The unit prices for the Sprague Avenue/Pines Road and Broadway Avenue/Thierman Streets intersections were $80.00 and $60.00 per ton, respectively. These prices were high because ACP was a relatively minor item on these projects. Four of the remaining intersections were included on larger resurfacing projects, and the unit bid price reflected project prices for mainline paving ranging from $27.94 to $42.09 per ton. The price for the 19th Avenue Intersection on SR 395 was $36.74 because the four intersections included in the contract were combined, for a total of 3,876 tons for the project. The remaining contracts involved inlays from the larger resurfacing projects abutting the reconstructed PCCP intersections.

Table 8. Asphalt concrete pavement unit bid prices.

SR	Intersection	Asphalt Class	Quantity (Ton)	Unit Price ($)
27	Pines Rd. and Sprague Ave.	Asphalt Conc. Pavement Cl. A	27	80.00
90	Broadway Ave. and Thierman St.	Polymer Modified Asphalt Conc. Pavement Cl. A	477	60.00
2	Division St. and Francis Ave.	Superpave Asphalt Concrete Pavement Cl. 12.5 mm	[1]	42.09
291	Francis Ave. with Maple and Ash Streets	Superpave Asphalt Concrete Pavement Cl. 12.5 mm	[1]	42.09
27	Pines Rd. and Broadway Ave.	Modified Asphalt Conc. Pavement Cl. A	[1]	27.94
395	SR 395 and 7th, 10th, 19th, and 27th Avenues	Special Asphalt Conc. Pavement	3,876[2]	36.74
2	Division St. and Third Ave.	Modified Asphalt Conc. Pavement Cl. A	[1]	35.92

[1] Asphalt used on these contracts were from the larger asphalt surfacing project and was inlayed to abut the concrete intersections.
[2] Project included four intersections. Quantity shown is the combined total for four intersections.

Table 9 provides a summary of the average unit bid prices for the major items of cement concrete pavement, crushed surfacing base course, roadway excavation, and ACP pavement. Bid prices for additional items for each intersection can be compared in Appendix A.

Table 9. Summary of average unit bid prices for major bid items.

Bid Item	Unit	Average Unit Bid Price ($)
Cement Concrete Pavement – 10 inch	Square Yard	38.83
Crushed Surfacing Base Course	Ton	16.28
Roadway Excavation	Cubic Yard	11.40
Asphalt Concrete Pavement	Ton	70.00[1]

[1] The $70.00 per ton price reflects the SR 27, Pines Road and Sprague Avenue and SR 90, Broadway Avenue and Thierman Street intersections where the asphalt was not part of a larger resurfacing project.

The final comparison for total contract prices is of major traffic items. Table 10 summarizes traffic control labor, vehicle, and supervisor costs for each of the intersections. The contract totals for Sprague Avenue and Pines Road on SR 27 and Broadway Avenue and Thierman Street near I-90 were obtained from the final contract totals, as these were individual intersection contracts. The contract totals for the 19th Avenue intersection on SR 395 were obtained by isolating the pay groups. The remaining contract totals were reconstructed as best as possible from available information such as pay notes and inspectors daily reports.

Table 10. Total costs for traffic control items.

SR	Intersection	Traffic Control Labor ($)	Traffic Control Vehicle ($)	Traffic Control Supervisor ($)	Total for Traffic Items ($)
27	Pines Rd. and Sprague Ave.	52,304	945	12,300	65,549
90	Broadway Ave. and Thierman St.	76,083	1,935	10,750	88,768
2	Division St. and Francis Ave.	9,680	1,750	9,240	20,670
291	Francis Ave./ Maple and Ash St.	8,250	1,450	7,656	17,356
27	Pines Rd. and Broadway Ave.	8,700	1,500	7,680	17,880
395	SR 395 and 19th Ave.	14,355	800	4,800	19,955
2	Division St. and Third Ave.	5,800	150	1,200	7,150

Table 11 shows the total cost for traffic items as a percentage of the contract subtotal. The range as shown is 4.0 to 16.9 percent. The 11.9 percent for the Broadway Avenue and Thierman Street intersection can be explained because of the extra traffic control labor needed for flaggers at the many entrances to the intersection in combination with the high truck volumes at the Broadway Avenue Truck stop. Upwards of 250 trucks a day entered the truck stop. The high percentage for the Sprague Avenue and Pines Road intersection can be explained by the early learning curve with concrete intersection construction in the Eastern Region. An additional factor was that ACP pavement was constructed as the base material beneath the PCCP, and additional time and exposure to traffic was necessary.

Table 11. Traffic control items expressed as a percentage of contract subtotal.

SR	Intersection	Project Subtotal ($)	Total for Traffic Items ($)	Percent of Subtotal (%)
27	Pines Rd. and Sprague Ave.	387,418	65,549	16.9
90	Broadway Ave. and Thierman St.	748,104	88,768	11.9
2	Division St. and Francis Ave.	520,436	20,670	4.0
291	Francis Ave./ Maple and Ash St.	359,734	17,356	4.8
27	Pines Rd. and Broadway Ave.	351,101	17,880	5.1
395	SR 395 and 19th Ave.	422,807	19,955	4.7
2	Division St. and Third Ave.	160,768	7,150	4.4

An example of reducing traffic control costs occurred on the SR 27, Pines Road and Sprague Avenue intersection. The project was originally estimated to require 24-hour traffic control. Both the Eastern Region and the prime contractor, Inland Asphalt of Spokane, Washington, desired to keep traffic impacts to a minimum. As a result, Inland Asphalt scheduled the major portion of the preparation work to be done at night. The traffic item "Labor for Traffic Control" under ran the estimated amount by $18,000, or 25 percent of the estimated quantity. To control costs, traffic signals were used during the day, and flaggers were used at night.

A comparison between estimated traffic control labor dollars and actual contract dollars for traffic control labor is seen in Table 12. In the three cases where precontract estimates were available, the estimated contract total versus the actual contract total was 30 to 53 percent less than the engineer's estimate. Different contractors constructed each of these projects.

Table 12. Estimated traffic control labor versus actual traffic control labor experienced on PCCP intersection contracts.

SR	Intersection	Estimated Traffic Control Labor ($)	Actual Traffic Control Labor ($)	Percent Under Estimate (%)
27	Sprague Ave. and Pines Rd.	75,000	52,304	30.3
90	Broadway Ave. and Thierman St.	162,500	76,083	53.2
395	SR 395 and 19th Ave.	29,000	14,355	50.5
395	SR 395 and 7th, 10th, 19th, and 27th Avenues[1]	121,800	63,336	48.0

[1] This estimate combined four intersections built on the contract.

LIFE CYCLE COST ANALYSES

Life cycle cost analyses were performed for each intersection to compare PCCP reconstruction and ACP reconstruction options. In addition, analyses were performed to compare reconstruction with PCCP and rehabilitation using traditional inlays at four-, six-, and eight-year intervals to rehabilitate rutted surfaces. A summary of the analyses performed in this section is shown in Appendix B. Assumptions used in the analyses include the following:

- A 40-year design period was used to compare PCCP reconstruction versus ACP reconstruction or inlay options.
- Four, six, and eight years were used for ACP inlay cycles.
- Analyses were performed with and without user delay costs.
- Analyses reflect total construction costs for PCCP, ACP reconstruction, or ACP inlays (see Appendix A).
- A 4 percent discount rate was used.

Life Cycle Cost Analysis without User Delay Costs

Tables 13 and 14 show the 40-year annualized cost analysis for the seven selected intersections. User delay costs were not included in the analysis. Table 13 compares PCCP reconstruction with ACP reconstruction followed by ACP inlays at four-, six-, and eight-year cycles. In almost every case the cost of PCCP reconstruction was lower than that of the ACP reconstruction alternative. In only one project was ACP reconstruction cheaper, and then only for an eight-year inlay cycle. Table 14 compares PCCP reconstruction with rehabilitating the existing ACP structure with 2.4-inch ACP inlays at four-, six-, and eight-year cycles.

Table 13. Comparison of 40-year annualized costs without user delay costs for reconstructing with PCCP or ACP. The ACP option includes future inlays of 2.4 inch thickness at four-, six-, and eight-year cycles following reconstruction.

SR	Intersection	40 Year Annualized Cost			
		PCCP Rebuild	ACP Rebuild with Inlays at 4 Years	ACP Rebuild with Inlays at 6 Years	ACP Rebuild with Inlays at 8 Years
27	Pines Rd. and Sprague Ave.	26,800	36,800	30,600	27,500
90	Broadway Ave. and Thierman St.	49,600	58,400	50,300	46,200
2	Division St. and Francis Ave.	34,100	60,200	47,500	41,000
291	Francis Ave/Maple and Ash St.	23,600	39,000	31,200	25,000
27	Pines Rd. and Broadway Ave.	23,000	37,900	30,300	26,500
395	SR 395 and 19th Ave.	27,600	43,000	35,200	31,300
2	Division St. and Third Ave.	10,500	14,600	12,200	11,000

Table 14. Comparison of 40-year annualized costs without user costs for reconstructing with PCCP or inlaying the existing pavement with 2.4 inch thickness of ACP at four-, six-, and eight-year cycles.

SR	Intersection	40 Year Annualized Costs			
		PCCP Rebuild	Inlays at 4 Years	Inlays at 6 Years	Inlays at 8 Years
27	Pines Rd. and Sprague Ave.	26,800	20,100	13,900	10,800
90	Broadway Ave. and Thierman St.	49,600	26,400	18,300	14,200
2	Division St. and Francis Ave.	34,100	41,700	28,900	22,500
291	Francis Ave./Maple and Ash St.	23,600	25,300	17,600	13,700
27	Pines Road and Broadway Ave.	23,000	24,700	17,100	13,700
395	SR 395 and 19th Ave.	27,600	25,300	17,600	13,700
2	Division St. and Third Ave.	10,500	7,600	5,300	4,100

When PCCP reconstruction is compared to inlaying with AC, Table 14 shows that inlaying at four-, six-, or eight-year cycles will provide the lowest 40-year annualized cost. However, an argument against inlaying only the existing pavement once distress becomes intolerable is the inconvenience to the traveling public. Not only does excessive rutting compromise user safety, but users must endure resulting traffic delays caused by rehabilitation or maintenance operations. Sometimes, as WSDOT has experienced, repairs may occur within two years of the inlay.

Life Cycle Cost Analysis with User Costs

User delay costs are difficult to apply to life cycle cost analyses for intersections. Currently, WSDOT estimates delay through a construction project by estimating the slow-down per vehicle through a construction zone. The slow-down through a construction zone does not work well for intersection reconstruction, as one approach leg or another is stopped, or there is a large build up in queued vehicles.

WSDOT is currently working toward applying actual user delay as the basis for quantifying user costs, as per the FHWA Technical Bulletin on LCCA [1]. For this study, the user costs were calculated from the actual delay a motorist would experience during construction beyond the delay that would be normally incurred under normal operating conditions.

To quantify user delay costs, the following assumptions were made in the analysis. The assumptions were based on field observations and discussions with project inspectors and region traffic offices.

- Maximum delay times for any motorist during peak traffic hours during construction ranged from 4 to 10 minutes, depending on the intersection (see Appendix C). Occasional delays of 15 to 20 minutes occurred. These isolated delays were not factored into the analysis.
- Construction-caused delay time beyond the normal signal delay was typically 1 to 4 minutes. Delay time due to normal signal operation was

not included as delay in the analysis.

- Approximately 30 percent of the normal ADT during construction hours found alternative routes.
- Delay time during non-construction hours was zero (queues outside normal signal operations did not occur).
- Average daily traffic (ADT) and the percentage of trucks were determined from the 1997 Washington State Pavement Management System and verified by the regional traffic offices.
- A 2 percent growth rate was used for estimating future ADT levels.
- Hourly traffic distribution factors for a typical urban arterial were based on the typical distribution factors for an urban arterial reported in the FHWA Technical Bulletin on LCCA [1].
- Delay costs per hour of delay were based on figures provided in the FHWA Technical Bulletin on LCCA [1].
    - Truck delay - $18.50 per hour
    - Auto delay - $11.50 per hour
- The number of construction days, for a given intersection, was determined from contract documents such as the Inspectors Daily Reports and Weekly Statement of Working Days.
- Delay time and user delay costs for PCCP and ACP reconstruction were assumed to be equal (industry sources indicates similar time frames and staging requirements).

The delay time for the construction period was computed by multiplying the ADT by the hourly traffic distribution factors by the construction days by the delay per vehicle. Appendix C provides a summary for total delay time for each intersection with the corresponding calculations for daily delay for PCCP reconstruction and ACP inlay options. The calculations show 24-hour delay times. Truck and auto delay hours for both legs of the intersection are shown.

The present worth for user delay costs over a 40-year period are shown in tables 15 and 16. Table 15 compares the present worth of delay costs for the PCCP reconstruction to ACP reconstruction with future inlay cycles at four, six, and eight years. Table 16 compares the present worth of delay costs for PCCP reconstruction to future inlays at four-, six-, and eight-year cycles over a 40-year period. The total delay costs (summarized in Appendix D) were calculated by multiplying the appropriate truck or auto delay cost by the total delay time summarized in Appendix C.

Table 15. Present worth of delay costs for reconstructing with PCCP or reconstructing with ACP followed by four-, six-, or eight-year inlay cycles. The present worth is calculated over a 40-year period.

SR	Intersection	Present Worth of Delay Costs			
		PCCP Rebuild ($)	ACP Rebuild with Inlays at 4 Years ($)	ACP Rebuild with Inlays at 6 Years ($)	ACP Rebuild with Inlays at 8 Years ($)
27	Pines Rd. and Sprague Ave.	121,941	169,726	153,178	143,071
90	Broadway Ave. and Thierman St.	95,856	116,201	109,157	104,858
2	Division St. and Francis Ave.	752,156	817,451	794,842	781,029
291	Francis Ave/Maple and Ash St.	185,354	234,865	217,717	207,246
27	Pines Rd. and Broadway Ave.	222,241	259,759	246,782	238,832
395	SR 395 and 19th Ave.	49,454	73,088	64,911	59,902
2	Division St. and Third Ave.	63,942	69,629	67,148	65,946

Table 16. Present worth of delay costs for reconstructing with PCCP or inlaying the existing pavement structure with ACP at four-, six-, or eight-year cycles.

SR	**Intersection**	**Present Worth of Delay Costs**			
		PCCP Rebuild ($)	**ACP Inlays at 4 Years ($)**	**ACP Inlays at 6 Years ($)**	**ACP Inlays at 8 Years ($)**
27	Pines Rd. and Sprague Ave.	121,941	55,462	38,914	28,807
90	Broadway Ave. and Thierman St.	95,856	23,614	16,570	12,271
2	Division St. and Francis Ave.	752,156	75,779	53,170	39,357
291	Francis Ave/Maple and Ash St.	185,354	57,462	40,314	29,843
27	Pines Rd. and Broadway Ave.	222,241	43,545	30,568	22,618
395	SR 395 and 19th Ave.	49,454	27,433	19,256	14,247
2	Division St. and Third Ave.	63,942	6,598	4,616	3,414

Table 17 compares PCCP reconstruction with ACP reconstruction followed by ACP inlays at four-, six-, and eight-year cycles. Again, the cost of PCCP reconstruction was lower than that of ACP reconstruction with future inlay alternatives. Table 18 compares PCCP reconstruction to rehabilitating the existing ACP structure with 2.4-inch inlays at four-, six-, and eight-year cycles. The replacement of traffic loops was not included in the inlay analyses, as it was assumed that the traffic loops were placed beneath the ACP inlay depth. In addition, many regions are heading toward the use of video detection systems, and many traffic loops will be abandoned.

Table 17. Comparison of 40-year annualized costs, including user delay costs for reconstructing with PCCP or ACP. The ACP option includes future inlays at four-, -six-, and eight-year cycles following reconstruction.

SR	Intersection	40 Year Annualized Costs			
		PCCP Rebuild	ACP Rebuild with Inlays at 4 Years	ACP Rebuild with Inlays at 6 Years	ACP Rebuild with Inlays at 8 Years
27	Pines Rd. and Sprague Ave.	33,000	45,400	38,400	34,800
90	Broadway Ave. and Thierman St.	54,500	64,300	55,800	51,500
2	Division St. and Francis Ave.	72,100	100,500	87,600	80,500
291	Francis Ave./Maple and Ash St.	32,900	50,800	42,200	35,500
27	Pines Road and Broadway Ave.	34,200	51,000	42,700	38,500
395	SR 395 and 19th Ave.	30,100	46,700	38,500	34,300
2	Division St. and Third Ave.	13,800	18,100	15,600	14,400

Table 18. Comparison of 40-year annualized costs, including user delay costs for reconstructing with PCCP or inlaying the existing structure with 2.4-inch of ACP at four-, six-, and eight-year cycles.

SR	Intersection	40 Year Annualized Costs			
		PCCP Rebuild	Inlays at 4 Years	Inlays at 6 Years	Inlays at 8 Years
27	Pines Rd. and Sprague Ave.	33,000	22,900	15,900	12,300
90	Broadway Ave. and Thierman St.	54,500	27,600	19,200	14,900
2	Division St. and Francis Ave.	72,100	45,500	31,600	24,500
291	Francis Ave./Maple and Ash St.	32,900	28,200	19,600	15,200
27	Pines Road and Broadway Ave.	34,200	26,900	18,700	14,500
395	SR 395 and 19th Ave.	30,100	26,700	18,500	14,400
2	Division St. and Third Ave.	13,800	8,000	5,500	4,300

TRAFFIC CONTROL/STAGING

Traffic control and construction staging is typically the primary issue associated with the construction of PCCP intersections. While some delay to the traveling public is unavoidable, the delay has proved to be tolerable, with a maximum delay during peak hours, on occasion, of about 15 to 20 minutes.

An important design element is to obtain input from any party that will be affected by the intersection reconstruction. These parties include, but are not limited to, local governments, fire and police agencies, business owners, and private citizens. An important element to contract administration has been the wide publicity by WSDOT Public Information to local governments, businesses, and to the media, including newspapers and radio.

The importance of communication cannot be minimized. For instance, during construction of the Broadway Avenue and Thierman Street intersection (see Photo 17), the communication loop included WSDOT, the contractor, local agencies, law enforcement, fire departments, and affected property owners. An open invitation, initiated by the project engineer, was offered to any party affected by or interested in the construction to attend weekly meetings. Concerns were voiced, at these meetings, regarding the contractor's proposed work for that week. In most cases the contractor was able to accommodate concerns, whether that meant accommodating staging for access to businesses or addressing safety issues. Weekly meetings were of major importance in moving heavy truck traffic to an adjacent truck stop.

Photo 17. Completed PCCP intersection at SR 90, Broadway Avenue and Thierman Street.

The Customer Focus Highway Construction Workshop [2], held in Seattle in January 1999, noted that the traveling public is a lot more tolerant during construction when people are kept informed. With widespread publicity to keep the public informed, WSDOT has noticed upwards of a 30 percent reduction in the ADT for intersection reconstruction projects. The 30 percent reduction represents people who have found alternative routes or have adjusted their schedules to avoid the construction project.

Staging options for PCCP intersection construction includes the following:

- complete closures with detours
- partial closures with detours
- construction under traffic
- complete closures during limited time periods
- combinations of the above.

WSDOT used complete closures, partial closures with detours, construction under traffic and a combination of construction under traffic and complete closures.

Complete Closures

The ideal construction situation is to completely close the roadway. Complete closures allow the contractor to remove and replace more roadway in a continuous and safe operation. Interaction with traffic is avoided, as complicated work zone lane configurations are eliminated. However, closing a major urban arterial is often not an option, particularly when detours are not available. Another concern is that complete closures restrict access to businesses that are adjacent to the intersection, therefore they are unpopular.

A complete closure was used successfully in Spokane to restrict traffic from the east- and westbound off-ramps of I-90 to the northbound approach on Division Street at Third Avenue (see Photo 18). Construction was thoroughly signed and well detoured and limited to five days, which proved to be more than adequate.

Photo 18. Complete closure on SR 2, Division Street at Third Avenue.

The South Central Region used complete closures on SR 395 in Kennewick, where the Clearwater Avenue, West Kennewick Avenue, and Yelm Street intersections were reconstructed. One intersection per weekend was reconstruction during September and October 2000. The contract specified closing each intersection by 7:00 p.m. Thursday evening and opening to traffic by 6:00 a.m. the next Monday morning. Local traffic was detoured to adjacent streets, while state highway traffic was detoured over nearby Interstate Highways.

Before the weekend closures, the South Central Region reconstructed under traffic the approach and leave legs to the intersections (see photos 19 and 20). During the weekend closures, ACME Construction and Materials from Spokane, Washington, removed and replaced the roadway within the intersection square (radius return to radius return) and a portion of each approach or leave legs of the adjoining city streets. Photo 21 shows reconstruction of the SR 395 and West Kennewick Avenue intersection on the Friday of the three-day closure. PCCP placement and curing proceeded well, with the roadway opened well ahead of the 6:00 a.m. Monday morning target. For all three closures, the roadway was opened to traffic by 6:00 p.m. Sunday. Following the closures, WSDOT received very favorable comments from both businesses and residents. Documentation of the West Kennewick Avenue intersection reconstruction is available through the Innovative Pavement Research Foundation [3].

Robert Seghetti, of ACME Materials and Construction, attributed the success of the Kennewick area intersection reconstruction to the following:

- WSDOT held preliminary meetings with the City of Kennewick to discuss construction impacts and City concerns
- businesses were invited to preconstruction meetings
- WSDOT met with contractors to discuss construction feasibility
- the public was kept informed via newspapers, radio, and television news broadcasts

- WSDOT's web page was updated with information
- WSDOT provided flyers to businesses each week
- WSDOT and ACME Materials and Construction partnered with the modifications to the traffic control plan allowing continuous work operations with increased safety for employees
- Clearwater Avenue and West Kennewick Avenue were constructed concurrently, maximizing crew efficiency
- ACME provided a detailed schedule with known milestones
- ACME's aggressive construction schedule was either met or exceeded
- work operations were continuous, some element of construction was always happening
- WSDOT and contractor decision makers were available to resolve issues.

Photo 19. Construction of the approaches while under traffic on SR 395 at the SR 395 and West Kennewick Avenue intersection.

Photo 20. Reconstructed approaches on SR 395 at the SR 395 and West Kennewick Avenue intersection prior to the weekend closure.

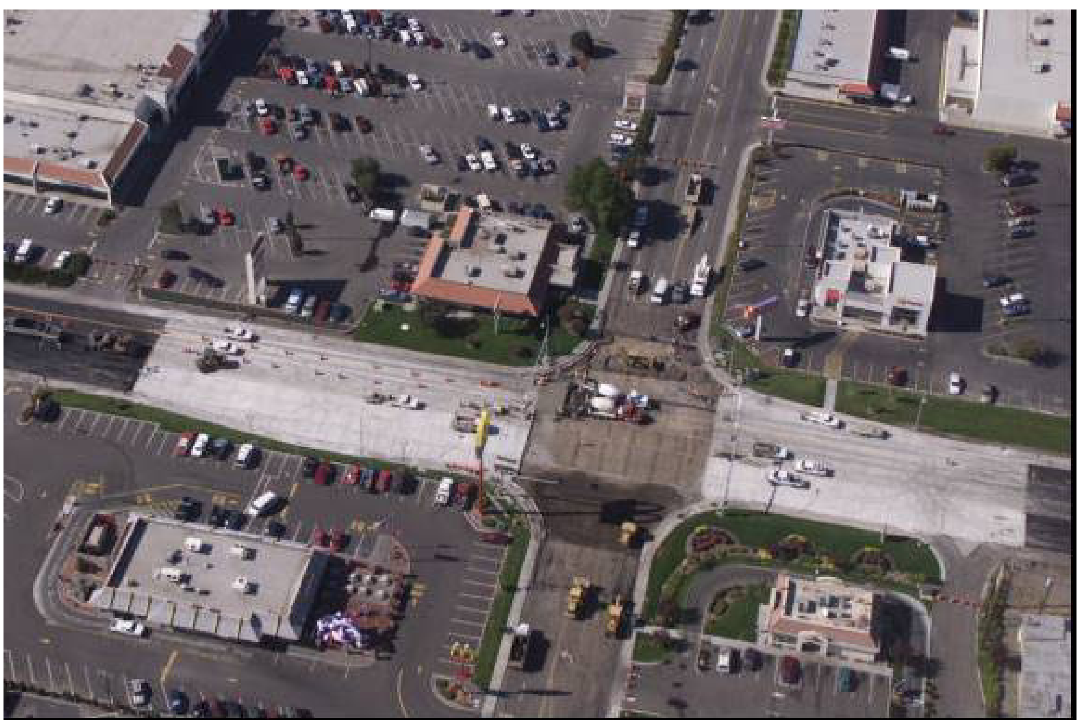

Photo 21. Reconstruction of the SR 395 and West Kennewick Avenue in Kennewick, Washington. The first loads of concrete are being placed during the Friday of the three-day closure (photo courtesy of Tri-City Herald).

Partial Closures

A partial closure was used on the Pines Road and Broadway Avenue Intersection in Spokane. This partial closure was coordinated with Spokane County and permitted since businesses were minimally impacted and detour routes for the minor legs of the intersection were available. Photo 22 shows the partial closure scenario used by ACME Construction and Materials of Spokane, Washington, to construct the Broadway Avenue approaches.

Photo 22. Partial closure scenario for reconstruction of SR 27, Pines Road and Broadway Avenue intersection.

With the partial closure at the Pines Road and Broadway Avenue in effect, left and right turns from Pines Road were eliminated. The Eastern Region reported that traffic flowed better through the intersection than when the intersection was fully functional. When the minor legs of the intersection were reopened and construction continued on Pines Road, turning movements to

Broadway Avenue were not restricted. Traffic flow was again severely reduced, causing the Region to consider restricting turning movements during future contracts.

Construction Under Traffic

Construction under traffic is more typical in WSDOT's experience because traffic flow must be maintained and detour routes are usually not available. On the Broadway Avenue and Thierman Street project, a variety of means were used to keep traffic moving. The adjacent truck stop and businesses, as well as turning movements to adjacent streets or ramps, had the potential to make traffic flow difficult. Daytime operations utilized a pilot car as shown in Photo 23. The resulting queues were minimal. Directional turning movements were allowed as traffic flowed from the east or west. Flaggers were well positioned where turning movements were allowed.

Photo 23. Broadway Avenue and Thierman Street construction under traffic.

For nighttime operations, utilizing the existing traffic lights in a flashing mode minimized traffic control. Therefore, the costs for "Labor for Traffic Control" was 44 percent lower than budgeted. An equitable adjustment to the contractor was provided, and the state realized a cost savings of $47,000.

The SR 27, Pines Road and Sprague Avenue intersection was also built under traffic. The state estimated that 24-hour traffic control would be required. However, Inland Asphalt of Spokane, Washington, scheduled the major portion of the preparation work to be done at night. Traffic was controlled by signals during the day, and flaggers were used for the nighttime construction. Traffic disruption was kept to a minimum, which also kept the cost to the state for traffic control at 25 percent below budget.

Photo 24 shows construction on SR 2, Francis Avenue with Maple and Ash Streets, where two lanes of traffic were maintained through the workzone. Traffic problems were minimal for this highway with an ADT of 31,000 vehicles. Photo 25 shows traffic being maintained while intersection construction proceeds on SR 2 Francis Avenue and Division Street.

Complete Closures During Limited Time Periods

Maintaining traffic to businesses sometimes requires that business approaches be built in stages or during limited time periods. If a business is closed evenings, the entire business access can be closed, and pavement removal and grade preparation may be done during the evening hours. Before the access is reopened, a temporary approach can be placed. During subsequent construction the temporary approach can be removed, and the new PCCP can be placed in stages to keep access open.

Photo 24. Reconstruction with PCCP of Francis Avenue with Maple and Ash Street under traffic.

Photo 25. SR 2, Division Street and Francis Avenue construction staging. Intersection reconstruction was staged to allow for construction under traffic.

Construction Staging

Figures 1 and 2 show variations in construction sequences, as summarized by the American Concrete Paving Association (ACPA) [4], to detour traffic with construction under traffic.

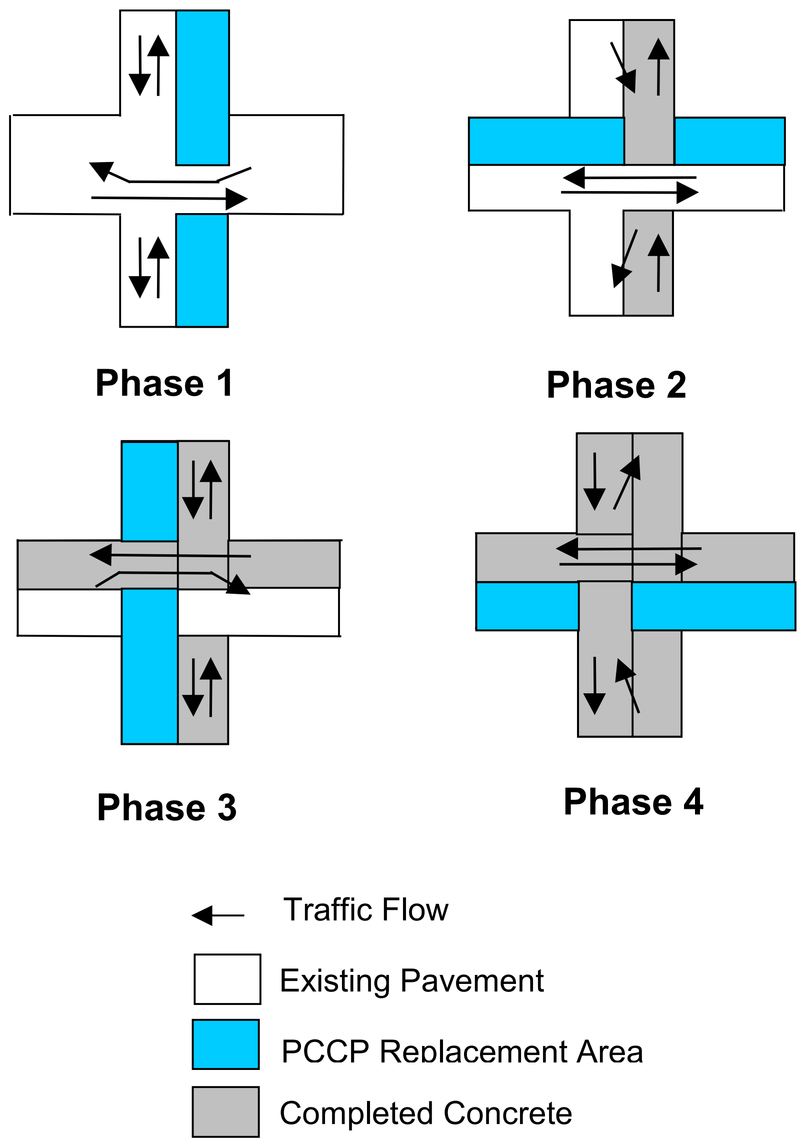

Figure 1. Traffic staging scenario – construction by lane (figure courtesy of American Concrete Paving Association).

The degree to which these recommended staging options are used depends upon the number of lanes and the number of businesses to which access must remain open. WSDOT has used variations of these sequences as each intersection required unique staging requirements.

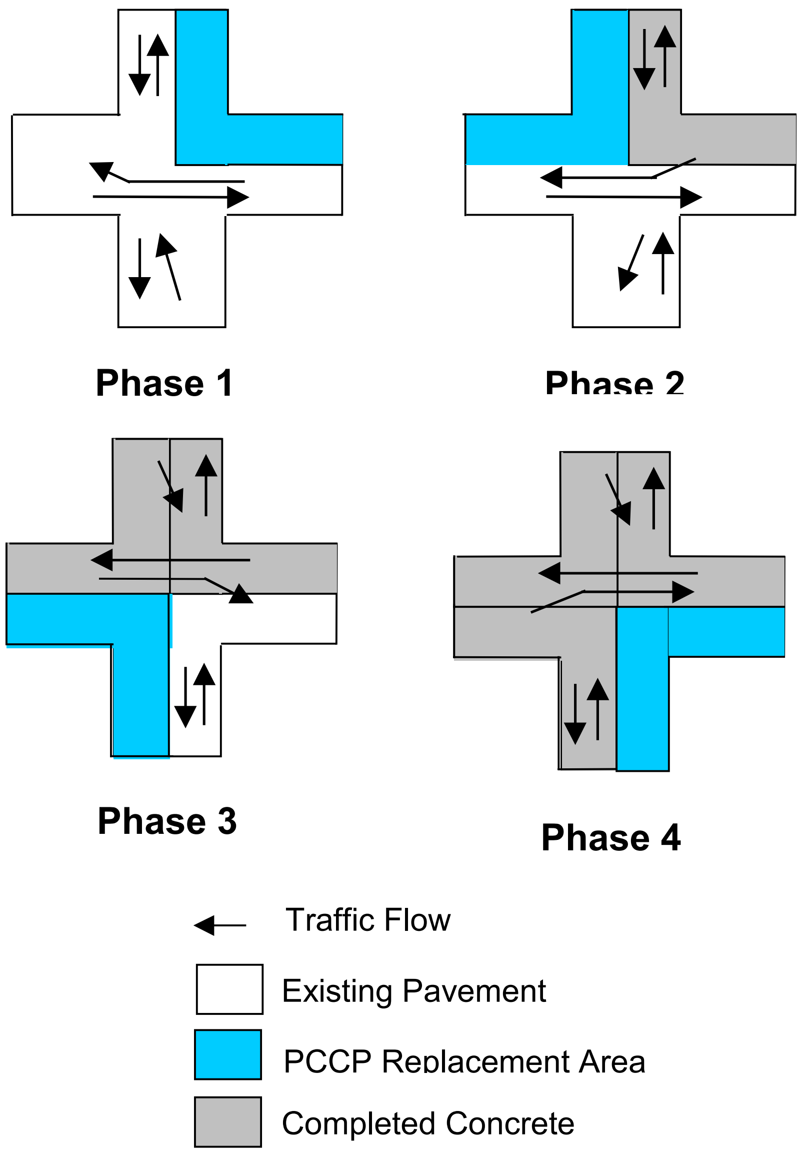

Figure 2. Traffic staging scenario – construction by quadrant (figure courtesy of American Concrete Paving Association).

Table 19 illustrates the number of pour days required to construct each intersection based on the staging used for each project. Projects using partial, complete, or a combination of closures reduced the number of pour days required.

Table 19. Summary of staging used and number of days of concrete pours required.

SR	Intersection	Staging	Number of Thru Lanes[1]	Concrete Pours (days)
27	Pines Rd. and Sprague Ave.	Construction Under Traffic	4	5
90	Broadway Ave. and Thierman St.	Construction Under Traffic	4	14
2	Division St. and Francis Ave.	Construction Under Traffic	6	19
291	Francis Avenue/Maple and Ash St.	Construction Under Traffic	4	12
27	Pines Rd. and Broadway Ave.	Partial Closure and Construction Under Traffic	4	9
395	SR 395 and 19th Ave.	Construction Under Traffic	4	6
2	Division St. and Third Ave.	Complete Closure	3	2
395	Yelm Street	Complete Closure and Construction Under Traffic	4	7
395	Clearwater Avenue	Complete Closure and Construction Under Traffic	4	8
395	West Kennewick Avenue	Complete Closure and Construction Under Traffic	4	7

[1] Each intersection also has left turn lanes.

Staging – Construction Under Traffic

The staging on SR 27, Pines Road and Sprague Avenue allowed concrete placement in quadrants as shown in Figure 2. This section was five lanes wide, the center being a left-turn lane. The ADT was 26,000.

Following removal of the existing ACP and a portion of the existing surfacing for the entire intersection, the contractor placed an ACP base. Since work was scheduled at night and the preparation work for the PCCP was completed, large areas of PCCP could be placed in a single pour. PCCP placement went smoothly for the five pours, with minimal traffic delays.

SR 2, Division Street and Francis Avenue was more complex. While only six shifts in traffic were necessary, nineteen pours were required to construct this eight-lane section, the two center lanes being left-turn lanes. Specific staging requirements for this section included:

- maintaining traffic flow for 32,000 ADT
- four lanes must remain open along Division Street (two lanes in each direction)
- left turns from Division Street must remain open
- two lanes must remain open along Francis Avenue (one lane in each direction)
- access to businesses, located on all four corners of the intersection, must remain open.

The staging for Division Street and Francis Avenue involved routing southbound traffic on the northbound lanes while the southbound lanes were constructed. Since no more than two lanes were constructed at a time, adjacent pours were necessary to build the eight-lane section. Six pours were needed to complete the southbound lanes on Division Street. Traffic was then routed on the southbound lanes, and construction proceeded in the northbound direction (Photo 26). The construction for the Francis Avenue approaches was similar. The construction staging used for Division Street and Francis Avenue as illustrated by Seghetti [5] is shown in Appendix E.

While construction on Division Street and Francis Avenue initially caused heavy traffic delays, the contractor, ACME Materials and Construction, noted a 20 to 30 percent decrease intraffic volumes after the first week of construction as commuters found alternative routes.

Allowing left turns from Division Street to Francis Avenue caused traffic delays along Division Street. In retrospect, eliminating left turns would have significantly reduced traffic delays. Access for material delivery for construction was not a problem.

Photo 26. Construction of the northbound lanes on SR 2, Division Street and Francis Avenue.

Photo 27 shows a view of the staging used on SR 2, Francis Avenue with Maple and Ash Streets. This intersection was built by staging eastbound traffic onto the westbound lanes. One lane of traffic was maintained in each direction. Left-turn movements were restricted for traffic on Francis Avenue. Once the south half of the intersection was built, traffic was diverted onto the completed PCCP. Construction was then concentrated on the north half of the intersection, and traffic was routed in a similar manner. Twelve separate concrete pours were necessary to complete the intersection.

Photo 27. SR 291, Francis Avenue with Maple and Ash Streets staging.

Staging – Partial Closure with Detours

The original traffic restrictions, provided in the contract documents, required maintaining traffic on all legs of the intersection for the reconstruction of Pines Road and Broadway Avenue. After evaluation of the staging plan submitted by the contractor, WSDOT allowed the closure of Broadway Avenue. The result was that left turn movements on Pines Road were eliminated. Broadway Avenue traffic used alternate routes. The Pines Road traffic signals were set on green for both northbound and southbound traffic. Traffic backups did not occur. The construction staging used for Pines Road and Broadway Avenue is illustrated in Appendix E [5].

Staging – Combination of Complete Closure and Construction Under Traffic

The intersections of West Kennewick Avenue and Clearwater Avenue with SR 395 were built concurrently using a combination staging of complete closures and construction under traffic. The ADT for these intersections was 30,000 with 20 percent trucks.

Building these consecutive intersections concurrently allowed WSDOT the ability to shift traffic simultaneously while the left turn lanes, the eastbound approaches, and then the westbound approaches were constructed under traffic. Following the construction of the approaches, each intersection was completely closed, on separate weekends, to reconstruct the intersection square (radius return to radius return). Building the intersections simultaneously allowed the contractor to keep construction moving as pour areas became available rather than building all the approaches at one intersection, moving traffic control, and then repeating the process. The construction staging used for SR 395 and the West Kennewick Avenue intersection is illustrated in Appendix E [5].

Staging Plans

On the initial PCCP intersection contracts, WSDOT provided staging plans in the contract documents. While providing staging plans is necessary in some instances, WSDOT learned that a more practical approach to traffic control is to specify traffic control restrictions in the contract and let the contractor provide staging plans with approval by WSDOT. Allowing the contractor to submit the staging plans, or to recommend changes to staging plans provided in the contract plans, allows the contractor the ability to utilize the workforce, equipment, and ingenuity in the most efficient manner. Staging plans typically correspond to the PCCP jointing plans that WSDOT includes in the contract.

The traffic control restrictions and staging plan requirements for the SR 2, Division Street and Francis Avenue and SR 395, SR 395 and 19th Avenue construction are shown in Appendix F.

DESIGN CONSIDERATIONS

The following is an overview of the most common design concerns for PCCP intersections. These design considerations include the following:

- PCCP construction limits
- jointing details – (PCCP jointing plan)
- construction and contraction joint terminology
- placement of dowel bars and tie bars at PCCP intersections
- pavement section
- pavement profile
- special provisions for cement concrete pavement construction
- PCCP materials
- construction time
- concrete to asphalt transitions
- traffic detection systems
- coordination with local agencies and utility companies.

PCCP Construction Limits

The limits for reconstruction with PCCP should be determined on the basis of an evaluation of the existing pavement condition. The area of pavement rutting or distress is usually easily identified, and vehicle start and stop areas typically define the area of needed reconstruction. The major arterial approach legs to intersections may require PCCP from 200 to 500 feet back from the crosswalk. The length of the arterial approach legs will depend upon the number, speed, and type of vehicles using the intersection. The approach legs on the minor arterial typically require 50 to 100 feet but may extend farther. The approach and leave legs should extend an equal distance from the intersection (see Figure 3). Equal extension allows more convenience for adjacent ACP rotomilling operations, as opposed to doglegs when approach and leave leg lengths are different. Also, joint sealing, along the doglegs, during intersection reconstruction and resealing during future maintenance is avoided. Reconstruction should be limited to the approach and leave legs and intersection area.

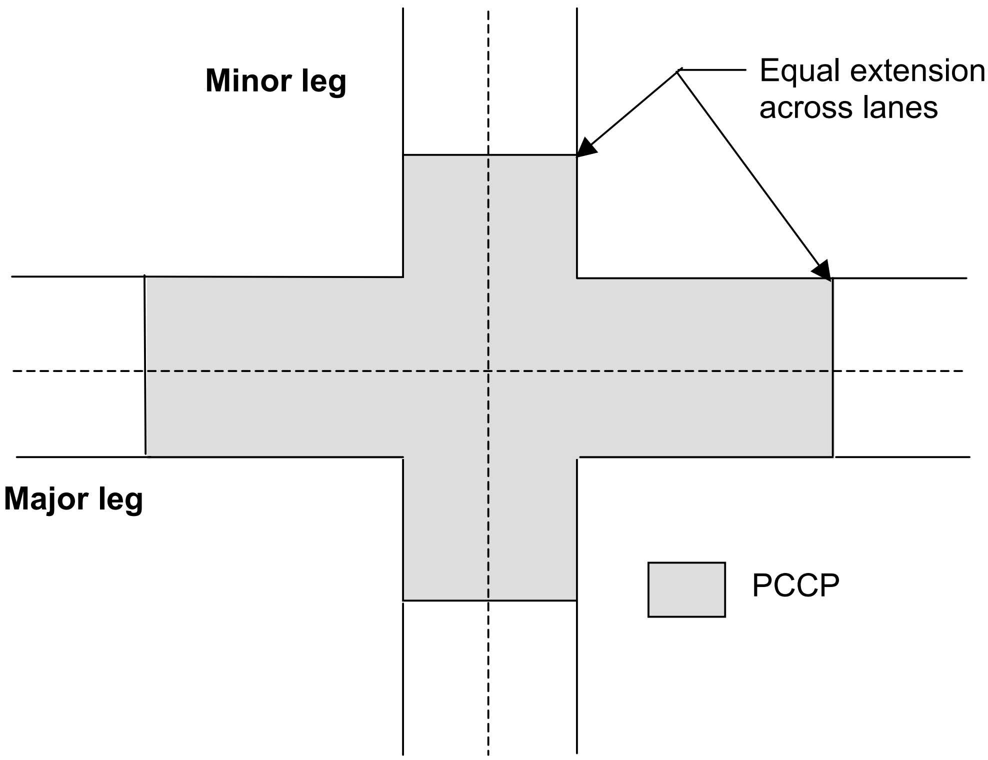

Figure 3. Equal extension of concrete across the leave and approach legs of a PCCP intersection.

Jointing Details – (PCCP Jointing Plan)

An important lesson learned by WSDOT is that it is critical to thoroughly design the joint layout details. When joint preplanning has not occurred, undesirable cracks have developed in the PCCP. These cracks will affect the PCCP performance and could have been avoided. If joint details are left undecided until the time of construction, visualizing the proper placement of joints is difficult because of construction staging.

WSDOT quickly learned the importance of joint preplanning on the SR 27, Pines Road and Sprague Avenue intersection project. During construction several newly placed PCCP panels experienced cracking, particularly for odd shaped areas. Following construction, the Eastern

Region recommended in its End of Project Report that contract plans include a plan view of the required jointing to ensure proper crack control. In addition, it recommended that more specific requirements for furnishing and installing reinforcing bars be included. Providing a joint layout in the plans would satisfy both recommendations, as these design decisions would then be made ahead of construction. Many agencies lack the experience to make the necessary decisions while the concrete is being placed.

The ACPA stresses that a well considered plan is vital to the success of the intersection. A good jointing plan, as summarized by the ACPA [4], accomplishes the following:

- eases construction by providing clear guidance and facilitates staging
- enables contractors to more accurately bid the project
- ensures that joints pass through fixtures embedded in the pavement such as manholes or drainage outlets.

Designers should prepare an intersection joint layout while developing project plans. In 1996 the ACPA prepared a step-by-step procedure [6] titled "Concrete Information – Intersection Joint Layout." This procedure is summarized in Appendix G. Appendix H provides jointing plans from several of the PCCP intersections built by WSDOT. A typical roadway section and joint details for each plan are provided. Following each jointing plan are the revisions WSDOT would make to provide consistency and clarity on future PCCP intersection projects.

The last section of Appendix H shows a typical jointing plan used by Spokane County on PCCP intersection projects. These plans are very detailed and supply all the necessary information to replace ACP with concrete.

Photos 28 through 48 show the cracking that will develop when joint planning is not considered. Photos showing ways to avoid cracking or improper utility placement are also included.

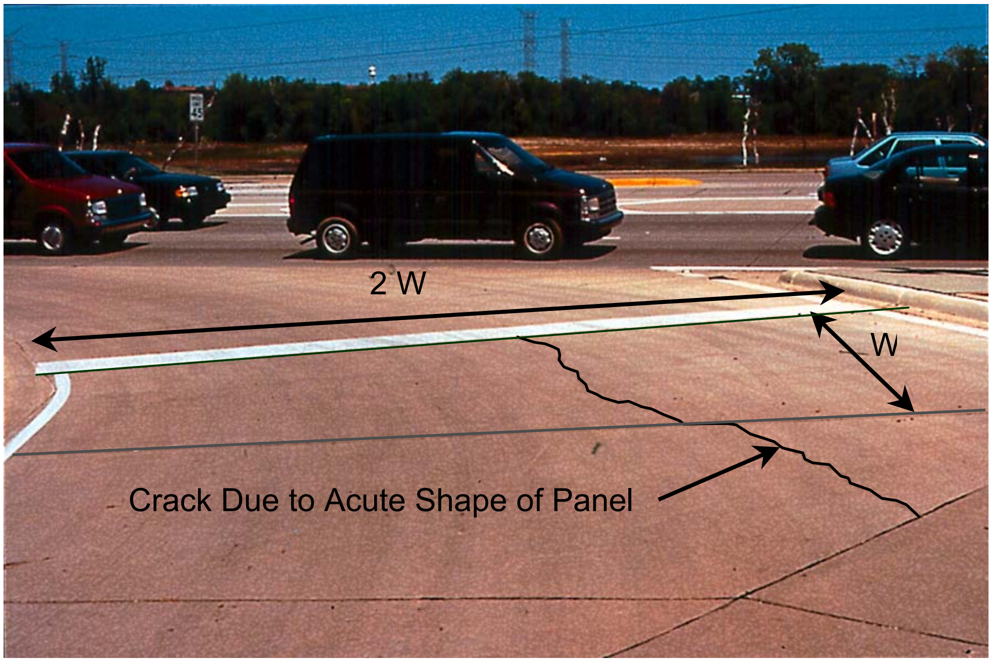

Photo 28. Cracking that will result when PCCP slabs are geometrically incorrect. Large, irregular, or rectangular slabs will crack (Photo courtesy of American Concrete Paving Association).

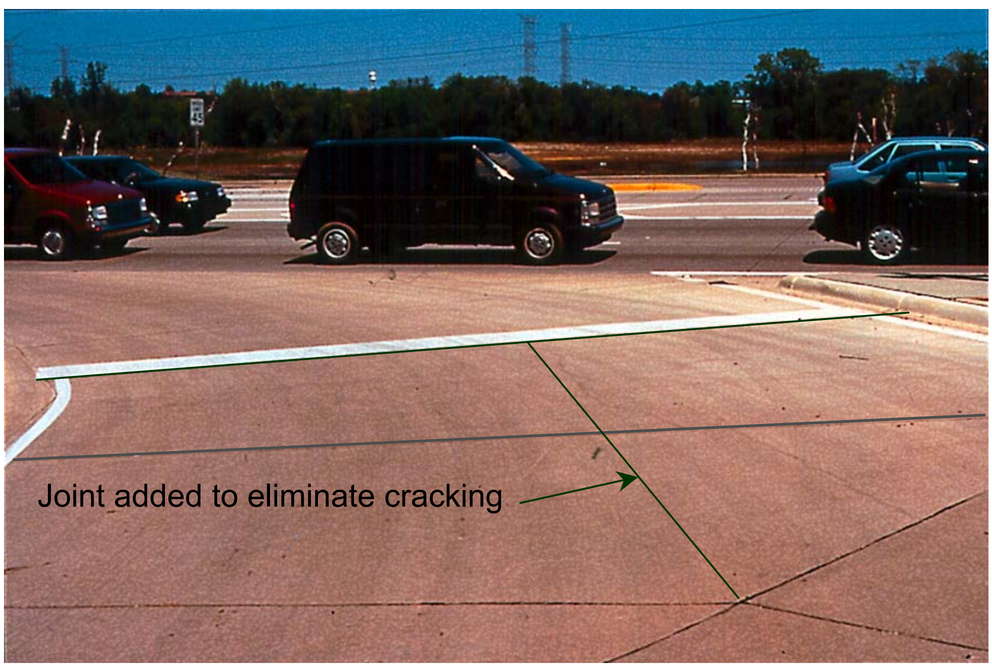

Photo 29. Jointing to eliminate cracking from irregularly shaped areas (Photo courtesy of American Concrete Paving Association).

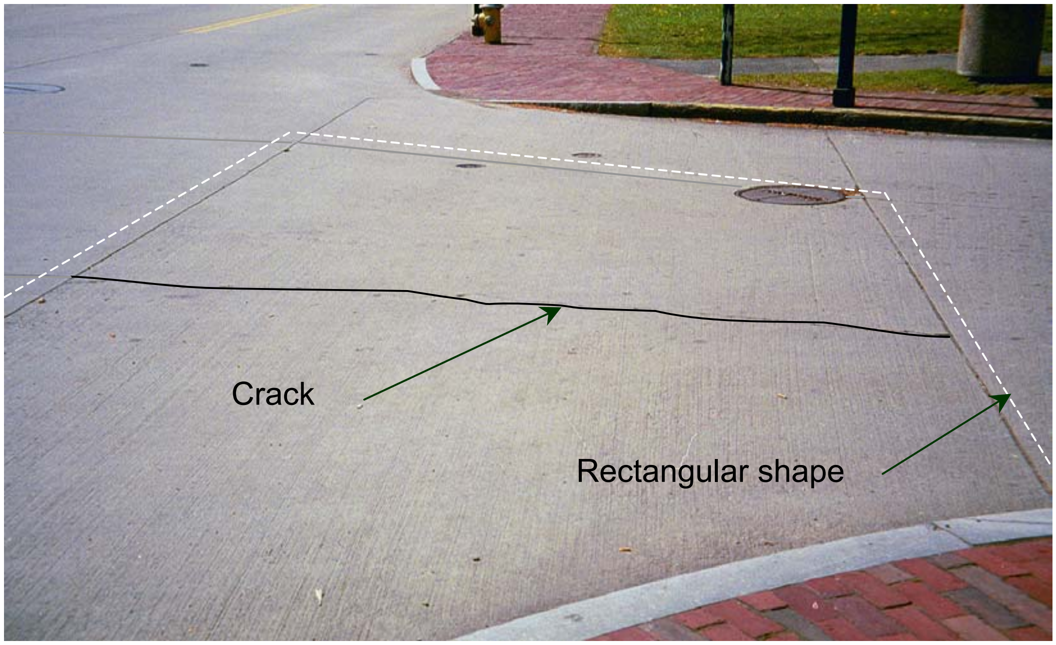

Photo 30. Cracking that results with rectangular slabs (Photo taken in Newport, Rhode Island).

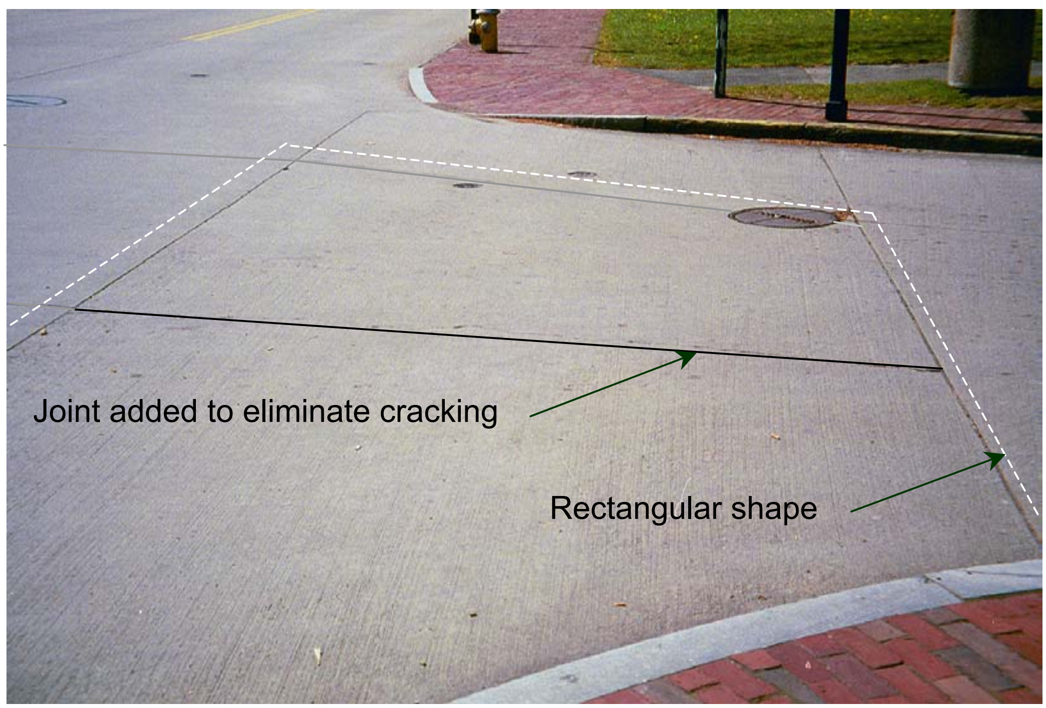

Photo 31. Correct jointing to eliminate cracking for rectangular areas (Photo taken in Newport, Rhode Island).

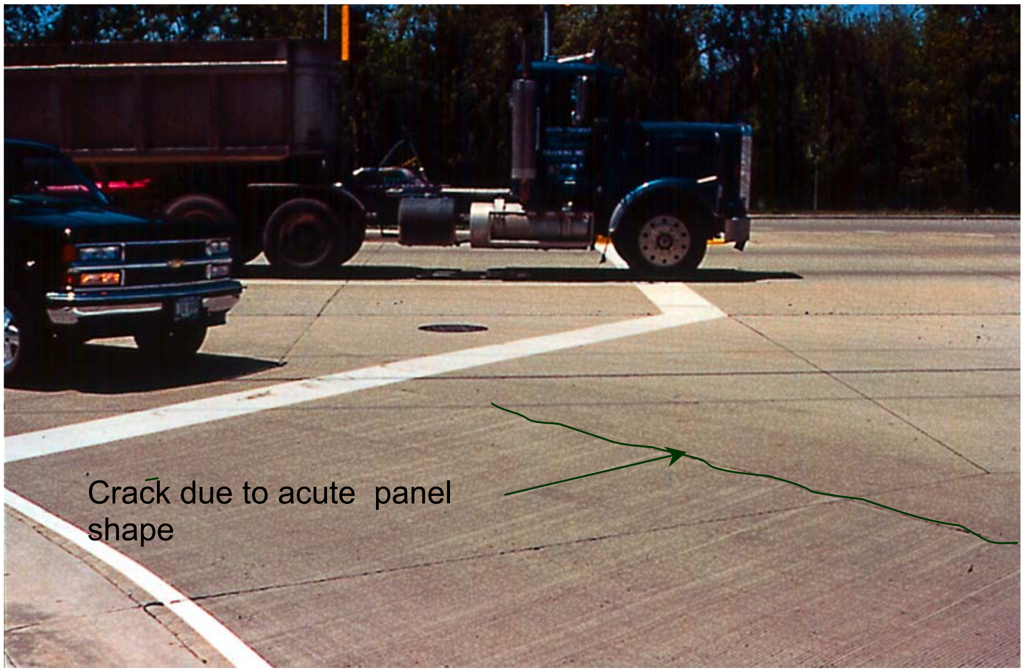

Photo 32. Cracking that resulted from an irregularly shaped panel (Photo courtesy of American Concrete Paving Association).

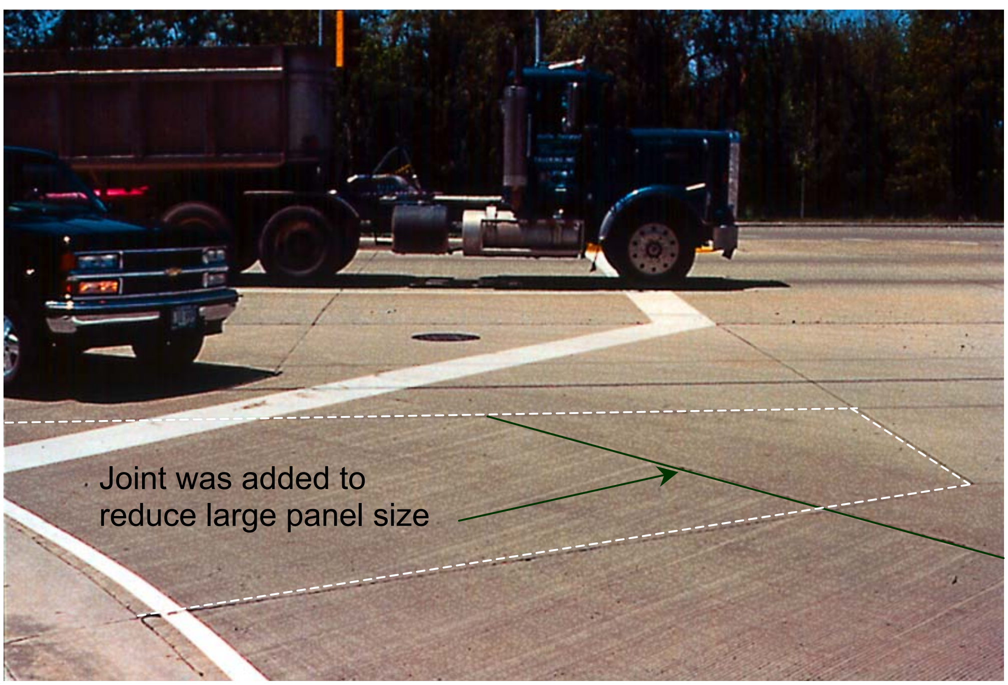

Photo 33. Irregularly shaped slab that has been jointed to reduce crack potential (Photo courtesy of American Concrete Paving Association).

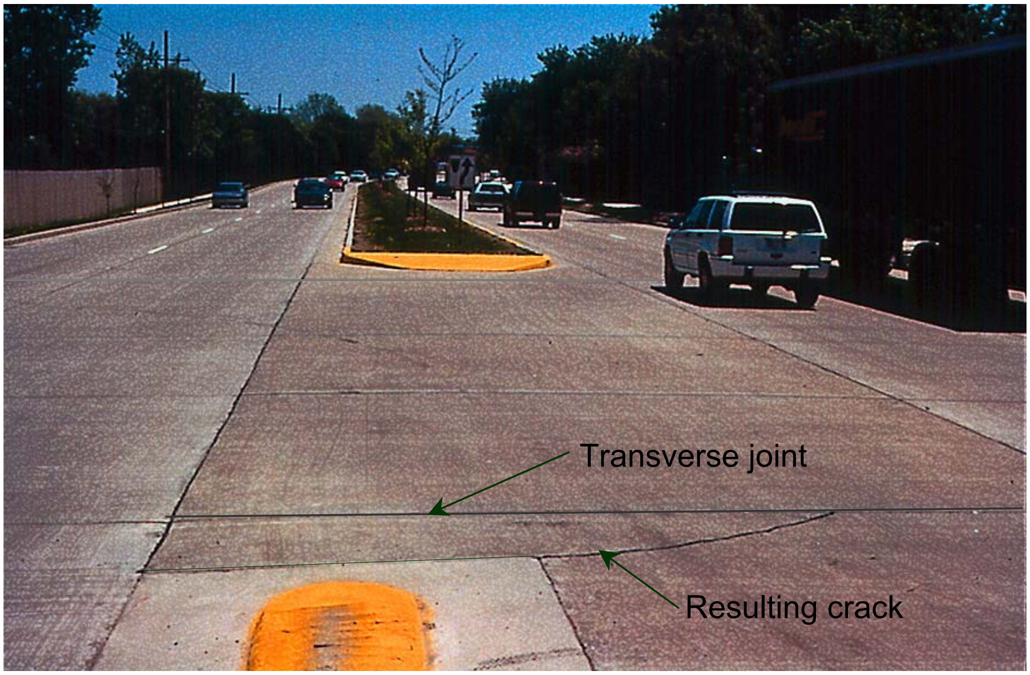

Photo 34. Crack developed when joints were not aligned with channelization. (Photo courtesy of American Concrete Paving Association).

Photo 35. Alignment of joints with channelization to eliminate cracking. (Photo courtesy of American Concrete Paving Association).

Photo 36. Corner cracking that occurs with joints intersecting at acute angles (angles of less than 60 degrees) (SR 90, Broadway Avenue and Thierman Street intersection).

Photo 37. Joint intersection at a concrete bridge approach. Joints do not intersect at acute angles (SR 90, Broadway Avenue and Thierman Street intersection).

Photo 38. Incorrectly jointed manhole boxout (Photo courtesy of American Concrete Paving Association).

Photo 39. Correct placement of a utility boxout to intersect joints (Photo courtesy of American Concrete Paving Association).

Photo 40. Cracking at a manhole due to poor joint planning (Photo courtesy of American Concrete Paving Association).

Photo 41. Skewed jointing which would eliminate cracking (Photo courtesy of American Concrete Paving Association).

Photo 42. Cracking at a manhole due to poor joint planning (Photo taken in Newport, Rhode Island).

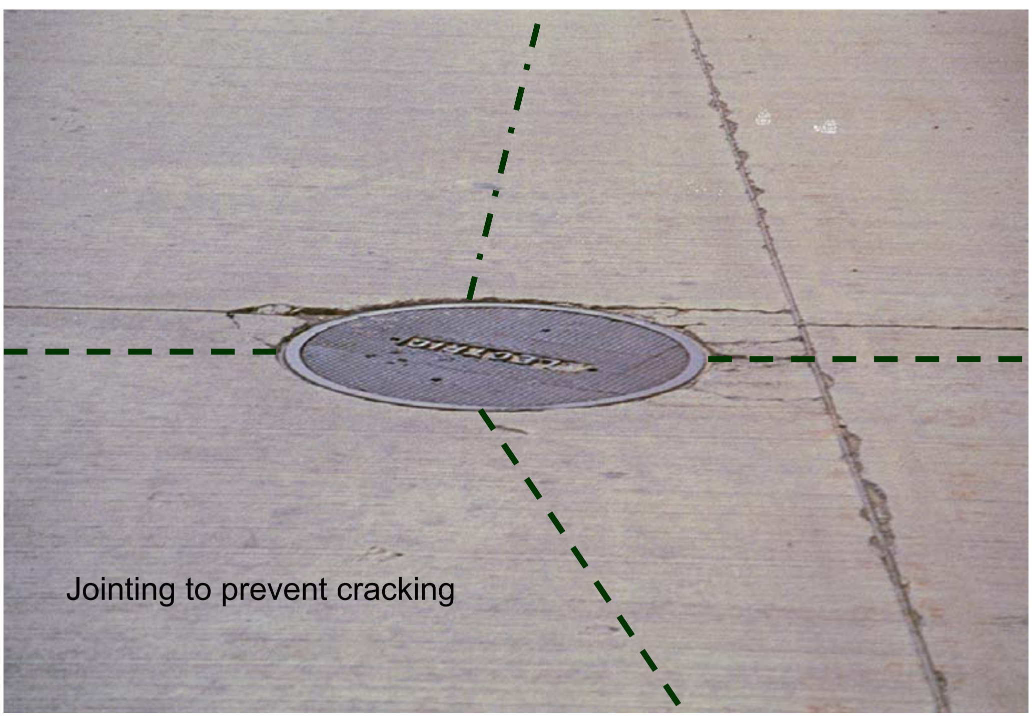

Photo 43. Jointing a manhole to eliminate cracking (Photo taken in Newport Rhode Island).

Photo 44. Placement of joints to prevent cracking for an intersection with multiple manholes (Photo courtesy of American Concrete Paving Association).

Photo 45. Proper alignment of a catch basin with a transverse joint. However, the transverse joint was only sawed across one lane for this two-lane pour. A sympathy crack resulted (SR 90, Broadway Avenue and Thierman Street intersection).

Photo 46. Sympathy crack that extended across five lanes of roadway. The initial pour was two lanes wide, and cracking likely occurred because of late sawing (SR 90, Broadway Avenue and Thierman Street intersection).

Photo 47. Sympathy crack resulting from a transverse joint intersecting a panel at mid length (Photo taken in Newport, Rhode Island).

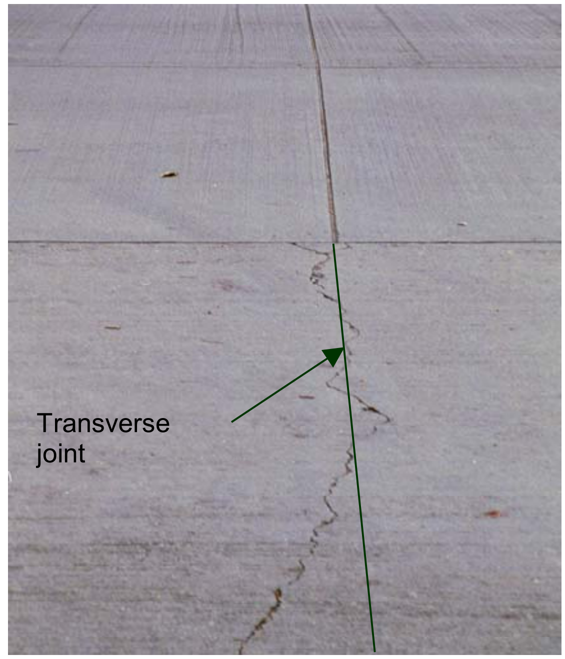

Photo 48. Jointing across an adjacent panel to reduce a sympathy crack (Photo taken in Newport, Rhode Island).

Construction and Contraction Joint Terminology

Two basic joint types must be considered:

- construction joints (transverse and longitudinal)
- contraction joints (transverse and longitudinal).

The following sections clarify the use for each.

Construction Joints - Transverse

Construction joints are used where paving is stopped (such as at the end of a workday). Because of the use of transverse header boards to form the terminus of paving, the two slab faces at the joint are relatively smooth. For this reason, little or no aggregate interlock exists, and dowel bars are required as noted in the WSDOT Construction Manual [7] and Standard Plan A-1 [8]. Dowel bar placement for construction joints is shown in Figure 4 and Photo 49. WSDOT uses 1 ½-inch-diameter dowel bars 18 inches long, spaced at 12-inch centers. Dowel bars should be spaced a minimum of 6 inches from longitudinal construction or contraction joints, as noted in Standard Plan A-1.

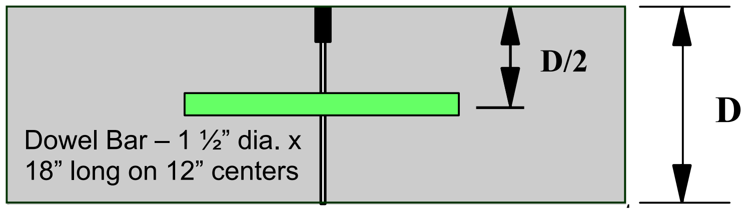

Figure 4. Construction joint (longitudinal or transverse).

Photo 49. Construction joint placed at the end of paving (SR 395, Hastings Road to Mile Post 172 PCCP paving project).

Construction Joints - Longitudinal

Longitudinal construction joints are constructed between adjacent lanes that are paved separately. Epoxy coated deformed No. 5 steel bars 32 inches long spaced 36 inches center-to-center are used to "tie" the lanes together. Tie bars should be placed 18 inches from transverse joints to avoid conflict with doweled transverse joints. Figure 5 shows the use of tie bars as described in WSDOT Standard Plan A-1. Photo 50 shows a longitudinal construction joint.

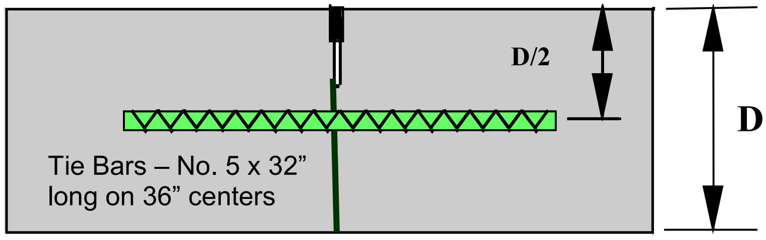

Figure 5. Longitudinal construction joint placed between adjacent lanes. Note the smooth joint through the concrete section.

Photo 50. Tie bars placed to straddle the transverse contraction joint and avoid conflict with doweled transverse joints (SR 90, Broadway Avenue and Thierman Street intersection).

Contraction Joints - Transverse

Transverse contraction joints run perpendicular to the pavement centerline and are essential to control cracking from stresses caused by shrinkage, thermal contraction or expansion, and moisture or thermal gradients. Typically these joints are at a right angle to the pavement centerline and edges. Since 1993, WSDOT PCCP paving projects have used dowel bars at transverse contraction joint locations to reduce the potential for joint faulting. Because of construction considerations, skewed joints are not necessary when dowel joints are specified. Skewed joints require complex jointing layouts.

A reasonable joint spacing when dowels are used is 12 feet; however, contraction joint spacings of up to 15 feet can be used. These contraction joint spacings are, in part, based on previous PCCP performance in Washington State, as described in the WSDOT Pavement Guide, Volume 2 [9].

Dowel bar placement for transverse joints is shown in Figure 6 and Photo 51 (the dowel bars are 1 ½ inch diameter by 18 inches long, spaced at 12-inch centers). Dowel bars should be spaced a minimum of 6 inches from longitudinal construction or contraction joints, as noted in Standard Plan A-1.

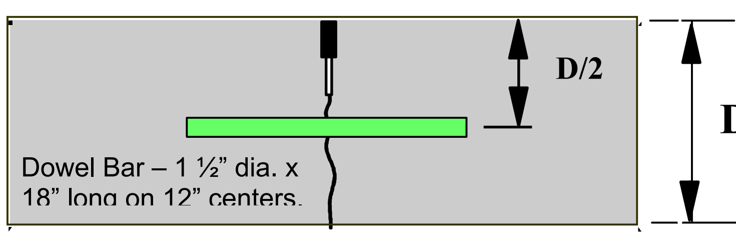

Figure 6. Transverse contraction joint. Note the crack contributing to aggregate interlock through the concrete section.

Photo 51. Dowel bars placed on transverse joints. Note that tie bars used on the longitudinal joints are spaced away from the dowel bar assembly (Boone and Monroe intersection, City of Spokane, Washington).

Contraction Joints - Longitudinal

Longitudinal contraction joints are sawed between adjacent lanes that are paved together. Epoxy coated deformed No. 5 steel bars 32 inches long, spaced 36 inches center-to-center, are used to "tie" the lanes together. Tie bars should be placed 18 inches from transverse joints to avoid conflict with doweled transverse joints. Figure 7 illustrates the use of tie bars, as described in WSDOT Standard Plan A-1. Photo 52 shows both a longitudinal contraction joint and longitudinal construction joint.

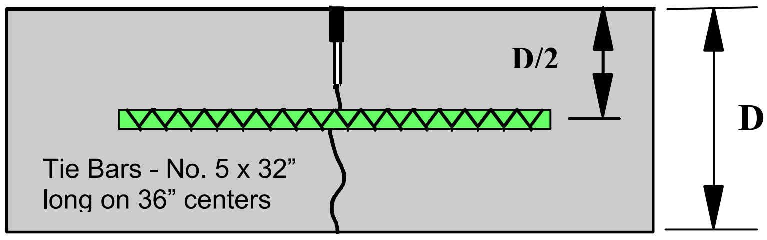

Figure 7. Longitudinal contraction joint placed between adjacent lanes. Note the crack through the concrete section.

Photo 52. Longitudinal construction joints with exposed tie bars are shown on the left. Longitudinal contraction joints placed in tie bar baskets prior to concrete placement are shown on the right (SR 2, Division Street and Francis Avenue intersection).

Placement of Dowel Bars and Tie Bars at PCCP Intersections

This section details the placement of dowel bars and tie bars within the physical area of the intersection. Both the areas of the intersection with cross traffic and areas within the approach or leave legs will be addressed.

Placement of dowel and tie bars may vary depending upon the traffic level. Typically, WSDOT has placed dowel bars on the transverse joints in the direction of the heavier traffic. Dowel bars may be placed on transverse joints in the direction of the lighter traffic, depending on the traffic level. In cases where the lighter traffic is significantly less than the heavier traffic, tie bars used on the transverse joints is sufficient.

The following discussion highlights placement of dowel bars and tie bars for

- heavy cross traffic both directions
- heavy cross traffic in one direction
- intersection approach and leave legs.

Appendix H provides additional details from several intersections built by WSDOT.

Intersections with Heavy Cross Traffic - Both Directions

WSDOT recommends placement of 1 ½-inch-diameter by 18-inch-long dowel bars at all joints with heavy cross traffic, as noted in Figure 8. A spacing of 18 to 24 inches from the edge of a panel to the first dowel bar along either of the joints will avoid dowels being placed too close together. Dowel bars on the other adjacent joint begin 6 inches from the panel edge. Most intersections built by WSDOT have included dowels placed on all joints within the cross traffic area (as illustrated in Figure 8).

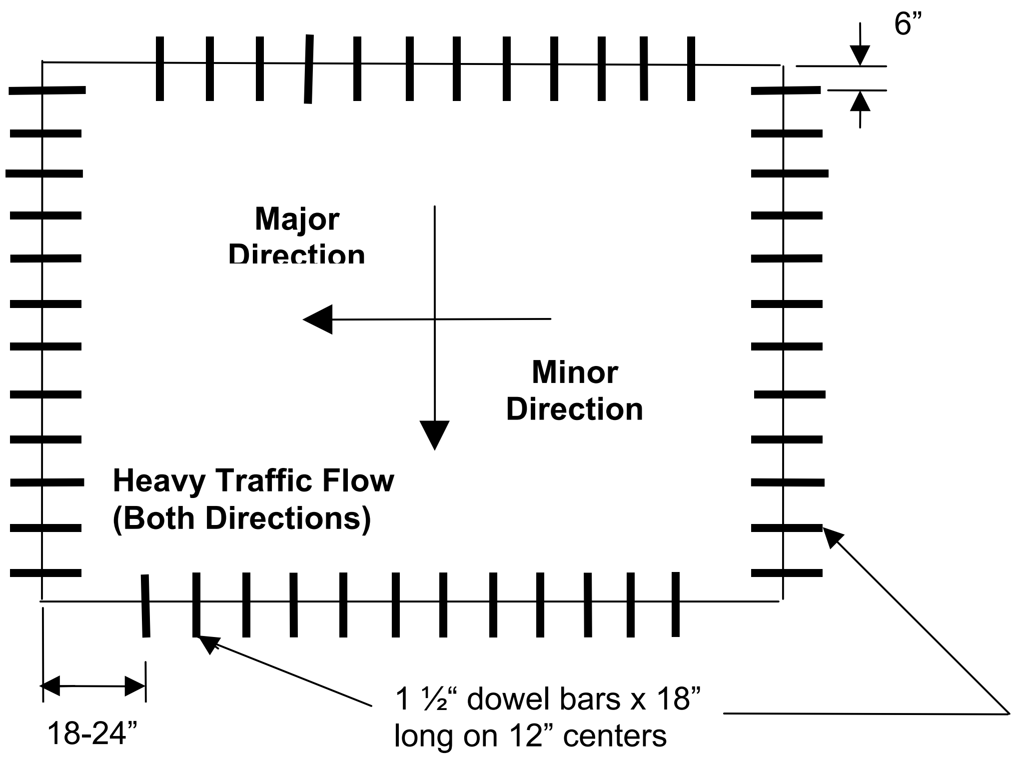

Figure 8. Dowel bar placement used where heavy traffic crosses in both directions.

Photos 53 and 54 show the placement of dowel bars across adjacent joints for areas of heavy cross traffic.

Photo 53. Alignment of dowel bars for the intersection area with heavy cross traffic (SR 2, Division Street and Francis Avenue intersection).

Photo 54. Dowel bars placed on adjacent joints for areas of heavy cross traffic. Note that dowel bars are spaced to avoid conflicting dowels at the panel corners (Boone and Monroe intersection, City of Spokane, Washington).

Intersections with Heavy Cross Traffic - One Direction

Placement of dowel and tie bars on intersections with heavy traffic flow in one direction is shown in Figure 9. In this instance, transverse joints in the direction of the heavy traffic receive 1 ½-inch by 18-inches-long dowel bars placed on 12-inch centers. No. 5, 32-inches-long tie bars placed on 36-inch centers are placed in transverse joints in the direction of light traffic. Spacing the first tie bar a minimum of 18 inches from the edge of a panel will eliminate conflicts with tie and dowel bars at panel corners. Dowel bars should begin 6 inches from the panel edge.

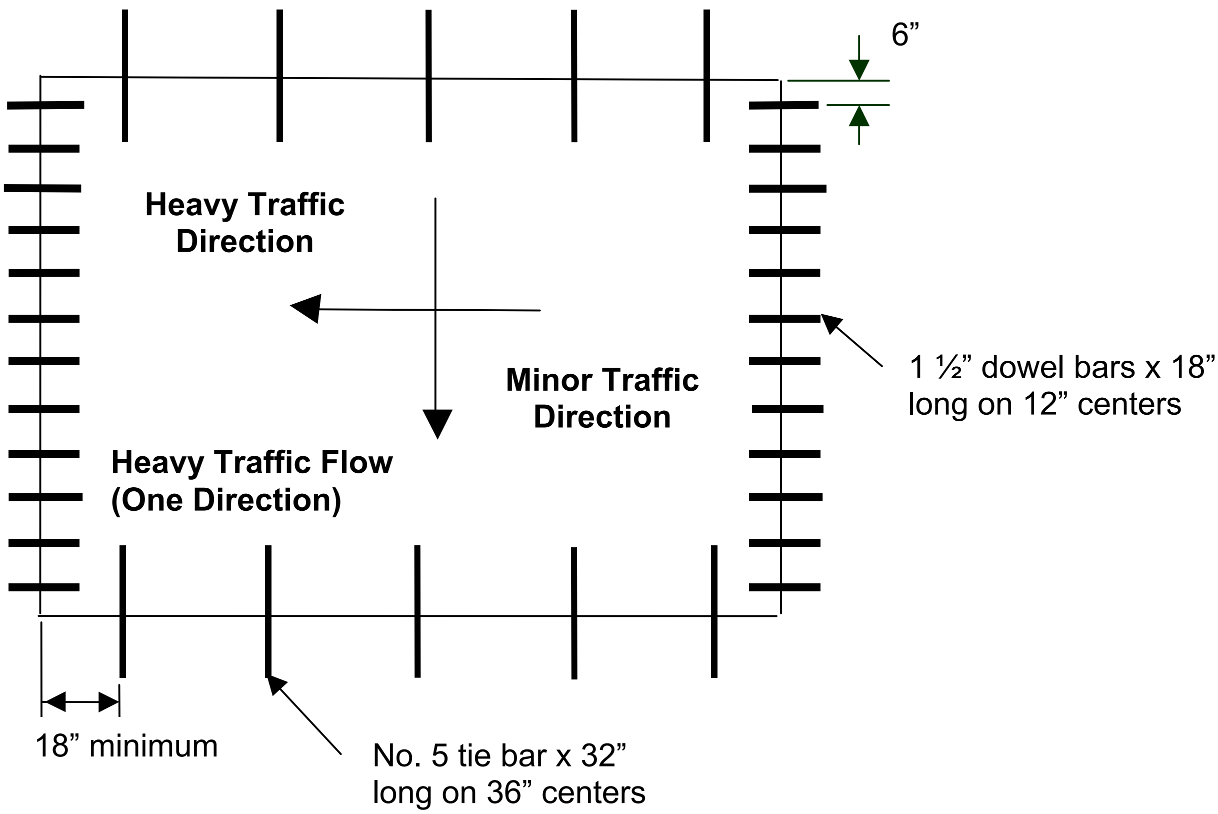

Figure 9. Dowel bar placement used where heavy traffic crosses in one direction.

Intersection Approach and Leave Legs

Placement of dowel bars and tie bars on approach legs is shown in Figure 10. In these instances, No. 5, 32-inch-long tie bars are placed along longitudinal joints on 36-inch centers. 1 ½-inch dowel bars 18 inches long on 12-inch centers are placed on transverse joints.

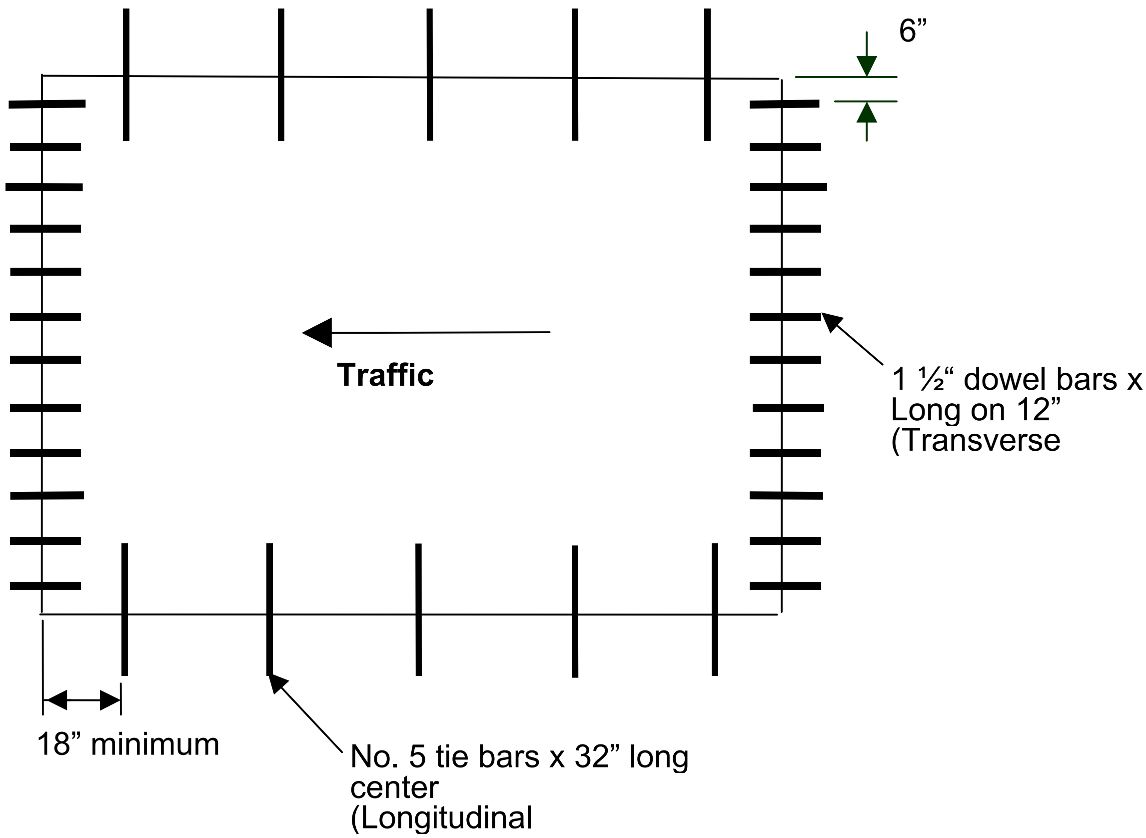

Figure 10. Tie bar and dowel bar placement for approach legs.

Photo 55 shows dowel bars placed in areas of cross traffic and tie bars used on the approach leg of the intersection. Photo 56 shows placement of the dowel and tie bar baskets before the PCCP pour.

Photo 55. Alignment of dowel bars for areas with cross traffic. Tie bars are placed on approach legs (SR 291, Francis Avenue with Maple and Ash Streets intersection).

Photo 56. Placement of dowel and tie bar cages before the PCCP pour. The baskets have not yet been properly aligned (SR 2, Division Street and Francis Avenue intersection).

Improperly Placed Dowel and Tie Bars

Photos 57 to 60 provide examples in which dowel bars or tie bars are improperly placed. The most common problems include placing tie or dowel bars too near or at joints and placing bars that conflict with each other.

Photo 57 Placement of a tie bar at a joint location. Correct placement should be about 18 inches from the joint (SR 195, Mile Post 44.40 to Bridge 195/34 PCCP paving project).

Photo 58. Tie bar placed over a dowel bar at a transverse joint (SR 195, Mile Post 44.40 to Bridge 195/34 PCCP paving project).

Photo 59. Dowel bars used for a construction joint are placed too close to the existing concrete (SR 90, Broadway Avenue and Thierman Street intersection).

Photo 60. Dowel and tie bars should not extend into the boxout area. Boxouts are placed to isolate the utility from differential movement between the utility and the PCCP (SR 2, Division Street and Francis Avenue intersection).

On past concrete intersection projects, WSDOT recommended that dowel and tie bars should not be placed within 2 feet of new signal detection loops. However, recent technology shows that this requirement may not be necessary, as background measurements can account for steel placed near or over induction loops. The manufacturer's recommendations should be followed. While WSDOT does not typically use fiberglass dowel bars for transverse joints, fiberglass dowel bars may be used adjacent to the detection loop if dowel bars are necessary.

Pavement Sections

The PCCP pavement sections for the intersections in this study were designed according to WSDOT policy, as detailed in Volumes 1 and 2 of the WSDOT Pavement Guide [9,10]. The PCCP section, including the base layer, was designed for 40-year ESALs. PCCP thickness ranged from 9 to 12 inches, as shown in Table 20. Subgrade for the intersections consisted of sandy gravels and silty sands. The subgrade resilient modulus for the intersections built by WSDOT ranged from 15,000 to 20,000 psi.

WSDOT has found that intersection reconstruction does not lend itself readily to placement of asphalt concrete base (Class E) beneath the PCCP. A primary reason is that PCCP intersections are often built in incremental pieces. This incremental work requires placement of the asphalt treated surfacing in small and irregular areas. Space is generally limited for paving equipment. Another reason is that the placement of asphalt treated surfacing adds an additional operation, thus slowing construction. These difficulties were experienced on the Pines Road and Sprague Avenue intersection.

Table 20. Pavement sections with associated ESALS used on WSDOT PCCP pavements.

SR	Year Const.	Intersection	PCCP Thickness (inch)	Base Thickness (inch)	Base Type	40 Year ESALs
27	1994	Pines Rd. and Sprague Ave.	10	4	ATB[2]	20,000,000
90	1996	Broadway Ave. and Thierman St.	10	Existing[1]	Crushed Stone	30,000,000
2	1997	Division St. and Francis Ave.	10	Existing[1]	Crushed Stone	10,000,000
291	1997	Francis Ave./Maple and Ash St.	9	Existing[1]	Crushed Stone	9,000,000
27	1998	Pines Rd. and Broadway Ave.	10	Existing[1]	Crushed Stone	20,000,000
395	1998	SR 395 and 19th Ave.	12	Existing[1]	Crushed Stone	53,000,000
2	1998	Division St. and Third Ave.	10	Existing[1]	Crushed Stone	16,000,000

[1] Existing untreated aggregate surfacing. The existing untreated surfacing ranged from 4.7 to 8 inches in depth.
[2] Asphalt Treated Base (ATB).

Placement of the asphalt concrete base on the Pines Road and Sprague Avenue intersection caused WSDOT to evaluate whether the existing crushed stone base (CSBC) needed to be removed and replaced with asphalt concrete base. Visually, the existing crushed surfacing appeared to be in very good condition.

On the following project, Broadway Avenue to Thierman Street, the asphalt concrete base, as designed in the plans, was changed to allow use of the existing crushed stone base. This occurred following removal of the existing asphalt, which revealed that the existing aggregate base was in sound condition. WSDOT has found that after excavation of the existing ACP, a small shim or addition of crushed stone to level the base surfacing followed by proper compaction is sufficient to prepare the base for placement of PCCP. As a minimum, roadway sections should be designed to meet frost penetration criteria, which can only be established by thorough pavement investigation. Use of the existing base material both facilitates construction and provides a cost savings.

WSDOT does not feel that performance problems will be encountered by using crushed stone base in lieu of asphalt concrete base. PCCP performance in Eastern Washington, where ESAL levels are relatively low and the subgrades are well drained, has been excellent, as is the case for the intersections reconstructed so far.

Pavement Profile

For the most recently constructed intersections, WSDOT has been cautious with profiles in contract plans. WSDOT provided a profile in the Sprague Avenue and Pines Road and Broadway Avenue and Thierman Street intersections but deviated from them because of field adjustments that became necessary. These deviations included matching the profile to the existing curbing and providing a cross-slope crown to match the staging sequences with paving operations. A change order was required on the Broadway Avenue and Thierman Street intersection to provide the contractor with additional compensation because of field changes.

However, with the software available today, there is no reason that profiles cannot be included. The key to a successfully constructed intersection is that sufficient effort is included during project development to ensure that a workable profile can be obtained with the existing conditions. Making the assumption that a profile can be obtained during construction can produce mismatched grades, leading to drainage and notable smoothness problems.

The profiles of the as-constructed intersections have been established to match existing curb grades. Removal of existing pavement adjacent to existing curbing has not been a problem, and generally only small portions of curb and sidewalk are replaced to accommodate road approaches or settled areas.

Cross slope for the direction of heavy travel typically starts at 2 percent at the approach legs and tapers down to 1 percent as the legs approach the radius returns of the intersection. Through the intersection, the cross slope continues at 1 percent and then increases back to 2 percent through the leave leg. Cross slopes for the direction of heavy travel for PCCP intersections are illustrated in Figure 11. WSDOT has built some intersections with a 2 percent slope through the length of the PCCP intersection, however, notable ride problems were detected for cross traffic. A 1 percent or less cross slope is recommended through the intersection.

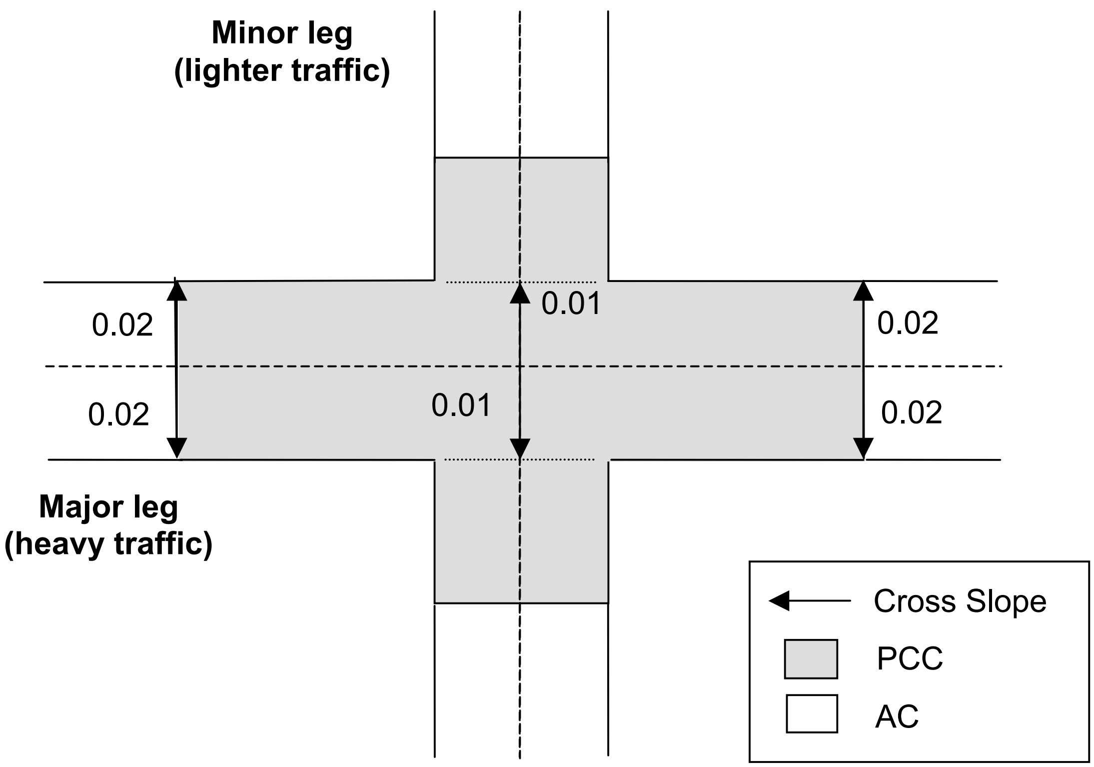

Figure 11. Cross slopes through a typical PCCP Intersection.

The profile and cross slope for the direction of lighter travel or approaches are best illustrated in Photo 61. The profile, in this instance, basically matches the existing roadway profile and ties into the cross slope from the mainline or heavily traveled direction. A match point into mainline at the curb line or edge of lanes works well.

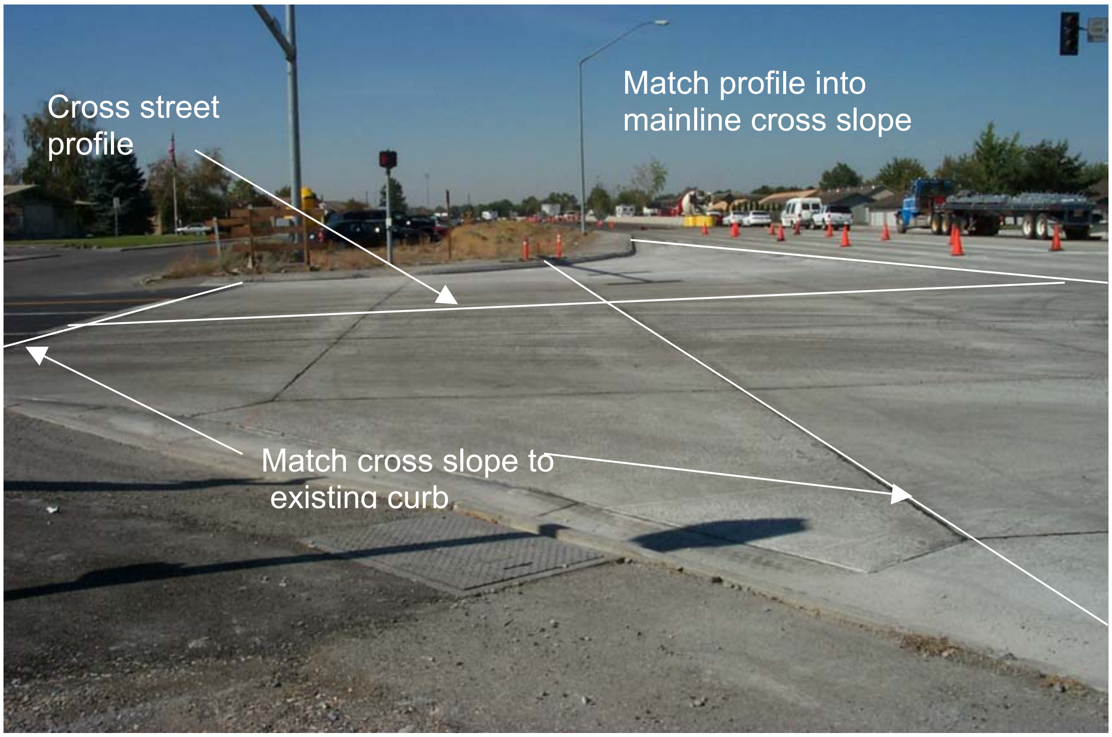

Photo 61. Illustration of the profile and cross slope for the direction of lighter traffic. (SR 395 and Yelm Street Intersection, Kennewick, Washington).

Establishing grades in the field requires surveying the entire intersection and developing the grades before setting the first form. However, WSDOT inspectors have found that achieving a workable grade is not an exact science. Small angle points are necessary where grades intersect or where staging necessitates breaks from separate pours or limitations in paving equipment. In most cases, small angle points within the intersection area will not jeopardize the ride, as traffic speeds are typically lower through intersections. Grades that are established during the design phase will require field adjustments, and slight angle points will be necessary.

Special Provision

A special provision that highlights the important elements for PCCP intersection construction is included in Appendix I. This special provision was written to complement WSDOT's Year 2000 Standard Specifications for Road, Bridge and Municipal Construction. The special provision in Appendix I is a summary of the special provisions that have been included on past PCCP intersection projects that have resulted in good construction.

PCCP Materials

In previous special provisions for intersection reconstruction, contract plans included mix proportions for the concrete. Since construction of these intersections, the Standard Specifications for Road, Bridge and Municipal Construction [11] has been revised, and contract plans should not typically provide mix proportions. The 2000 Standard Specifications places the responsibility for the mix design on the contractor, with WSDOT listing the requirements for opening the roadway to traffic. A sample special provision showing the requirement for opening to traffic can be seen in Appendix I. The special provision can be easily modified when early opening to traffic is required.

WSDOT has typically used Type I or II cement for PCCP roadways. Performance has been excellent, with some pavements on Interstate 5 and 90 exceeding the original design ESALs by a substantial amount. WSDOT has been experimenting with fast track mixes that use Type III cement for intersection construction. Fast Track mixes develop strength rapidly and are beneficial when early opening of the pavement is necessary, as is the case with urban intersections. WSDOT has typically required a fast track paving mix when the road must be opened to traffic in 24 to 72 hours.

Figure 12 shows the compressive and flexural strength gains for a PCCP mix [12] with 705 pounds per cubic yard of Type III cement that has been used on several intersections. Typically, a compressive strength of 2,500 psi, as required by the 2000 Standard Specification for opening the roadway to traffic, has been met or exceeded in 12 to 15 hours. For comparison, a PCCP mix [13] using 565 pounds of Type I-II cement is shown in Figure 13. The Type I-II cement provides sufficient strength to open the roadway in 48 to 72 hours. WSDOT estimates that a concrete mix with 705 pounds of Type I-II cement would allow opening to traffic in 24 to 36 hours.

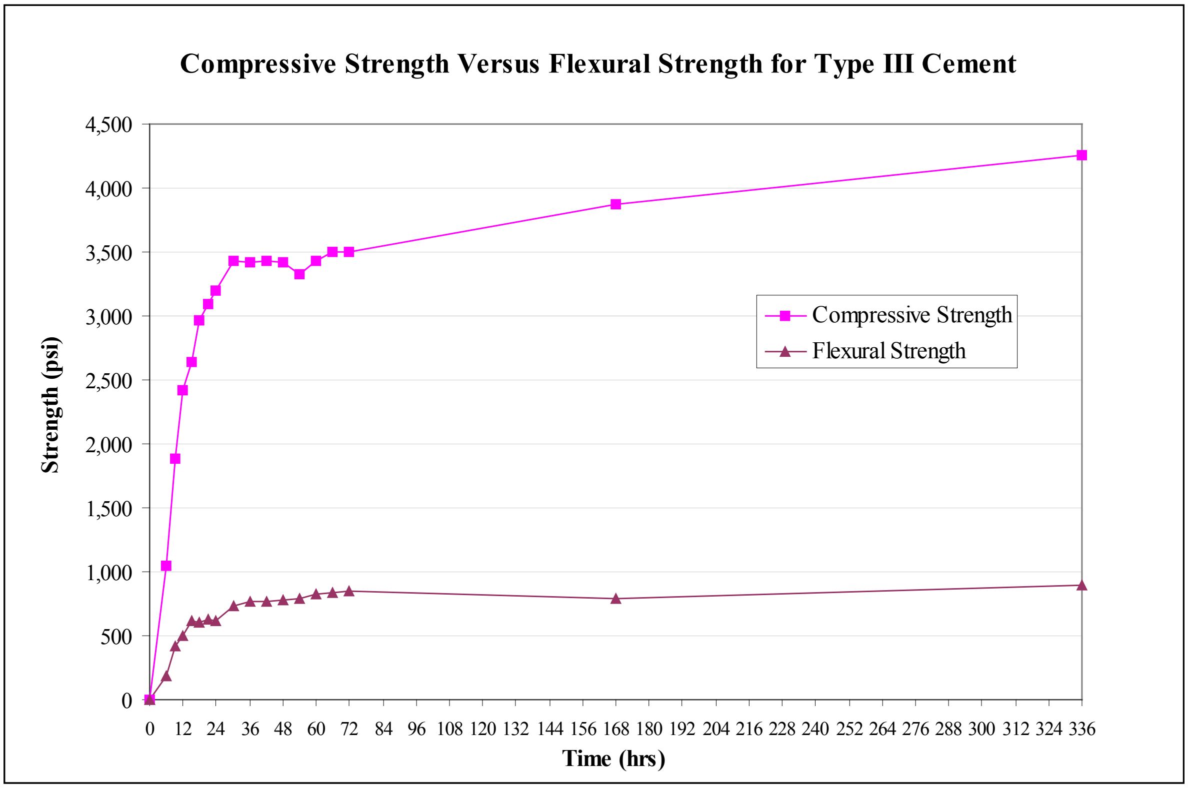

Figure 12. Comparison of compressive and flexural strength gain for a Type III mix with 705 pounds of cement per cubic yard used on PCCP intersection projects (courtesy ACME Construction and Materials, Spokane, Washington).

The intersection contracts to date have all included provision for a PCC 24-hour cure time (to achieve a minimum compressive strength of 2,500 psi). However, in most instances, traffic has not been placed on the roadway within 24 hours following paving. Part of the reason is that staging does not necessarily open a large enough area to move traffic completely to the new pavement. Typically, it has been easier to complete a continuous section of roadway and then move traffic onto the new concrete rather than shifting traffic back and forth through short segments. For the majority of the intersections constructed so far, Type I-II cement would have provided sufficient cure time to allow a compressive strength of 2,500 psi for opening to traffic.

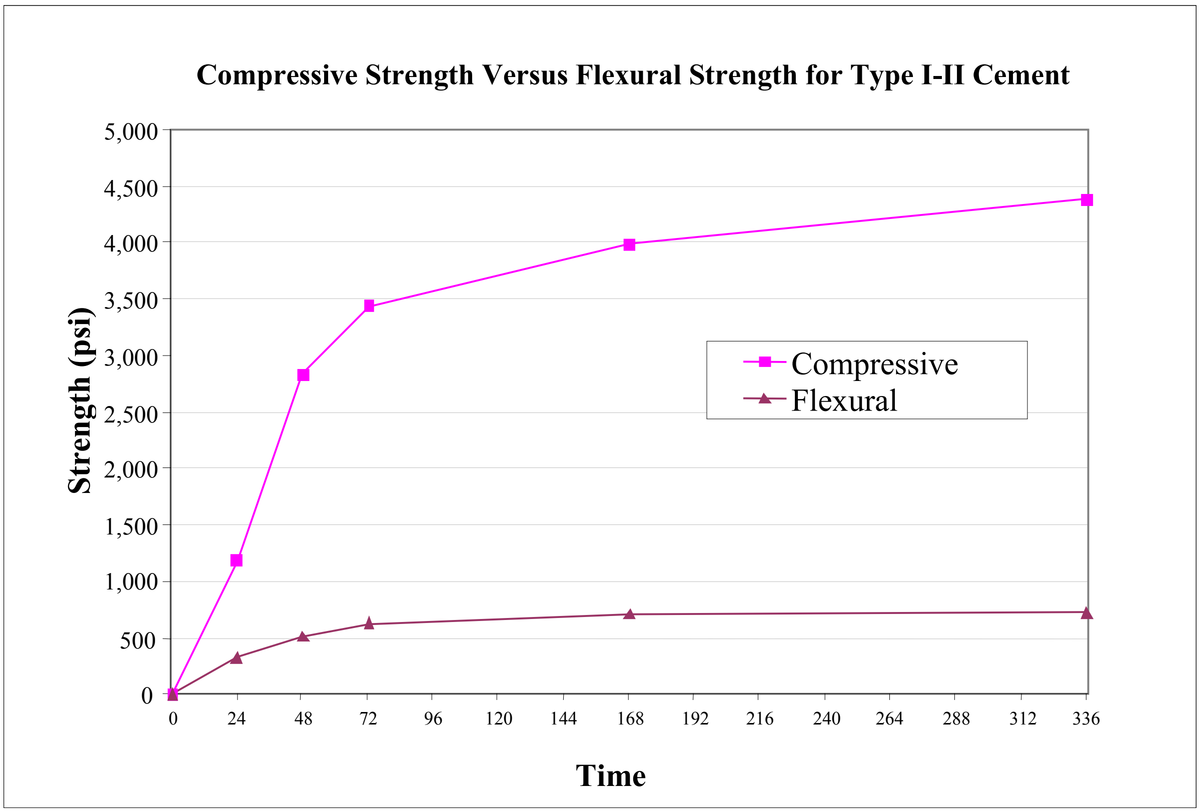

Figure 13. Comparison of compressive and flexural strength gain for a typical Type I-II mix with 565 pounds per cubic yard used on WSDOT paving projects (courtesy ACME Construction and Materials, Spokane, Washington).

WSDOT could save the additional expense of the Type III cement by limiting its use to closure pours or where traffic will be moved onto concrete within 24 hours as specified in contract plans. The cost savings for using 705 pounds of Type I-II cement in lieu of 705 pounds of Type III cement is approximately $2.11 per cubic yard, or $0.59 per square yard, for a 10-inch-thick PCCP section (costs are based on $80 per ton for Type I-II cement and $86 per ton for Type III cement). The cost savings for using 565 pounds of Type I-II cement in lieu of 705 pounds of Type III cement is approximately $7.72 per cubic yard, or $2.13 per square yard, for a 10-inch-thick PCCP section. WSDOT will continue monitoring the performance of Type III mixes for long term-performance.

Construction Time

The construction times experienced by WSDOT to reconstruct an existing intersection are shown in Table 21. Time requirements on complete intersection projects were easiest to determine, as the contract days required were charged to the contract. A reasonable estimate was made from contract documents for the time required for intersections that were part of larger ACP resurfacing projects. The number of working days allowed by the contract documents and the number of contract days required to construct the intersection are both shown. In some cases the contractor chose to work weekends, which are not reflected under the number of contract days. An estimate of the number of actual days required, which includes any additional work done on weekends, is shown under actual days required.

Table 21 shows that intersection reconstruction for four of the ten intersections took 30 to 40 working days. These four intersections were reconstructed under traffic. By comparison, the intersection on SR 27, Pines Road and Broadway Avenue, required only 16 days. This substantial reduction was due to the partial traffic closure on Broadway Avenue. The Yelm Street, Clearwater Avenue, and West Kennewick Avenue intersections only took 9, 12, and 13 days, respectively, because of the use of a combination of full closures and construction under traffic. SR 2, Division Street and Third Avenue, under full closure, required three contract days. However, only one approach leg was reconstructed.

Table 21. Summary of days needed to construct PCCP intersections.

SR	Intersection	Working Days Allowed	Contract Days Required	Actual Days Required[3]	Actual Work Period (Intersection Reconstruction)
27	Pines Rd. and Sprague Ave.	30	36	37	August 23, 1994 to November 17, 1994
90	Broadway Ave. and Thierman St.	47	39	42	April 15, 1996 to May 29, 1996
2	Division St. and Francis Ave.	126[1]	34.5	34.5	September 8, 1997 to October 24, 1997
291	Francis Ave./ Maple and Ash St.	126[1]	30	30	July 7, 1997 to August 14, 1997
27	Pines Rd. and Broadway Ave.	37[1]	16	16	May 2, 1998 to June 1, 1998
395	SR 395 and 19th Ave.	80[2]	18	18	September 16, 1998 to November 13, 1998
2	Division St. and Third Ave.	45	3	4	July 28, 1998 to August 3, 1998
395	Yelm Street	85[1]	7	9	September 11, 2000 to September 19, 2000
395	Clearwater Avenue	85[1]	10	12	September 20, 2000 to October 3, 2000
395	West Kennewick Avenue	85[1]	11	13	September 22, 2000 to October 8, 2000

[1] Total number of days for the PCCP intersection and larger ACP resurfacing project.
[2] This project included four intersections.
[3] Actual days required includes additional days used for weekend work but not counted as contract days.

Following construction on SR 2, Division Street and Francis Avenue, the contractor noted that a 25 percent reduction in contract days required would have been realized had they removed the existing ACP from the entire intersection and allowed traffic to run on the existing crushed surfacing. This likely would not have been a problem, since the existing aggregate base and subgrade were excellent. Some maintenance would have been required.

Table 22 is provided to show the time period from the approximate beginning of excavation to the final pour for the PCCP roadway. The impacts to traffic occurred mainly during this period. Once the PCC was placed, the impacts to traffic caused by activities such as joint sealing or striping were minimal. Typically, the roadway excavation and concrete placement period was well within the contract period, which included other work such as extruded curbing, sealing joints, and cleanup.

Table 22. Summary of construction dates for excavation and concrete pour and the contract period.

SR	Intersection	PCCP Excavation and Pour Period	Contract Period (Intersection Reconstruction)
27	Pines Rd. and Sprague Ave.	September 9, 1994 to September 21, 1994	August 23, 1994 to November 17, 1994
90	Broadway Ave. and Thierman St.	April 20, 1996 to May 14, 1996	April 15, 1996 to May 29, 1996
2	Division St. and Francis Ave.	September 12, 1997 to October 22, 1997	September 8, 1997 to October 24, 1997
291	Francis Ave./ Maple and Ash St.	July 18, 1997 to August 14, 1997	July 7, 1997 to August 14, 1997
27	Pines Rd. and Broadway Ave.	May 6, 1996 to May 21, 1996	May 2, 1998 to June 1, 1998
395	SR 395 and 19th Ave.	September 16, 1998 to November 13,1998	August 21, 1998 to April 9, 1999
2	Division St. and Third Ave.	July 28, 1998 to August 3, 1998	July 28, 1998 to August 3, 1998
395	Yelm Street, Clearwater Avenue, and West Kennewick Avenue	September 12, 2000 to October 8, 2000	September 12, 2000 to October 8, 2000

Concrete to Asphalt Transitions

WSDOT has not experienced a significant problem with bumps at ACP and concrete transitions. However, bumps as seen in Photo 62 can occur. Some reasons include ACP rutting or shoving, or the movement of slabs over crushed stoned caused by impact loading. The bumps in Photo 62 were caused by the downhill plastic flow of AC as it transitioned onto the concrete in the warm temperatures of Eastern Washington.

Photo 62. Bump at the transition of ACP with PCCP (Hamilton Avenue and Foothills Boulevard, City of Spokane, Washington).

WSDOT typically backfills any adjacent excavation at the transition of ACP and concrete structures with ACP and crushed stone to match or exceed the thickness of the concrete. While compaction is difficult to measure for such small areas, WSDOT takes extra efforts to ensure that both the crushed surfacing and the ACP are well compacted. Most projects have also included 1.8- to 2.4-inch overlays to tie the existing ACP with the newly placed PCCP.

Figure 14 demonstrates an impact slab for newly placed pavement recommended by the ACPA [4]. WSDOT has not tried this design but is considering including it on some upcoming intersection work. Additional concrete to asphalt transitions can be found in "Concrete Intersections – A Guide for Design and Construction." [4]

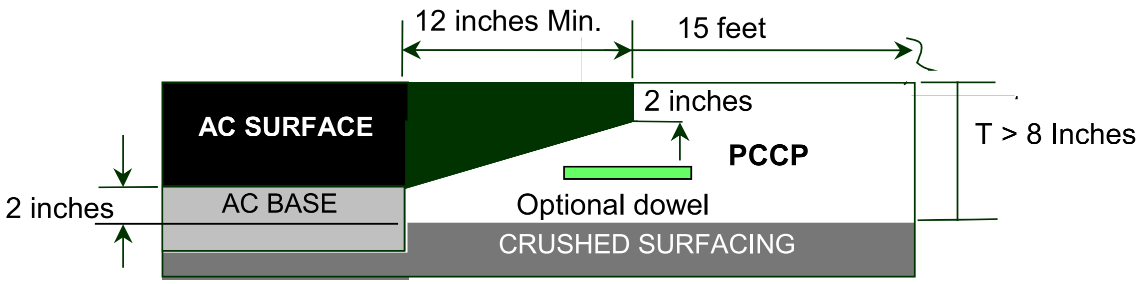

Figure 14. Asphalt to concrete transition (details courtesy of American Concrete Paving Association).

Channelization - Jointing

The correct jointing for channelization placed on top of PCCP is shown in photos 63 and 64. Channelization without relief joints will crack at the PCCP transverse locations because of contraction and expansion of the concrete roadway. Traffic islands placed on PCCP should be jointed in a similar manner.

Photo 63. Transverse joints across the PCCP panels and channelization are aligned (SR 90, Sprague Avenue and Fancher Street intersection).

Photo 64. Jointing concrete channelization across a transverse joint (SR 2, Division Street and Francis Avenue intersection).

Traffic Detection Systems

The traffic detector systems for reconstructed intersections include the following:

- preformed induction loop system
- video detection system

The choice for either technology has been up to the region's traffic office. The Eastern Region has used both but is currently leaning toward preformed induction loops for future PCCP intersection projects. The Eastern Region has experienced better reliability with preformed induction loops, particularly in adverse weather. Table 23 shows which technology has been used for the fifteen PCCP intersections built on WSDOT Highways.

Table 23. Detection systems used on PCCP Intersections.

SR	Intersection	Region	Detector Type
97	Dolar Way Intersection	South Central	Stop Signs
27	Sprague Avenue and Pines Road	Eastern	Preformed Induction Loop
90	Broadway Avenue and Thierman Street	Eastern	Preformed Induction Loop
90	Fancher Road and Sprague Avenue	Eastern	Preformed Induction Loop
2	Division Street and Francis Avenue	Eastern	Video Camera
291	Francis Avenue/Maple and Ash Streets	Eastern	Preformed Induction Loop
27	Broadway Avenue and Pines Road	Eastern	Preformed Induction Loop
395	SR 395 and 7th, 10th,Avenue	South Central	Video Camera
395	SR 395 and 10th, 19th and 27th Avenues	South Central	Video Camera
2	Division Street and Third Avenue	Eastern	Timed Signals
395	SR 395 and Yelm Street, Clearwater Avenue and West Kennewick Avenue	South Central	Preformed Induction Loop

Placement of preformed induction loops is typically constructed according to the Standard Plan J-8a, along with contract special provisions and contract plans. Round or rectangular induction loops can be used. A sample special provision that could be used for traffic is provided in Appendix J. Vendors with acceptable products are also listed.

Induction loop placement methods are sawed or embedded, or placed underneath the PCCP. The preferred method within the Eastern Region is to place induction loops underneath the PCCP, 3 inches into the crushed stone base. Either sand or crushed stone can be placed over the induction loops. Photo 65 shows the preformed detection loops placed on the crushed stone base at the SR 395 and Yelm Street intersection in Kennewick.

Photo 65. Placement of preformed induction loops prior to placing concrete on SR 395 at the SR 395 and Yelm Street intersection.

On past concrete intersection projects, WSDOT recommended that dowel and tie bars not be placed within 2 feet of new signal detection loops. However, recent technology has shown that this requirement may not be necessary. The manufacturer's recommendations should always be followed. While WSDOT does not typically use fiberglass dowel bars for transverse joints, fiberglass dowel bars may be used adjacent to the detection loop if dowel bars are necessary.

Coordination with Local Agencies and Utility Companies

PCCP intersection reconstruction typically involves some type of utility upgrading before the placement of the concrete. Therefore, involvement with local agencies such as cities and counties and local utility companies should be coordinated as early as possible to facilitate both the planning and construction stages.

Coordination during the planning stage will prevent other agencies or utilities from removing and patching sections of a newly placed PCCP pavement. Photos 66 and 67 show two intersections where coordination was marginal. Coordination also has the benefit of allowing any utility construction to occur during the intersection project. Impacts to traffic occur only once, rather than months before or after the intersection reconstruction.

Photo 66. Utility work and resulting AC patch at a PCCP intersection (Photo taken in Newport, Rhode Island).

Photo 67. Utility trenches cut in PCCP pavement at an intersection (Photo taken in Tacoma, Washington).

CONSTRUCTION CONSIDERATIONS

Other than the limitations of placing concrete under traffic with constricted working areas, the construction of PCCP intersections is straightforward and follows Section 5-05 of the 2000 Standard Specification for Road, Bridge and Municipal Construction [11], supplemented by the special provision provided in Appendix I. The basic steps involved with PCCP intersection construction include the following:

- removing or planing the existing pavement
- preparing the grade
- setting forms
- placing in-place pavement fixtures (objects that will be placed into the PCCP)
- other considerations prior to placing the PCCP
- placing the concrete
- finishing the concrete
- texturing the concrete
- curing the concrete
- sawcutting the pavement
- sealing sawed contraction joints
- placing asphalt adjacent to the new PCCP
- channelization – jointing
- opening to traffic.

Removing or Planing the Existing Pavement

The method of removing the existing roadway largely depends on the equipment and experience of the contractor. Two commonly used methods are cold milling and breaking up the roadway with bulldozers, loaders, or backhoes and then loading the material into dump trucks. If the existing roadway is concrete, contractors sometimes choose to lift sections and transport them off the roadway.

Cold milling has become an excellent method, provided that the urban intersection is large enough to warrant continual operation. A variety of cold milling machines are available. Some cold milling machines can remove up to 6 inches in one pass, while others can remove the entire thickness of existing ACP plus additional crushed stone material. In some instances, the excavation depth can be a foot or greater. Cold milling machines can provide excellent grade control by removing both ACP and crushed stone materials to obtain the desired profile elevation.

On the SR 90, Broadway Avenue to Thierman Street intersection, staging was complex and divided into small removal areas. The contract plans limited the excavation method to the use of a backhoe and dump trucks because of the staging requirements. Weaver Construction Company of La Grande, Oregon, proposed and provided a more efficient operation by using cold milling to excavate the entire roadway in one operation. Construction time and impacts to traffic were reduced. Traffic was run successfully on the existing crushed stone, with little maintenance required.

Factors that influence the removal method include intersection size, work hours allowed, underground utilities, and environmental factors such as noise and dust. Restrictions placed on construction from any or all of these factors will cause the contractor to choose the most productive method for a particular intersection. Construction for WSDOT intersections have included both cold milling and excavation with backhoes, as can be seen in photos 68 and 69.

Photo 68. Roadway Excavation on SR 2, Division Street and Francis Avenue intersection.

Photo 69. Planing bituminous pavement as a method of asphalt removal (SR 395, SR 395 and Yelm Street intersection).

Preparing the Grade

Preparation of the base and subgrade at an urban intersection requires the same care and construction practices as any newly constructed roadway. Construction practices as noted in the WSDOT Standard Specifications should be utilized to ensure that the underlying support beneath the PCCP will provide a long life roadway. Photo 70 shows compaction control taken at the SR 2, Division Street and Francis Avenue intersection.

Photo 70. Ensuring density for underlying surfacing before PCCP placement (SR 2, Division Street and Francis Avenue intersection).

Following removal of the asphalt, all areas that show failed subgrade or base material should be addressed. Removal and replacement of the distressed material should be done if necessary. The placement of additional crushed stone directly on visibly poor material does not provide the uniform support required by PCCP. The projected 40-year design life will be reduced when a sound subgrade or base is not established.

For newly constructed intersections, crushed stone base is typically placed uniformly on a geotextile laid on the prepared subgrade. WSDOT pavement designs have typically provided 4 to 6 inches of crushed surfacing base course (CSBC). Additional thickness may be necessary to meet frost design criteria. WSDOT does not typically use a thickened PCCP edge design, so grading the crushed stone to allow thickened PCCP edges has not been necessary.

Reconstruction of an existing intersection will typically utilize the existing crushed stone. Additional CSBC may be required as a shim to bring the base layer to the proper grade. Compaction equipment needs to match the size of the intersection. Compaction of the CSBC layer should be a priority, as inadequate compaction will lead to PCCP performance problems.

Special attention should be given to compaction around any utility installation such as sewer, telephone, and power conduits, water lines, and any type of manhole, catch basin, or valve. The lack of compaction at or adjacent to these installations may leave soft spots and lead to excessive settlement of the crushed surfacing layer (see Photo 71). Poor compaction around utility installations will eventually jeopardize the performance of the PCCP intersection.

Photo 71. Excessive settlement in the crushed stone or subgrade, causing cracking in PCCP (Photo taken in Newport, Rhode Island).

Controlled density fill (CDF) materials provide an alternative to crushed stone backfill, as the CDF is flowable around the installations and does not require compaction. CDF is stiff enough (< 100 psi compressive strength) to prevent settlement, yet it is friable enough to allow removal with a backhoe or other type of excavator. CDF should be limited to backfilling below the crushed stone base layer.

Except for the intersection on SR 27, Pines Road and Sprague Avenue, all PCCP intersections built by WSDOT have been placed on crushed stone. As was discussed in Design Considerations, ACP may be used as an alternative, depending upon construction limitations. The placement of curbs and gutters for stormwater drainage systems in urban areas makes permeable bases, such as asphalt treated permeable base (ATPB) impractical. Curbs and gutters with inlets to storm sewer systems will typically address drainage concerns.

Setting Forms

PCCP intersections require some type of fixed-form construction to accommodate short paving segments, varying paving widths, and curved paving areas. For uniform sections, and particularly areas with long runs, concrete forms are typically placed to allow 12- to 24-feet (one or two lanes) paving widths as shown in Photo 72. The contractor typically selects form placement to correspond with staging requirements. In addition, placement must correspond to jointing requirements as specified on jointing plans (see Photo 73). As was described under Design Considerations, effort should be made during contract preparation to ensure that any profile calculated during construction is workable and provides the proper drainage.

Photo 72. Setting forms on SR 395, SR 395 and Yelm Street intersection.

Photo 73. Placing forms to match preplanned joints. Note that dowel bar locations are clearly marked before PCCP placement (SR 291, Francis Avenue with Maple and Ash Streets intersection).

Placing In-Place Pavement Fixtures

Fixtures include items that are placed into the concrete, such as

- boxouts for utilities, such as inlets, catch basins and manholes
- telescoping manholes or valves
- dowel bar baskets and tie bars
- traffic loop inductors.

The ACPA has a good reference [4] that summarizes key points related to placing in-place pavement fixtures. Most of the following comments were taken from that reference.

Boxouts

Boxouts for inlets and manholes are placed to ensure that cracking does not occur because of the differential movement of the utility and PCCP panel. The need for isolation depends upon the casting design and potential for differential movement. Boxouts with a perimeter isolation joint should be placed for non-telescoping manholes, where ribs or flanges from the utility lie within the PCCP [4] as shown in Figure 15.

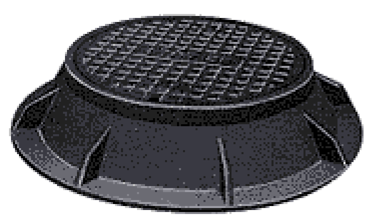

Figure 15. Manhole riser with ribs around the perimeter (graphic courtesy Deeter Foundry, Inc., Lincoln, Nebraska).

Figures 16 and 17 show typical boxouts for both a manhole and inlet. Boxout forms should be placed 1.0 foot from the fixture. Dowel bars or tie bars should not extend into the boxout area (see Photo 60). Following the placement of concrete outside of the boxout and removal of the forms, a compressible filler meeting the requirements of ASTM D 1751, D 1752, or D 994, should be placed at full depth around the perimeter of the boxout, thus forming the isolation joint. The ACPA recommends placing the fixture and boxout forms ½ inch below the finished PCCP elevation to ensure drainage and that no conflicts with the screed from the paving operation will occur. Figures 18 to 20 provide several examples for isolating utilities.

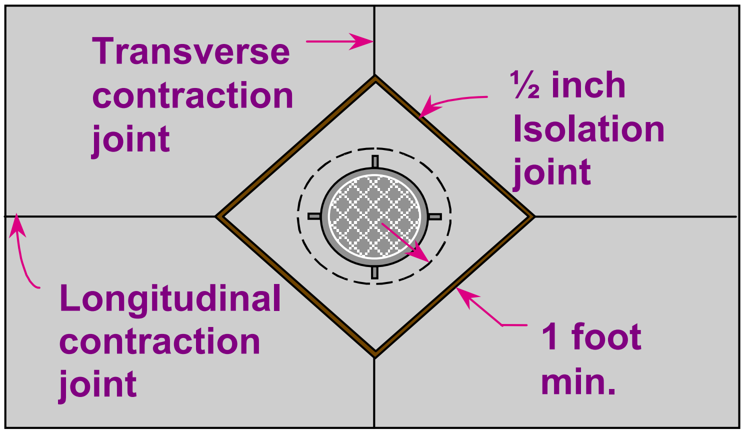

Figure 16. Example of a manhole boxout with intersection jointing (figure courtesy of American Concrete Paving Association).

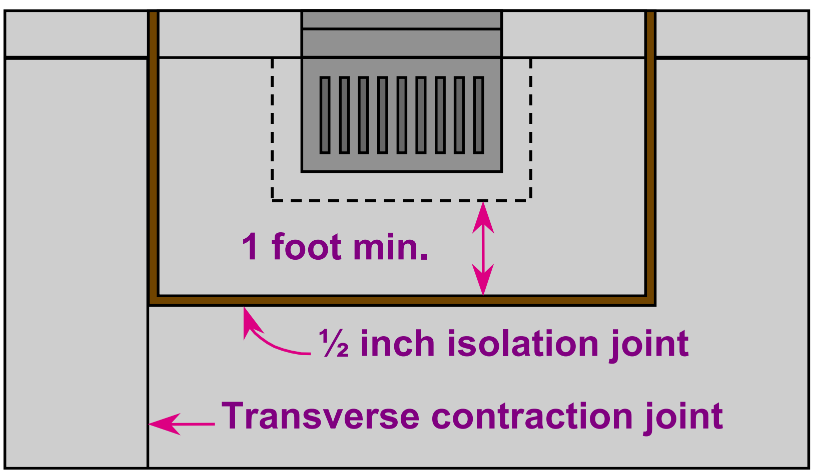

Figure 17. Example of an inlet adjacent to a transverse joint (figure courtesy of American Concrete Paving Association).

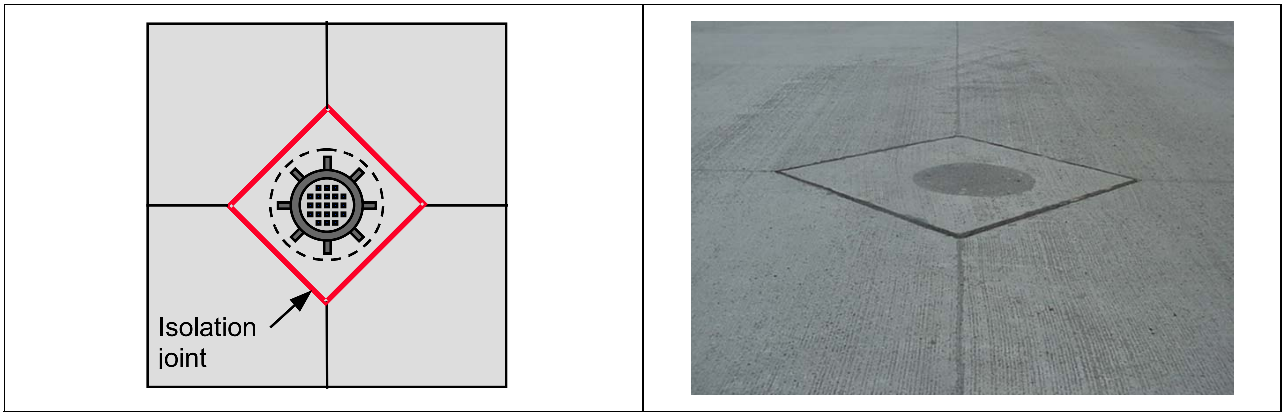

Figure 18. Square boxout (figure courtesy of American Concrete Paving Association. Photo taken at Aero Road and Westbow Road intersection, Spokane County, Washington).

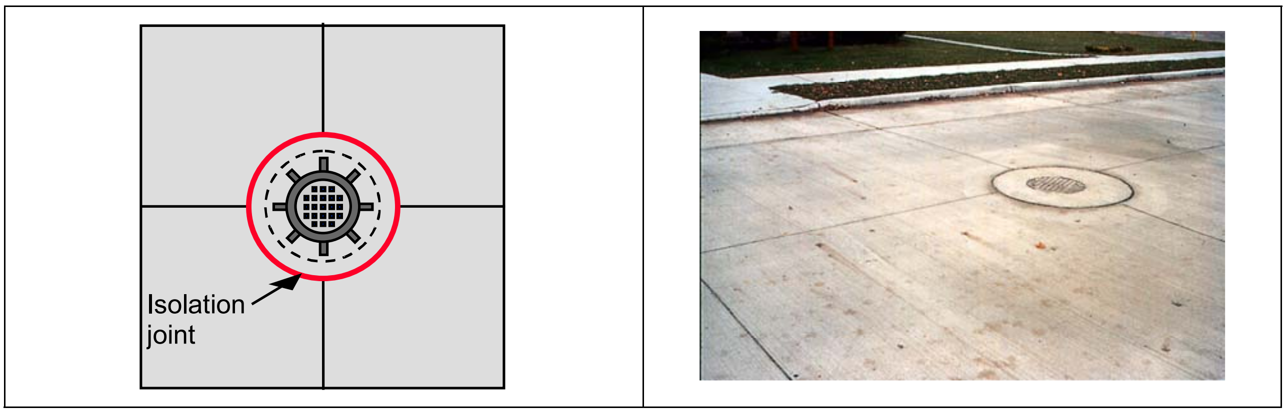

Figure 19. Round boxout (figure and photo courtesy of American Concrete Paving Association).

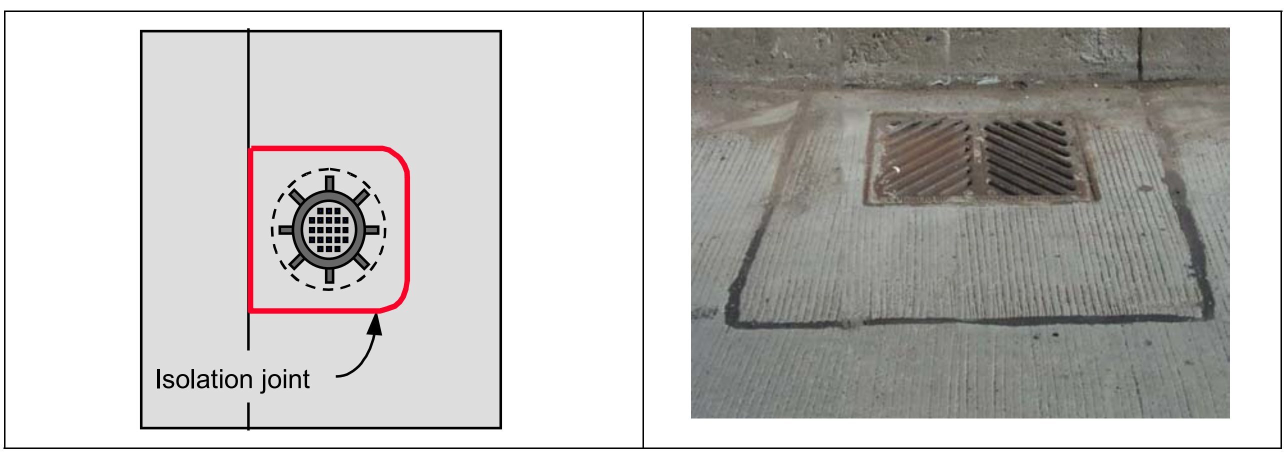

Figure 20. Square boxout (figure courtesy of American Concrete Paving Association. Photo taken at SR 2, Division Street and Francis Avenue intersection).

Corner cracks may occur where the utility boxout is centered along a longitudinal joint between transverse joints, leaving small rectangular shapes prone to cracking (Figure 21). WSDOT has minimized corner cracks by placing at least one transverse joint adjacent to the utility boxout, thus improving the panel geometry (Figure 22). Sometimes fillets (as shown in figure 20) are placed at the corners of boxouts to reduce the possibility of cracks initiating at boxout corners. Rounded boxouts can also be used (see Photo 74). Additional jointing to reduce corner cracks are shown in photos 75 and 76.

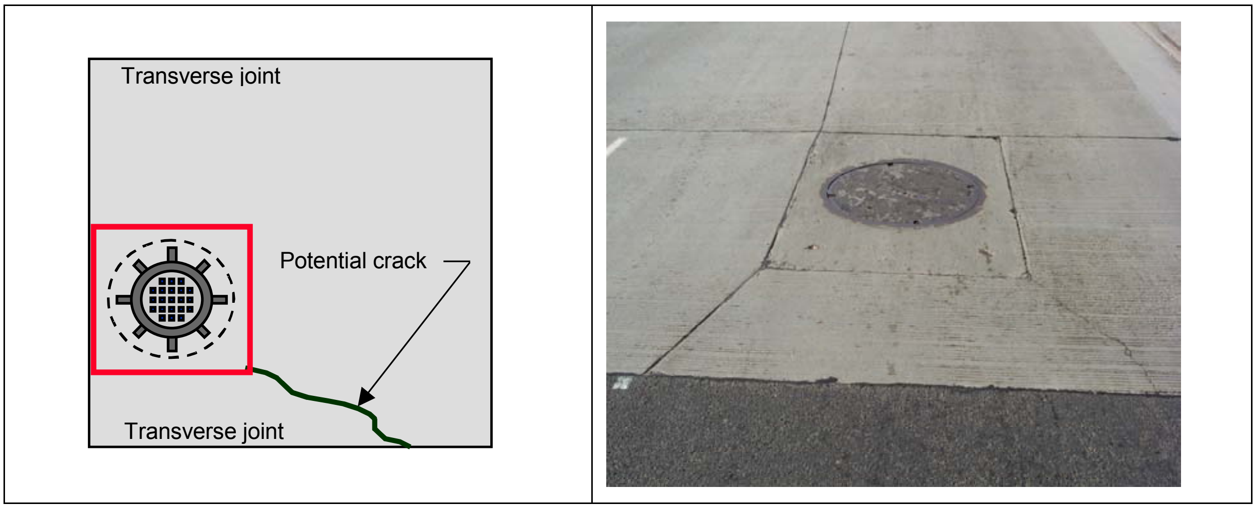

Figure 21. Cracking that will typically occur when boxouts are placed near a transverse joint leaving small rectangular shapes (figure courtesy of American Concrete Paving Association. Photo taken at SR 2, Division and Third Avenue intersection).

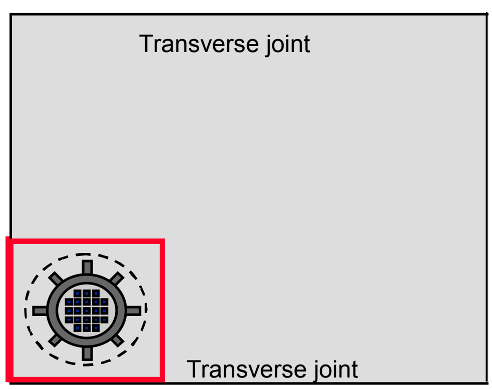

Figure 22. Placement of a utility boxout adjacent to a transverse joint.

Photo 74. Boxout with a rounded perimeter (SR 2, Division Street and Francis Avenue intersection).

Photo 75 and 76. Jointing to eliminate corner cracking (photos taken in Newport, Rhode Island).

The ACPA mentions that in some cases, boxing out fixtures may be undesirable. Boxing out fixtures for accelerated construction requires additional time to place the concrete after the roadway gains strength. In some instances the presence of too many utilities makes uniform jointing difficult, and casting the utility into the concrete might be the best solution. However, the risk of undesirable cracking increases when boxouts to isolate the fixtures are not provided. In cases where boxouts are not used, the ACPA reports that some agencies wrap the casting with a pliable expansion joint filler or suitable bond breaker. Examples of utilities placed without boxouts are shown in figures 23 and 24. Inlets in these cases are typically smooth sided and only require an isolation joint.

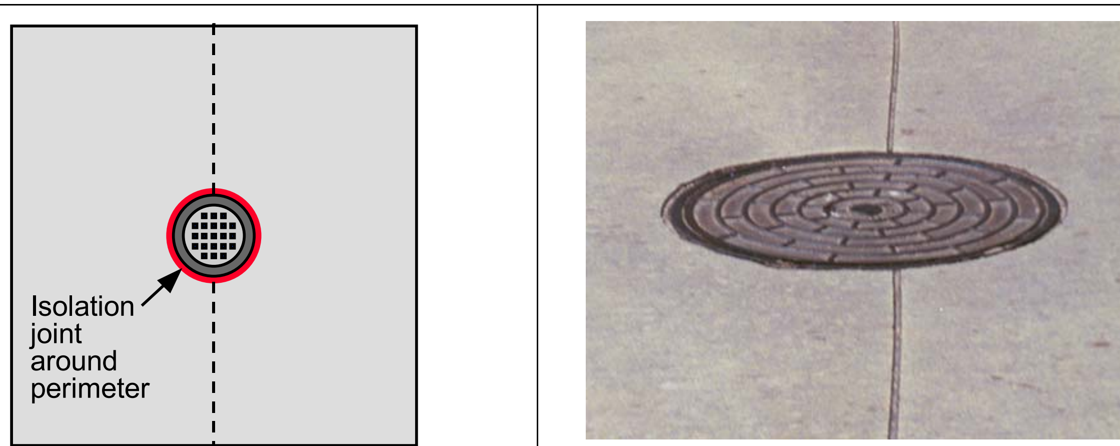

Figure 23. Manhole requiring only an isolation joint (figure courtesy of American Concrete Paving Association. Photo taken in Newport, Rhode Island).

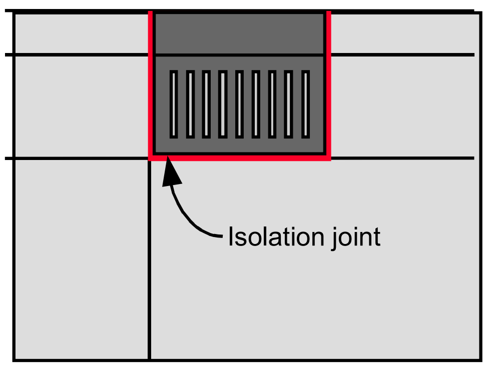

Photo taken in Newport, Rhode Island

Photo courtesy of American Concrete Paving Association

Figure 24. Inlet requiring only an isolation joint (figure courtesy of American Concrete Paving Association).

Telescoping Manholes or Valves

Telescoping manholes can be cast directly into the roadway without boxouts or isolation joints. Telescoping manholes consist of a frame and a base flange (see Figure 25). The base flange, which is below the level of PCCP, keeps the frame in place during concrete placement. Following paving, the frame section becomes an integral part of the pavement, free to move with the slab itself under loading, heaving, or settlement. These fixtures can be cast integrally with the placement of the PCCP for the intersection. Cast-in-place fixtures such as telescoping manholes (see Figure 25) or valves should be adjusted ½ inch below the finished PCCP grade to avoid conflict with the paving screed or in some cases snowplow operations. Valves can typically be placed in the PCCP without isolation joints (see Photo 77).

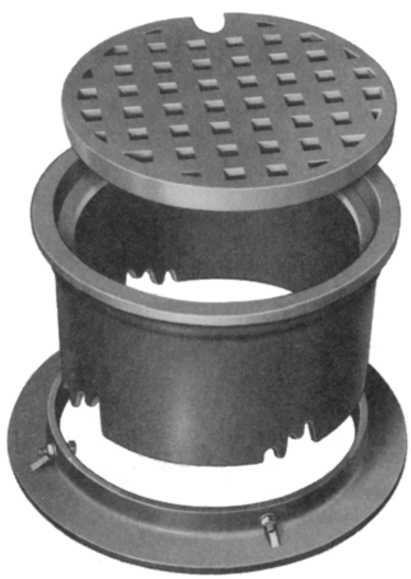

Figure 25. Telescoping manhole showing the base flange, frame section, and lid (graphic courtesy of Neenah Foundry Company, Neenah, Wisconsin).

Photo 77. Valves placed in concrete. Isolation joints are not typically required (photo taken in Newport, Rhode Island).

Placing Dowel and Tie Bars

Dowels and tie bars should be properly aligned, and the baskets should be firmly anchored to the base to prevent movement during concrete placement. Securing dowel and tie bar baskets is important to ensure that the bars do not become misaligned during the concrete placing operation. The FHWA [14] recommends that the dowel baskets be secured with steel stakes with a minimum diameter of 8 mm and embedded to at least 100 mm into stabilized bases, 150 mm in treated permeable bases, and 250 mm for untreated bases or subgrade. A minimum of eight stakes per basket is recommended. Once dowel bars have been placed, a reference mark should be used to note the alignments of the dowel bar or tie bar basket for sawcutting the contraction joints.

The exception to securing the baskets with stakes is when the concrete is placed with chutes over the top of the baskets and the contractor demonstrates that the baskets will not move. Often, concrete trucks back into the pour area, and the baskets have to be placed just ahead of the concrete placement. Securing the baskets down between the back of the truck and the end of the chute (about 10 to 15 feet) becomes very hazardous to the people placing the dowel bars, let alone trying to secure them with spikes (see photos 78 and 79).

Photo 78. Placement of concrete dropped vertically on dowel bars (SR 90, Broadway Avenue and Thierman Street intersection).

Photo 79. Dowel bar baskets placed directly behind the concrete truck (SR 90, Broadway Avenue and Thierman Street intersection).

All dowel and tie bars should be epoxy coated. Furthermore, dowels should be lightly coated with grease or some other substance for their entire length to prevent bonding with the PCCP. In the past, it was common to coat only one-half of each dowel bar, but apparently this practice has resulted in some performance problems. The FHWA [14] notes "… The dowel must be free to slide in the concrete so that the two pavement slabs move independently, thus preventing excessive pavement stresses. Only a thin coating should be used, as a thick coating may result in large voids in the concrete around the dowels."

The placement tolerances for tie bars are within 1 inch of the middle of the concrete slab, within 1 inch of being centered over the joint, and within 1 inch of the vertical and horizontal plane. The placement tolerances for dowel bars are within 1 inch of the middle of the concrete slab and parallel to centerline within ½-inch of the vertical and the horizontal plane. Dowel bar and tie bar requirements are specified in Section 5-05.3(10) of the WSDOT Standard Specifications [11].

Tie bars for longitudinal construction joints and dowel bars for construction joints are often inserted into holes along the sides of the fixed forms. Otherwise, drill holes are required, and dowel and tie bars must be placed with epoxy resin as noted in Section 5-05.3(10).

Other Details – Prior to Placing PCCP

The following section summarizes details that need to be addressed before concrete is placed.

Placing a Bond Breaker Between the PCCP and Existing Concrete

On the most recently constructed intersections, WSDOT has been placing lightweight roofing paper as a debonding agent between existing concrete surfaces and new concrete to prevent transverse cracking in newly placed PCCP (see photos 80 and 81). Without a debonding agent, freshly placed concrete can become bound to rough surfaces such as existing curbing. Excessive cracking can then develop from the stresses created in the new concrete by expansion and contraction. WSDOT has also used white pigment curing compound as a bond breaker for very smooth surfaces between existing concrete and new PCCP.

Photo 80. Lightweight roofing paper placed between existing curbing and the new concrete (SR 2, Division Street and Francis Avenue intersection).

Photo 81. Lightweight roofing paper placed between the existing curbing and new PCCP (SR 2, Division Street and Francis Avenue intersection).

Excess concrete on the face of the curbing, as shown in Photo 82, should be removed to provide a vertical surface before the placement of a bond breaker. Photo 83 shows a vertical surface where roofing paper or approved debonding agent can be applied.

Photo 82. Excess concrete on the face of curbing that should be removed before PCCP placement (Boone and Monroe intersection, City of Spokane, Washington).

Photo 83. Excess concrete on the face of curbing has been removed. Roofing paper or a debonding agent can now be applied before PCCP placement (Boone and Monroe intersection, City of Spokane, Washington).

Referencing Transverse (doweled) and Longitudinal (tied) Joint Locations

Dowel bar and tie bar locations must be clearly referenced before concrete placement. This requirement may seem obvious, but is often overlooked, making the proper location of joints that correspond with dowel bars or tie bars difficult. References that can be easily located after a concrete pour can be made on existing curbing or forms as has been done in Photo 84. If forms are utilized, references should be transferred to the PCCP before form removal.

Photo 84. Reference marks for dowel bar baskets before a concrete pour on SR 395, SR 395 and Yelm Street intersection.

Preplanning Skewed Joints

If a transverse or longitudinal joint is within 4 feet of a manhole or catch basin, the joint should be skewed or adjusted to pass through the center of the utility or boxout. Skewing or adjusting the joint will improve the slab geometry and prevent undesirable cracking, as shown in Photo 85. Examples of skewed joints are illustrated in photos 86 and 87.

Photo 85. Cracking that could be avoided with skewing joints (Photo taken in Newport, Rhode Island).

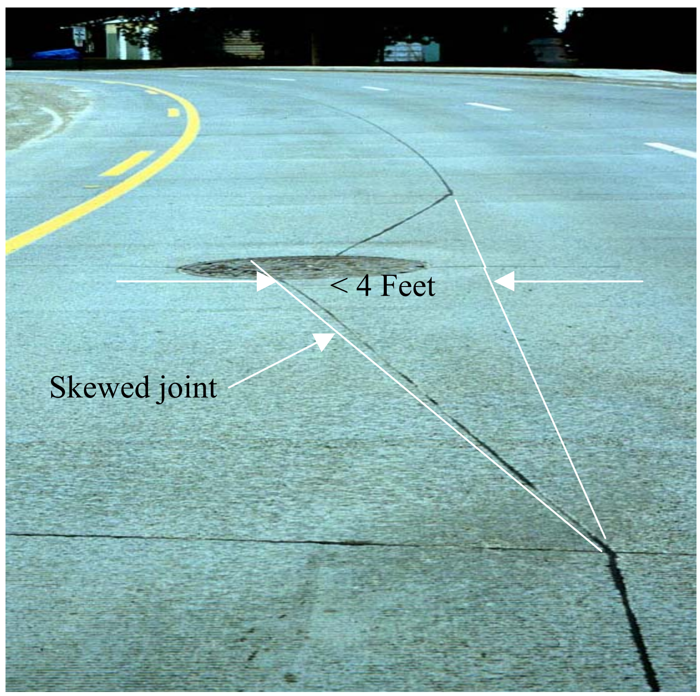

Photo 86. Skewed joint to a manhole along a longitudinal joint. Joints can also be skewed along transverse joints (Farwell Road, Spokane County, Washington).

Photo 87. Skewed joints to a utility boxout (SR 291, Francis Avenue with Maple and Ash Street intersection).

If the utility is located toward the center of the slab (see Photo 88), skewing the joint is not necessary. Typically the jointing plan will detail skewed joints toward utilities, but if not, care should be taken to skew joints when necessary.

Photo 88. Manhole placed in the approximate center of the PCCP panel (Photo taken in Newport, Rhode Island).

WSDOT recommends skewing the joint if the distance between the valve and joint is less than 12 inches. Valves placed closer than 12 inches to a joint may crack, as illustrated in Photo 89. Providing a skewed joint reduces the cracking potential. Photo 90 shows a joint that has been adjusted to pass through a valve.

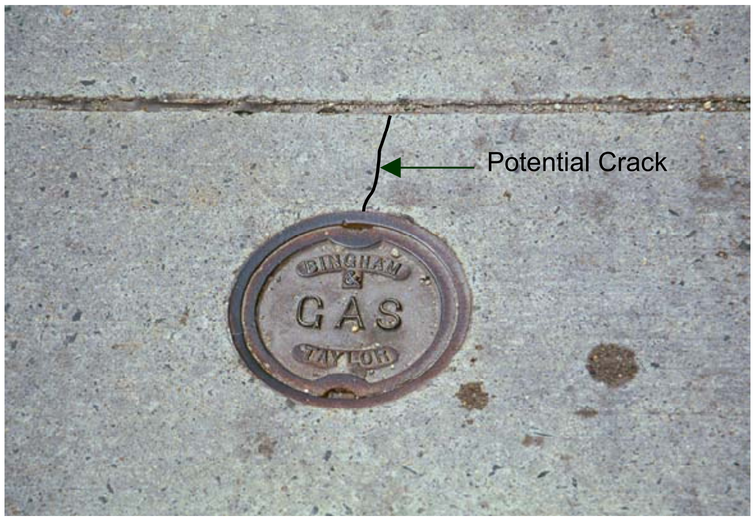

Photo 89. Valves placed closer than 12 inches from a joint may crack to the joint (Photo taken in Newport, Rhode Island).

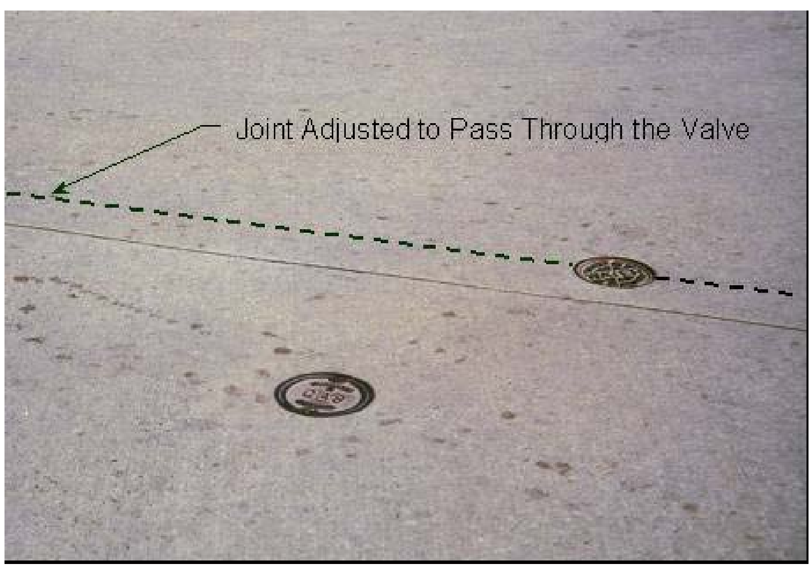

Photo 90. Valves placed in PCCP pavement (Photo taken in Newport, Rhode Island).

Placing the Concrete

Placing the concrete typically requires fixed-form construction, with placement accomplished by vibratory screeds, roller screeds, or bridge deck finishing machines such as a Bidwell or a Whiteman Screed. Table 24 shows the various placement methods used on WSDOT intersections. Each of these placement methods are shown in photos 91 through 95.

Table 24. Placement methods for WSDOT PCCP intersections.

SR	Intersection	Vibratory Screed	Roller Screed	Bridge Deck Machine	Whiteman Screed
27	Pines Rd. and Sprague Ave.	X			
90	Broadway Ave. and Thierman St.	X	X	X	
2	Division St. and Francis Ave.		X		X
291	Francis Ave./ Maple and Ash St.		X	X	
27	Pines Rd. and Broadway Ave.		X		X
395	SR 395 and 7th, 10th, 19th and 27th Avenues		X		X
2	Division St. and Third Ave.				X
395	SR 395 and Yelm Street, Clearwater Avenue and West Kennewick Avenue		X		X

The contractor will likely choose the operation that best suits the size and shape of the concrete pour. Intersection approaches that are long and continuous may warrant use of a paving machine, such as a Bidwell. Bidwells can be used where there is sufficient room and length to warrant the two to three days of set up required for their use; however, most intersections have irregularly shaped areas. Use of vibratory screeds or roller screeds may be more practical.

Photo 91. Vibratory screed (photo courtesy MBW Incorporated).

Photo 92. Roller screed used for a continuous pour on SR 2, Division Street and Francis Avenue.

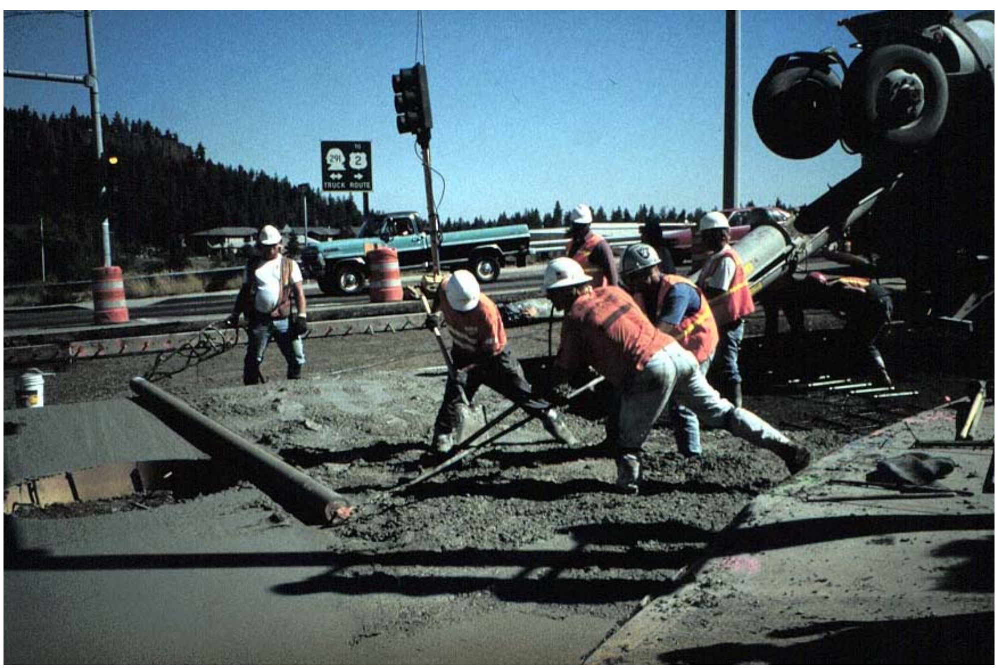

Photo 93. Roller screed used around a radius return area on SR 291, Francis Avenue with Maple and Ash Streets.

Photo 94. Paving machine used for a continuous pour area on SR 90, Broadway Avenue and Thierman Street.

Photo 95. Placement of concrete before a paving machine (SR 90, Broadway Avenue and Thierman Street).

Most recently, WSDOT has seen the use of a new piece of concrete placing equipment called a Whiteman Screed. The Whiteman Screed is a self-powered unit operated by one person that rides on rollers on the fixed forms. This screed is easily maneuverable and can make several passes to screed the concrete. In some instances the "fixed forms" can be existing curbing or even new PCCP.

ACME Materials of Spokane, Washington first used this equipment on the SR 2, Francis Avenue and Division Street, intersection and then again on SR 395 on the 7th, 10th, 19th, and 27th Avenue intersections. Use of the Whiteman Screed is shown in photos 96 to 98. The Whiteman screed has increased production and reduced personnel needs in comparison to a roller or vibratory screed. The Whiteman screed has been used to pave 12 to 24 foot widths, however, since it is adjustable, wider widths can be accommodated.

Photo 96. Use of a Whiteman Screed on the SR 395, SR 395 and Yelm Street intersection.

Photo 97. Roller on the Whiteman Screed rides on fixed forms or existing concrete (SR 395, SR 395 and Yelm Street).

Photo 98. Back of the Whiteman Screed riding on fixed forms (SR 395, SR 395 and Yelm Street intersection).

Slipform paving is another means of placing the concrete but the ACPA indicates that intersections constructed with this method are the exception [4]. Slipform paving applications are best applied to new mainline construction.

Finishing the Concrete

Finishing the freshly placed concrete is mostly done with hand-operated tools to smooth any surface imperfections or make minor grade corrections. Regular straight edging using a 10- to 16-foot straight edge typically provides a reasonable grade. PCCP intersections built so far have not relaxed surface smoothness requirements. However, some relaxation of WSDOT Standard Specification 5-05.3(12) has occurred where adjusting the longitudinal or transverse profile has been necessary to meet fixtures such as manholes or drainage inlets, existing curbs and gutters, and cross-road connections. The intersection designs to date have used the requirement by which no variations greater than 1/8 inch can be present when tested with a 10-foot straightedge parallel to centerline. The requirement for transverse measurements is ¼ inch with a 10-foot straightedge. Finishing the concrete on the SR 395 and West Kennewick Avenue intersection is shown in Photo 99.

Photo 99. Finishing concrete behind the Whiteman Screed on SR 395, SR 395 and West Kennewick Avenue intersection.

WSDOT recommends that all edges around fixed forms or curbing be edged with a ½-inch-radius edger. Edging prevents the new concrete from spalling around form edges when the forms are removed. Photos 100 and 101 illustrate these differences.

Photo 100. Concrete edge finished without a half-inch radius edger, spalling results (SR 291, Francis Avenue with Maple and Ash Street Intersections).

Photo 101. Concrete edge finished with a half-inch radius edger. Note the absence of spalling (SR 2, Division Street and Francis Avenue intersection).

Texturing the Surface

Normal texturing requirements, as noted in Standard Specification 5-05.3(11), apply. Photo 102 shows tines being placed on the SR 395, SR 395 and Yelm Street intersection.

Photo 102. Placing tine marks in the PCCP following finishing (SR 395, SR 395 and Yelm Street intersection).

Curing the Concrete

Curing compound should be applied as soon as the water sheen has left the concrete surface and texturing is complete as specified in WSDOT Standard Specification 5-05.3(13)A. The special provision in Appendix I notes that white pigment curing compound placed at 1½ times the normal rate should be applied. Curing compound should also be applied to vertical edges once the forms have been removed. Spraying curing compound on new concrete is shown in Photo 103.

Photo 103. Spraying curing compound on SR 395, SR 395 and Yelm Street intersection.

Following the placement of curing compound, WSDOT has often required the use of insulating blankets to assure concrete strength gain. However, there are questions regarding their use. Several contracts required the use of insulating blankets (R value of 6) until a minimum compressive strength of 2,500 psi was obtained. On hot days, typically in excess of 90 degrees Fahrenheit, there are fears that hot temperatures and rapid cure will damage the concrete, particularly with Type III cement. A question being considered is whether air temperature limits should be added to the contract special provisions, requiring the use of insulating blankets when air temperatures fall below a certain temperature, but requiring another method when air temperatures are above a certain temperature.

Since most of the contracts for intersections have required a 24-hour mix for opening to traffic, the intent of the insulating blanket special provision has been to ensure that concrete strength would be obtained. However, with the mixes used to date, obtaining strength in 12 to 15 hours has not been a problem, and it appears that blankets have not been needed during hot weather. In some instances, blankets were not in place for several hours, as they were partially or completely removed for sawcutting purposes. Blankets could also be detrimental to concrete properties if, on hot days, the mix cures too rapidly, resulting in shrinkage cracks. ACME Materials and Construction reported the cost of labor to provide blankets on the 7th, 10th, 19th and 27th Avenue intersections on SR 395 at $30,000.

Insulating blankets should be used during cooler weather to retain the heat in the PCCP for hydration. The ACPA [4] supports the use of insulating blankets to insulate fast-track concrete to aid early strength gain in <u>cool</u> weather conditions.

Sawcutting the Pavement

Recommendations provided in the FHWA Technical Adivisory 5040.30 [14] note, "Time of initial sawing, both in the transverse and longitudinal directions, is critical in preventing uncontrolled shrinkage cracking. It is very important that sawing begins as soon as the concrete is strong enough to both support the sawing equipment and to prevent raveling during the sawing operation. This is particularly critical during hot weather. Once sawing begins, it should be a continuous operation and should only be stopped if raveling begins to occur."

The concrete used for PCCP intersections has typically allowed commencement of green sawing within 6 hours of concrete placement. Saw cuts are provided at <u>predetermined</u> locations, as shown in the jointing plan and as referenced on the construction grade, to match dowel and tie bar locations. WSDOT has had good success using the sawcutting depths shown in the Standard Plans [8], which are D/3 for transverse joints and D/4 for longitudinal joints. Photo 104 shows sawcutting on SR 395 at the SR 395 and Yelm Street intersection.

Photo 104. Sawcutting newly placed concrete (SR 395, SR 395 and Yelm Street intersection).

Sealing Sawed Contraction Joints

Following concrete curing the sawed contraction joints are sealed according to the requirements of Section 5-05.3(8)B of the 2000 Standard Specifications [11] and the Standard Plans [8]. WSDOT has experience with many contracts in which the sealing contractor has overfilled the sawed contraction joints. Underfilling the joints by ¼ inch provides the best results, as bumps are eliminated and the joint sealer will not be forced or tracked out of the joint. In addition, a more appealing appearance to the newly placed PCCP is provided. Photo 105 shows joint sealing on the SR 395 and Yelm Street intersection. Photo 106 shows joint sealant placed cleanly inside a sawed contraction joint.

Photo 105. Joint sealing sawed contraction joints on SR 395 and Yelm Street intersection.

Photo 106. Sealant correctly recessed in a sawed contraction joint. Sealant is contained within the sawed joint (SR 395, Hastings Road to Mile Post 172 PCCP paving project).

Placing Asphalt Concrete Adjacent to New PCCP

The final step to completing the intersection is to place the ACP adjacent to the concrete approach, leave legs, and at the ends of the PCCP intersection. Construction of the adjacent ACP is straightforward, and little discussion is necessary. Generally, construction of concrete intersections has required 2 to 3 feet of excavation along the adjacent approach or leave legs. On the initial intersections built by WSDOT, the excavated area was replaced with crushed stone and ACP to match the existing surfacing depths. A portion of the ACP was typically placed as part of an inlay that resurfaced all the adjacent ACP.

Recently, WSDOT has experimented with replacing the adjacent excavated areas with controlled density fill (CDF) to the level of the inlay that abuts the PCCP.

While the placement of the CDF significantly eases construction before the placement of asphalt, the long-term effects of doing so are unknown. Many municipalities limit the use of CDF to subsurface work because it is not considered a crushed stone material. The performance of the asphalt above the CDF may be different than that over the existing ACP because of differing material stiffness, particularly when the CDF is used near or in the wheel path.

An alternative to CDF is to place concrete (see photo 107). Concrete offers greater stiffness and the ACP placed on the concrete can be easily rotomilled and inlayed for future rehabilitation cycles. CDF was intended as a fill material, and it is recommended that CDF be limited below the ACP and crushed stone base.

Photo 107. Concrete placed in the excavated area adjacent to the PCCP and existing ACP surfacing.

Opening to Traffic

WSDOT allows the intersection to be opened to traffic when the PCCP compressive strength is 2,500 psi. The intersections built to date have used cylinders to determine the compressive strength, along with a maturity meter (photos 108 and 109). The 2000 Standard Specifications includes the use of a maturity meter for this determination. However, some have questioned why the maturity method cannot be used in place of acceptance cylinders or beams. This question will be addressed in the Quality Control section. Currently, WSDOT has limited the use of the maturity meter to the determination of the opening to traffic (see Photo 110).

Photo 108. Commercial maturity meter.

Photo 109. Placement of probes that will be attached to the maturity meter.

Photo 110. Maturity meter attached to probes within the newly placed PCCP.

QUALITY CONTROL

Testing Frequency

There has been some concern with the testing frequency required for concrete placement within PCCP intersections. Previous contracts, placed under the 1998 Standard Specifications, required one set of air content, cement factor, and beams for flexural strength to be performed every 2,500 square yards. Amendments to the 1998 Standard Specifications allow cylinders to be tested for compressive strength when correlated to beams before construction instead of flexural strength. The 2,500-square-yard frequency is more relevant for slip-form paving and side-form construction where miles are being poured a day.

The 2,500-square-yard frequency, as specified in the WSDOT Construction Manual [7], converts to 833 cubic yards of concrete. Within an intersection, only one or two tests would be required for the largest pours, and some days could go without any testing until the required square yards were accumulated. Table 25 portrays a typical intersection placed in Washington State (SR 291, Francis Avenue with Maple and Ash Streets intersection).

For comparison with concrete structures, Section 6-02.3(5) G of the Standard Specifications states that the sampling and testing frequency may decrease to one out of every five truck loads after two successive passing tests. This specification is too tight for placement of concrete at intersections. The intent of the specification relates better to smaller pours on structures where the time between trucks is greater. On some of the intersections, the contractor placed concrete from two or three trucks at a time. Testing every five trucks would require at least two testing crews.

Table 25. Summary of required testing at a 2,500 square yard test frequency for the SR 291, Francis Avenue with Maple and Ash Streets.

Pour Dates	Square Yards	Cumulative Square Yards	Tests Required with 2,500 Yd^2 Frequency[1]
July 18	1,903.0	1,903.0	
July 21	260.7	2,163.7	
July 22	147.9	2,311.6	
July 24	168.0	2,479.6	1
July 28	130.1	2,609.7	
July 29	370.3	2,980.0	
August 5	83.4	3,063.4	
August 6	247.6	3,311.0	
August 11	80.1	3,391.1	
August 13	1,464.0	4,855.1	
August 14	873.1	5,728.2	2
August 15	324.8	6,053.0	3

[1] Cumulative number of tests.

The Eastern Region took a sensible approach to the testing. On the SR 2 and SR 291 projects, the project office tested the first two trucks and then calculated random numbers on the next ten trucks to arrive at a testing frequency. By using this method, WSDOT inspectors did not delay placement of the concrete, and inspectors could "catch their breath" between tests. At a minimum, at least one test a day was performed. This approach is similar to the revisions that were made in the 2000 Standard Specifications and are discussed in the following section.

Acceptance of Portland Cement Concrete Pavement

The 2000 Standard Specifications provides for acceptance of PCCP based on statistical evaluation for air content and strength per section 1-06.2(2). Each truckload of concrete must have a certificate of compliance in accordance with section 6-02.3(5)B. With regard to testing frequency, the 2000 Standard Specification section 5-05.3(4)A states the following:

> For the purpose of acceptance sampling and testing a lot is defined as the total quantity of material to be used that was produced from the same operation. All of the test results obtained from the same material shall be evaluated collectively and shall constitute a lot. The quantity represented by each sample will constitute a sublot. Sampling and testing for statistical acceptance shall be performed on a random basis at the frequency of one sample per sublot. Sublot size shall be determined to the nearest 10 cubic yards to provide not less than three uniform sized sublots with a maximum sublot size of 500 cubic yards.

Interpretation of this specification suggests that infrequent testing could be a problem if acceptance tests are taken every 500 cubic yards. Table 26 shows that only 3 tests would have been required for the intersection on SR 291, Francis Avenue with Maple and Ash Streets. However, since 500 cubic yards is the maximum allowable sublot size, WSDOT recommends a minimum of one test per day. Requiring one test per day increases the statistical analysis, thus reducing any penalty to the contractor should a particular sublot yield poor results.

Table 26. Summary of required testing at a 500- cubic-yard test frequency for the SR 291, Francis Avenue with Maple and Ash Streets.

Pour Date	Square Yards (yd^2)	Cubic Yards (yd^3)	Cumulative Cubic Yards (yd)	Cumulative Number of Tests Using 500 CY Lot Size	Cumulative Number of Tests Using One Test Per Day
July 18	1,903.0	475.8	475.8		1
July 21	260.7	65.2	541.0	1	2
July 22	147.9	37.0	578.0		3
July 24	168.0	42.0	620.0		4
July 28	130.1	32.5	652.5		5
July 29	370.3	92.6	745.1		6
August 5	83.4	20.9	766.0		7
August 6	247.6	61.9	827.9		8
August 11	80.1	20.0	847.9	2	9
August 13	1,464.0	366.0	1,213.9		10
August 14	873.1	218.3	1,432.2		11
August 15	324.8	81.2	1,513.4	3	12

Use of Maturity Meter

Since the 2000 Standard Specifications now includes the use of a maturity meter to determine time of opening to traffic, some have wondered why the maturity method cannot be used in the place of acceptance cylinders or beams. ASTM C 1074 *Standard Practice for Estimating Concrete Strength by the Maturity Method* [15] states that "This practice can be used to estimate the in-place strength of concrete to allow the start of critical construction activities . . . ." The Design and Control of Concrete Mixtures [16] from the Portland Cement Association states:

> The maturity concept is not precise and has some limitations. The concept is useful only in checking the curing of concrete and estimating strength in relation to time and temperature. It presumes that all other factors affecting concrete strength have been properly controlled. Thus, the maturity concept is another method for monitoring temperatures, but it is no substitute for quality control and proper concreting practices.

The biggest drawbacks to the maturity method are the following:

- The method does not take into account the fact that high early temperatures lead to rapid strength gain but reduce the long-term strength of the concrete.
- The accuracy of the estimated strength depends on the determination of the curve, which changes with mix proportion and component changes.

Currently, WSDOT has limited the use of the maturity meter to testing for the opening of traffic.

RECOMMENDATIONS AND CONCLUSIONS

While PCCP construction is not new to WSDOT, construction of urban intersections is. WSDOT's experiences with constructing PCCP intersections convinced engineers that design and construction details were important. Resulting random cracking and construction difficulties provided valuable learning experiences. This report has documented these experiences and can be used as guidelines for state and local agencies that are considering full-depth PCCP construction at urban intersections.

Recommendations and conclusions for the use of PCCP at urban intersections follow:

Construction Costs

Full-depth PCCP reconstruction at urban intersections costs approximately 25 to 30 percent more than full-depth ACP construction. Construction costs have been lower when urban intersection construction has been included as part of larger ACP resurfacing projects. Traffic control costs typically run 4 to 5 percent of the project subtotal when intersection construction is included as part of a larger ACP resurfacing project, and 12 to 17 percent of the project subtotal when intersections are constructed as a separate contract.

Life Cycle Cost Analysis

The 40-year annualized costs for intersections with and without user delay costs show that full-depth PCCP intersection reconstruction typically costs less than full-depth ACP reconstruction with future ACP inlays when intersection reconstruction is necessary. When user delay costs are used, this study showed that PCCP reconstruction for six of the seven intersections was 5.5 to 14 percent less than ACP reconstruction. A comparison of the 40-year annualized costs for reconstructed PCCP intersections with and without user delay costs to ACP inlays at four-, six-, and eight-year cycles showed that ACP inlays will always cost less than reconstructing with PCCP at an urban intersection. However, with ACP inlays, the state or local agency must decide whether inlays meet the expectations of the public. The public's view of rehabilitation of the same section of roadway at four-, six- or eight-year-cycles does not reflect well on the agency, even if the section needs rehabilitation because of the distress present. In addition, the public does not appreciate delays during roadway rehabilitation.

Traffic Management

WSDOT has experienced faster reconstruction of PCCP intersections when some type of closure has been used. Intersection projects with minimal or no detours have required 30 to 42 days for the PCCP reconstruction. Allowing at least some type of closure (such as closing minor legs) has shortened the number of construction days to 15 to 20. Full closure of the intersection has facilitated the fastest construction period. On one project, three separate intersections were reconstructed during weekend closures. The approach legs were reconstructed on the days preceding the weekend closure, and the intersection square (radius return to radius return) was reconstructed during the weekend closures. The approach legs for the three intersections were reconstructed under traffic. On average, a total of 9 days per intersection were required (three days of which were over the weekend closures).

Design Considerations

A key element of constructing PCCP intersections is the planning of transverse and longitudinal joints. Often, state and local agencies are not prepared to make on-the-fly jointing decisions once intersection construction is under way. Therefore, joint planning is necessary to prevent distresses such as sympathy cracks, random cracks, and misalignment of joints with manholes and valves. WSDOT strongly recommends the preparation of jointing plans to be included in contract documents.

Construction Considerations

PCCP intersection construction requires the same care and consideration as any other PCCP project. However, PCCP intersections require special jointing considerations, especially around curb radii and utility fixtures. Field adjustments are often needed to avoid random cracking. As mentioned under Design Considerations, the best way to avoid random cracking is to provide PCCP jointing plans in the contract documents. Even with the best of jointing plans, field adjustments will still be needed, and project personnel need to be aware of the options.

REFERENCES

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12. ACME Construction and Materials, Type III Mix Characterization, Spokane, Washington, July 1998.

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14. Federal Highway Administration, "Concrete Pavement Joints," Technical Advisory 5040.30, FHWA, Washington D.C., November 30, 1990.

15. American Society for Testing and Materials, *1999 Annual Book of ASTM Standards*, Volume 04.02, West Conshohocken, Philadelphia, 1999.

16. Portland Cement Association, *Design and Control of Concrete Mixtures*, Skokie, Illinois, 1992.

APPENDIX A – PROJECT COSTS

Tables A-1 to A-21 show cost estimates for PCCP and ACP initial construction and ACP inlays.

The intersections are presented in the following order:

Tables	**Intersection**
A-1 to A-3	SR 27, Pines Road and Sprague Avenue
A-4 to A-6	SR 90, Broadway Avenue and Thierman Street
A-7 to A-9	SR 2, Division Street and Francis Avenue
A-10 to A-12	SR 291, Francis Avenue with Maple and Ash Streets
A-13 to A-15	SR 27, Pines Road and Broadway Avenue
A-16 to A-18	SR 2, Division Street and Third Avenue
A-19 to A-21	SR 395, SR 395 and 19th Avenue

Table A-1. SR 27, Pines Road and Sprague Avenue initial PCCP construction cost estimate.

Contract 4486 SR 27 Pines Road and Sprague Avenue			Construction Year: 1994 0.83' PCCP		
Initial Cost of PCCP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Actual)	L.S.	$30,000	L.S.	$30,000.00
0188	REMOVING TEMPORARY PAVEMENT MARKING	L.F.	$0.30	0	$0.00
	GRADING				
0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$16.00	2,086	$33,376.00
	SURFACING				
5120	CRUSHED SURFACING TOP COURSE	TON	$16.00	1,155	$18,480.00
	LIQUID ASPHALT				
5334	ANTI-STRIPPING ADDITIVE	DOL	$458.85	1	$458.85
	ASPHALT TREATED BASE				
5510	ASPHALT TREATED BASE	TON	$40.00	839	$33,560.00
	CEMENT CONCRETE PAVEMENT				
	MODIFIED CONC. CLASS 4000 1 DAY 0.83 FT. SECTION	S.Y.	$43.00	4,116	$176,988.00
	ASPHALT CONCRETE PAVEMENT				
5764	ASPHALT CONC. PAVEMENT CL. A	TON	$80.00	27	$2,160.00
	TRAFFIC				
6821	PAINT STRIPE	L.F.	$0.30	1,413	$423.90
6827	PAINTED CROSSWALK STRIPE	L.F.	$2.25	710	$1,597.50
6844	PAINTED STOP BAR	L.F.	$3.25	180	$585.00
6860	PAINTED TRAFFIC ARROWS	EACH	$20.00	4	$80.00
6888	TEMPORARY PAVEMENT MARKING	L.F.	$0.30	1,314	$394.20

6956 SEQUENTIAL ARROWS SIGNS	HOUR	$3.30	1599	$5,276.70
6955 ADDITIONAL SEQUENTIAL ARROWS SIGNS	DOL	$1.00	0	$0.00
6959 CHANNELIZATION DEVICES	L.S.	$1,800.00	1	$1,800.00
6979 TRAFFIC CONTROL LABOR	HOUR	$28.00	1868	$52,304.00
6968 TRAFFIC CONTROL VEHICLES	DAY	$35.00	27	$945.00
6969 TRAFFIC CONTROL SUPERVISOR	DAY	$300.00	41	$12,300.00
6982 CONSTRUCTION SIGNS CLASS A	S.F.	$8.00	184	$1,472.00
VEHICLE DETECTION LOOP REPLACEMENT	L.S.	$11,000.00	L.S.	$11,000.00
OTHER ITEMS				
7340 ADJUST CONC. INLET	EACH	$500.00	1	$500.00
3080 ADJUST MANHOLE	EACH	$500.00	1	$500.00
6243 ADJUST VALVE BOX	EACH	$300.00	8	$2,400.00
7380 ADJUST MONUMENT CASE AND COVER	EACH	$400.00	2	$800.00
7480 ROADSIDE CLEANUP	DOL	$0.00	0	$0.00
CONTRACT SUBTOTAL				$387,417.92
WASHINGTON STATE SALES TAX		8.10%		$31,380.85
PROJECT SUBTOTAL				$418,798.77
PRELIMINARY ENGINEERING		(Actual)		$50,531.00
CONSTRUCTION ENGINEERING		(Actual)		$61,941.00
TOTAL ESTIMATED COST				**$531,270.77**

Table A-2. SR 27, Pines Road and Sprague Avenue initial ACP construction cost estimate.

Contract 4486			Construction Year: 1994		
SR 27			0.70' ACP		
Pines Road and Sprague Avenue					
Initial Cost of ACP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Same as PCCP)	L.S.		L.S.	$30,000.00
0188	REMOVING TEMPORARY PAVEMENT MARKING	L.F.	$0.30	0	$0.00
	GRADING				
0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$16.00	2,086	$33,376.00
	SURFACING				
5120	CRUSHED SURFACING TOP COURSE	TON	$16.00	2,043	$32,688.00
	LIQUID ASPHALT				
5325	ASPHALT FOR TACK COAT	TON	$200.00	2	$400.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$1,974.00	1	$1,974.00
	ASPHALT CONCRETE PAVEMENT				
5764	ASPHALT CONC. PAVEMENT CL. A	TON	$38.00	1,974	$75,012.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$2,250.36	1	$2,250.36
5835	COMPACTION PRICE ADJUSTMENT	DOL	$1,500.24	1	$1,500.24
	TRAFFIC				
6821	PAINT STRIPE	L.F.	$0.30	1,413	$423.90
6827	PAINTED CROSSWALK STRIPE	L.F.	$2.25	710	$1,597.50
6844	PAINTED STOP BAR	L.F.	$3.25	180	$585.00
6860	PAINTED TRAFFIC ARROWS	EACH	$20.00	4	$80.00
6888	TEMPORARY PAVEMENT MARKING	L.F.	$0.30	1,314	$394.20
6956	SEQUENTIAL ARROWS SIGNS	HOUR	$3.30	1,599	$5,276.70
6955	ADDITIONAL SEQUENTIAL ARROWS SIGNS	DOL	$0.00	0	$0.00
6959	CHANNELIZATION DEVICES	L.S.	$1,800.00	L.S.	$1,800.00
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	1,868	$52,304.00
6968	TRAFFIC CONTROL VEHICLES	DAY	$35.00	27	$945.00
6969	TRAFFIC CONTROL SUPERVISOR	DAY	$300.00	41	$12,300.00

6982	CONSTRUCTION SIGNS CLASS A	S.F.	$8.00	184	$1,472.00
	VEHICLE DETECTION LOOP REPLACEMENT	L.S.	$11,000.00	L.S.	$11,000.00
	OTHER ITEMS				
7340	ADJUST CONC. INLET	EACH	$500.00	1	$500.00
3080	ADJUST MANHOLE	EACH	$500.00	1	$500.00
6243	ADJUST VALVE BOX	EACH	$300.00	8	$2,400.00
7380	ADJUST MONUMENT CASE AND COVER	EACH	$400.00	2	$800.00
7480	ROADSIDE CLEANUP	DOL	$0.00	0	$0.00
	CONTRACT SUBTOTAL				$269,578.90
	WASHINGTON STATE SALES TAX		8.10%		$21,835.89
	PROJECT SUBTOTAL				$291,414.79
	PRELIMINARY ENGINEERING		(Same as PCCP)		$50,531.00
	CONSTRUCTION ENGINEERING		(Same as PCCP)		$61,941.00
	TOTAL ESTIMATED COST				**$403,886.79**

Table A-3. SR 27, Pines Road and Sprague Avenue ACP inlay cost estimate.

Contract 4486 SR 27 Pines Road and Sprague Avenue			Construction Year: 1994 0.20' Inlay		
ACP Inlay Construction Cost					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of all items)	L.S.		L.S.	$4,900.00
0188	REMOVING TEMPORARY PAVEMENT MARKING	L.F.	$0.05	2,996	$149.80
	LIQUID ASPHALT				
5325	ASPHALT FOR TACK COAT	TON	$200.00	1	$200.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$570.00	1	$570.00
	ASPHALT CONCRETE PAVEMENT				
5711	PLANING BITUMINOUS PAVEMENT	S.Y.	$3.00	4,116	$12,348.00
5764	ASPHALT CONC. PAVEMENT CL. A	TON	$38.00	570	$21,660.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$649.80	1	$649.80
5835	COMPACTION PRICE ADJUSTMENT	DOL	$433.20	1	$433.20
	TRAFFIC				
6821	PAINT STRIPE	L.F.	$0.10	1,413	$141.30
6827	PAINTED CROSSWALK STRIPE	S.F.	$2.25	710	$1,597.50
6844	PAINTED STOP BAR	L.F.	$3.25	180	$585.00
6860	PAINTED TRAFFIC ARROWS	EACH	$20.00	4	$80.00
6888	TEMPORARY PAVEMENT MARKING	L.F.	$0.15	2,996	$449.40
6956	SEQUENTIAL ARROWS SIGNS	HOUR	$3.00	120	$360.00
6959	CHANNELIZATION DEVICES	L.S.	$1,800.00	L.S.	$1,800.00
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	180	$5,040.00
6968	TRAFFIC CONTROL VEHICLES	DAY	$100.00	3	$300.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$35.00	30	$1,050.00
6982	CONSTRUCTION SIGNS CLASS A	S.F.	$6.00	184	$1,104.00
	OTHER ITEMS				
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00

CONTRACT SUBTOTAL		$53,918.00
WASHINGTON STATE SALES TAX	8.10%	$4,367.36
PROJECT SUBTOTAL		$58,285.36
ENGINEERING	20.00%	$11,657.07
CONTINGENCIES	5.00%	$2,914.27
TOTAL ESTIMATED COST		$72,856.70

Table A-4. SR 90, Broadway Avenue and Thierman Street initial PCCP construction cost estimate.

Contract 4800 SR 90 Broadway Avenue and Thierman Street			Construction Year: 1996 0.83' PCCP		
Initial Cost of PCCP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Actual)	L.S.	$80,000.00	L.S.	$80,000.00
0048	REMOVING CATCH BASIN	EACH	$350.00	2.0	$700.00
0188	REMOVING TEMPORARY PAVEMENT MARKING	L.F.	$0.05	1,001	$50.05
0215	REMOVING MISCELLANEOUS TRAFFIC MARKING	L.S.	$12,000.00	L.S.	$12,000.00
	GRADING				
0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$10.00	3,600	$36,000.00
	C.O. #1 - ROADWAY EXCAVATION CREDIT	L.S.	($5,150.00)	L.S.	($5,150.00)
	DRAINAGE				
1046	CONCRETE INLET	EACH	$850.00	1	$850.00
1180	SCHEDULE A CULV. PIPE 12 INCH DIAM.	L.F.	$20.00	72	$1,440.00
1182	SCHEDULE A CULV. PIPE 18 INCH DIAM.	L.F.	$40.00	212	$8,480.00
	STORM SEWER PIPE				
3090	CATCH BASIN TYPE 1L	EACH	$1,400.00	2	$2,800.00
	SURFACING				
5120	CRUSHED SURFACING TOP COURSE	TON	$20.00	1889	$37,780.00
	LIQUID ASPHALT				
5325	ASPHALT FOR TACK COAT	TON	$300.00	0.53	$159.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$112.64	1	$112.64
	CEMENT CONCRETE PAVEMENT				
	MODIFIED CONC. CL. 4000 1 DAY, 0.83 FT SECTION	S.Y.	$40.00	6,657	$266,280.00
	C.O. #4 - ADDITIONAL CONCRETE POUR	L.S.	$750.00	L.S.	$750.00

	C.O. # 7 - ADDITIONAL ENGINEERING	L.S.	$3,000.00	L.S.	$3,000.00
	EPOXY-COATED TIE BAR	EACH	$4.00	245	$980.00
5685	EPOXY-COATED DOWEL BAR	EACH	$15.00	5,099	$76,485.00
	C.O. #2 - EPOXY COATED DOWEL BAR MODIFIED JOINT	EACH	$7.50	136	$1,020.00
	ASPHALT CONCRETE PAVEMENT				
	BRIDGE APPROACH SLAB GRINDING	HOUR	$450.00	15	$6,750.00
5711	PLANING BITUMINOUS PAVEMENT	S.Y.	$2.50	2,110	$5,275.00
	C.O. #6 - ADDITIONAL PLANING - FORCE ACCOUNT	DOL	$2,841.30	1	$2,841.30
	POLYMER MODIFIED ASPHALT CONC. PAVEMENT CL. A	TON	$60.00	477	$28,620.00
	EROSION CONTROL AND PLANTING				
6419	SEEDING AND FERTILIZING BY HAND	S.Y.	$3.00	506	$1,518.00
	TRAFFIC				
6714	CEMENT CONC. BARRIER CURB	L.F.	$10.00	524	$5,240.00
6828	PLASTIC CROSSWALK STRIPE	L.F.	$3.00	270	$810.00
6829	PLASTIC STOP BAR	L.F.	$5.00	209	$1,045.00
6833	PLASTIC TRAFFIC ARROWS	EACH	$50.00	16	$800.00
6888	TEMPORARY PAVEMENT MARKING	L.F.	$0.05	1,001	$50.05
6954	TRAFFIC SAFETY DRUM	EACH	$25.00	111	$2,775.00
6956	SEQUENTIAL ARROWS SIGNS	HOUR	$2.00	2,860	$5,719.00
6958	TYPE III BARRICADE	EACH	$50.00	4	$200.00
6959	CHANNELIZATION DEVICES	L.S.	$200.00	L.S.	$200.00
6979	TRAFFIC CONTROL LABOR	HOUR	$21.00	3,623	$76,083.00
	C.O. #8 - EQUITABLE ADJUSTMENT	L.S.	$13,291.74	L.S.	$13,291.74
6968	TRAFFIC CONTROL VEHICLES	DAY	$45.00	43	$1,935.00
6969	TRAFFIC CONTROL SUPERVISOR	DAY	$250.00	43	$10,750.00
6982	CONSTRUCTION SIGNS CLASS A	S.F.	$14.00	308	$4,312.00
	VEHICLE DETECTION LOOP REPLACEMENT	L.S.	$30,000.00	L.S.	$30,000.00
	OTHER ITEMS				
7006	STRUCTURE EXCAVATION CL. B INCL HAUL	C.Y.	$5.00	241	$1,205.00
	C.O. #3 - SHORING OR EXTRA EXCAVATION CL. B	S.F.	$1.00	781	$781.00
7340	ADJUST CONC. INLET	EACH	$200.00	4	$800.00
7725	REIMBURSEMENT FOR THIRD PARTY DAMAGES	DOL	$0.00	0	$0.00
7400	TRAINING	HOUR	$1.00	283	$283.00
7480	ROADSIDE CLEANUP	DOL	$3,083.78	1	$3,083.78
7490	TRIMMING AND CLEAN-UP	L.S.	$20,000.00	L.S.	$20,000.00
	CONTRACT SUBTOTAL		(Actual)		$748,104.56
	WASHINGTON STATE SALES TAX		8.10%		$60,596.47

	PROJECT SUBTOTAL		$808,701.03
	PRELIMINARYENGINEERING	(Actual)	$85,006.15
	CONSTRUCTION ENGINEERING	(Actual)	$88,473.94
	TOTAL COST		**$982,181.12**

Table A-5. SR 90, Broadway Avenue and Thierman Street initial ACP construction cost estimate.

Contract 4800 SR 90 Broadway Avenue and Thierman Street		Construction Year: 1996 0.80 ' ACP			
Initial Cost of ACP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Same as PCCP - Actual)	L.S.		L.S.	$80,000.00
0048	REMOVING CATCH BASIN	EACH	$350.00	2.0	$700.00
0188	REMOVING TEMPORARY PAVEMENT MARKING	L.F.	$0.05	1,001.0	$50.05
0215	REMOVING MISCELLANEOUS TRAFFIC ITEM	L.S.	$12,000.00	L.S.	$12,000.00
	GRADING				
0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$10.00	2,823	$28,230.00
	DRAINAGE				
1046	CONCRETE INLET	EACH	$850.00	1	$850.00
1180	SCHEDULE A CULV. PIPE 12 INCH DIAM.	L.F.	$20.00	72	$1,440.00
1182	SCHEDULE A CULV. PIPE 18 INCH DIAM.	L.F.	$40.00	212	$8,480.00
	STORM SEWER PIPE				
3090	CATCH BASIN TYPE 1L	EACH	$1,400.00	2	$2,800.00
	SURFACING				
5120	CRUSHED SURFACING TOP COURSE	TON	$20.00	1,889	$37,780.00
	LIQUID ASPHALT				
5325	ASPHALT FOR TACK COAT	TON	$200.00	2.8	$560.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$3,937.00	1	$3,937.00
	ASPHALT CONCRETE PAVEMENT				
	BRIDGE APPROACH SLAB GRINDING	HOUR	$450.00	15	$6,750.00
5711	PLANING BITUMINOUS PAVEMENT	S.Y.	$2.50	2,110	$5,275.00
5764	ASPHALT CONC. PAVEMENT CL. A	TON	$38.00	3,937	$149,606.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$4,488.18	1	$4,488.18
5835	COMPACTION PRICE ADJUSTMENT	DOL	$2,992.12	1	$2,992.12

EROSION CONTROL AND PLANTING				
6419 SEEDING AND FERTILIZING BY HAND	S.Y.	$3.00	506	$1,518.00
TRAFFIC				
6714 CEMENT CONC. BARRIER CURB	L.F.	$10.00	524	$5,240.00
6828 PLASTIC CROSSWALK STRIPE	L.F.	$3.00	270	$810.00
6829 PLASTIC STOP BAR	L.F.	$5.00	209	$1,045.00
6833 PLASTIC TRAFFIC ARROWS	EACH	$50.00	16	$800.00
6888 TEMPORARY PAVEMENT MARKING	L.F.	$0.05	1,001	$50.05
6954 TRAFFIC SAFETY DRUM	EACH	$25.00	111	$2,775.00
6956 SEQUENTIAL ARROWS SIGNS	HOUR	$2.00	2,860	$5,719.00
6958 TYPE III BARRICADE	EACH	$50.00	4	$200.00
6959 CHANNELIZATION DEVICES	L.S.	$200.00	L.S.	$200.00
6979 TRAFFIC CONTROL LABOR	HOUR	$21.00	3,623	$76,083.00
6968 TRAFFIC CONTROL VEHICLES	DAY	$45.00	43	$1,935.00
6969 TRAFFIC CONTROL SUPERVISOR	DAY	$250.00	43	$10,750.00
6982 CONSTRUCTION SIGNS CLASS A	S.F.	$14.00	308	$4,312.00
VEHICLE DETECTION LOOP REPLACEMENT	L.S.	$30,000.00	L.S.	$30,000.00
OTHER ITEMS				
7006 STRUCTURE EXCAVATION. CL. B INCL. HAUL	C.Y.	$5.00	241	$1,205.00
SHRNG OR EXTRA EXCAVATION CL. B	S.F.	$1.00	781	$781.00
7340 ADJUST CONC. INLET	EACH	$200.00	4	$800.00
7725 REIMBURSEMENT FOR THIRD PARTY DAMAGES	EST.	$0.00	DOL.	$0.00
7400 TRAINING	HOUR	$1.00	283	$283.00
7480 ROADSIDE CLEANUP	DOL	$3,083.78	1	$3,083.78
7490 TRIMMING AND CLEAN-UP	L.S.	$20,000.00	L.S.	$20,000.00
CONTRACT SUBTOTAL				$512,528.18
WASHINGTON STATE SALES TAX		8.10%		$41,595.78
PROJECT SUBTOTAL				$555,123.96
PRELIMINARY ENGINEERING		(Same as PCCP)		$85,006.15
CONSTRUCTION ENGINEERING		(Same as PCCP)		$88,473.94
TOTAL ESTIMATED COST				**$728,604.05**

Table A-6. SR 90, Broadway Avenue and Thierman Street ACP inlay construction cost estimate.

Contract 4800 SR 90 Broadway Avenue and Thierman Street			Construction Year: 1996 0.20' ACP Inlay		
	ACP Inlay Construction Cost				
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of all items)	L.S.		L.S.	$6,500.00
0188	REMOVING TEMPORARY PAVEMENT MARKING	L.F.	$0.05	4,936	$246.80
	LIQUID ASPHALT				
5325	ASPHALT FOR TACK COAT	TON	$200.00	1.4	$280.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$912.00	1	$912.00
	ASPHALT CONCRETE PAVEMENT				
5711	PLANING BITUMINOUS PAVEMENT	S.Y.	$2.10	6,657	$13,979.70
5764	ASPHALT CONC. PAVEMENT CL. A	TON	$38.00	912	$34,656.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$1,039.68	1	$1,039.68
5835	COMPACTION PRICE ADJUSTMENT	DOL	$693.12	1	$693.12
	TRAFFIC				
6828	PLASTIC CROSSWALK STRIPE	S.F.	$3.00	270	$810.00
6829	PLASTIC STOP BAR	L.F.	$5.00	209	$1,045.00
6833	PLASTIC TRAFFIC ARROWS	EACH	$50.00	16	$800.00
6956	SEQUENTIAL ARROW SIGNS	HOUR	$3.00	120	$360.00
6888	TEMPORARY PAVEMENT MARKING	L.F.	$0.15	4,936	$740.40
6959	CHANNELIZATION DEVICES	L.S.	$200.00	L.S.	$200.00
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	180	$5040.00
6968	TRAFFIC CONTROL VEHICLE	DAY	$100.00	3	$300.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$35.00	30	$1,050.00
6982	CONSTRUCTION SIGNS CLASS A	S.F.	$6.00	308	$1,848.00
	OTHER ITEMS				
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00

CONTRACT SUBTOTAL			$71,000.70
WASHINGTON STATE SALES TAX	8.10%		$5,751.06
PROJECT SUBTOTAL			$76,751.76
ENGINEERING	20.00%		$15,350.35
CONTINGENCIES	5.00%		$3,837.59
TOTAL ESTIMATED COST			**$95,939.70**

Table A-7. SR 291, Division Street and Francis Avenue initial PCCP construction cost estimate.

Contract 5132 SR 2 Division Street and Francis Avenue **Initial Cost of PCCP Construction**			**Construction Year: 1997** **0.83' PCCP**		
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Same as ACP)	L.S.		L.S.	$39,000.00
0585	REMOVING TRAFFIC ISLAND	M2	$5.25	45	$236.25
0590	REMOVING TRAFFIC CURB	M	$16.25	300	$4,875.00
	REMOVING MONUMENT CASE AND COVER	EACH	$105.00	1	$105.00
	GRADING				
2955	ROADWAY EXCAVATION INCL. HAUL	M3	$11.00	4,115	$45,265.00
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$17.00	1,996	$33,932.00
	CEMENT CONCRETE PAVEMENT				
	MODIFIED CONC. CLASS 28 1 DAY 250 MM SECTION	M2	$41.50	8,603	$357,024.50
	ASPHALT CONCRETE PAVEMENT				
8915	LONGITUDINAL JOINT SEAL	M	$2.45	205	$502.25
	TRAFFIC				
9249	PAINT STRIPE	M	$0.25	1,880	$470.00
9251	PLASTIC STRIPE	M	$2.15	2,215	$4,762.25
9257	PLASTIC GORE STRIPE	M	$3.75	525	$1,968.75
9289	PLASTIC CROSSWALK STRIPE	M2	$20.50	74	$1,517.00
9273	PLASTIC STOP BAR	M	$10.50	74	$777.00
6833	PLASTIC TRAFFIC ARROWS	EACH	$43.00	6	$258.00
6871	PLASTIC TRAFFIC LETTERS	EACH	$17.00	16	$272.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.35	1,880	$658.00
6890	PERMANENT SIGNING	L.S.	$1,600.00	L.S.	$1,600.00
6956	SEQUENTIAL ARROWS SIGNS	HOUR	$2.75	800	$2,200.00

9380	TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$200.00	L.S.	$200.00
6979	TRAFFIC CONTROL LABOR	HOUR	$27.50	352	$9,680.00
6968	TRAFFIC CONTROL VEHICLES	DAY	$50.00	35	$1,750.00
6969	TRAFFIC CONTROL SUPERVISOR	HOUR	$33.00	280	$9,240.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$65.00	5	$338.00
	OTHER ITEMS				
	QUALITY CONTROL PROGRAM	L.S.	$250.00	L.S.	$250.00
9602	ADJUST INLET	EACH	$435.00	1	$435.00
3080	ADJUST MANHOLE	EACH	$340.00	5	$1,700.00
3100	ADJUST CATCH BASINS	EACH	$340.00	1	$340.00
6243	ADJUST VALVE BOX	EACH	$180.00	6	$1,080.00
	CONTRACT SUBTOTAL				$520,436.00
	WASHINGTON STATE SALES TAX		8.10%		$42,155.32
	PROJECT SUBTOTAL				$562,591.32
	ENGINEERING		20.00%		$112,518.26
	TOTAL ESTIMATED COST				**$675,109.58**

Table A-8. SR 291, Division Street and Francis Avenue initial ACP construction cost estimate.

Contract 5132			Construction Year: 1997		
SR 2			0.70' ACP		
Division Street and Francis Avenue					
Initial Cost of ACP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of Subtotal)	L.S.		L.S.	$39,000.00
0585	REMOVING TRAFFIC ISLAND	M2	$5.25	45	$236.25
0590	REMOVING TRAFFIC CURB	M	$16.25	300	$4,875.00
	REMOVING MONUMENT CASE AND COVER	EACH	$105.00	1.0	$105.00
	GRADING				
2955	ROADWAY EXCAVATION INCL. HAUL	M3	$11.00	3,933	$43,263.00
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$17.00	2,744	$46,648.00
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200.00	4	$800.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$4,476.00	1	$4,476.00
	ASPHALT CONCRETE PAVEMENT				
8870	ASPHALT CONC. PAVEMENT CL. A	TONNE	$42.00	4,476	$187,992.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$5,639.76	1	$5,639.76
5835	COMPACTION PRICE ADJUSTMENT	DOL	$3,759.84	1	$3,759.84
	TRAFFIC				
9249	PAINT STRIPE	M	$0.25	1,880	$470.00
9251	PLASTIC STRIPE	M	$2.15	2,215	$4,762.25
9257	PLASTIC GORE STRIPE	M	$3.75	525	$1,968.75
9289	PLASTIC CROSSWALK STRIP	M2	$20.50	74	$1,517.00
9273	PLASTIC STOP BAR	M	$10.50	74	$777.00
6833	PLASTIC TRAFFIC ARROWS	EACH	$43.00	6	$258.00
6871	PLASTIC TRAFFIC LETTERS	EACH	$17.00	16	$272.00
6888	TEMPORARY PAVEMENT MARKING	M	$0.35	1,880	$658.00

6890 PERMANENT SIGNING	L.S.	$1,600.00	L.S.	$1,600.00
6956 SEQUENTIAL ARROWS SIGNS	HOUR	$2.75	800	$2,200.00
9380 TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$200.00	L.S.	$200.00
6979 TRAFFIC CONTROL LABOR	HOUR	$27.50	352	$9,680.00
6968 TRAFFIC CONTROL VEHICLES	DAY	$50.00	35	$1,750.00
6969 TRAFFIC CONTROL SUPERVISOR	HOUR	$33.00	280	$9,240.00
9398 CONSTRUCTION SIGNS CLASS A	M2	$65.00	5	$338.00
OTHER ITEMS				
9602 ADJUST INLET	EACH	$435.00	1	$435.00
3080 ADJUST MANHOLE	EACH	$340.00	5	$1,700.00
3100 ADJUST CATCH BASINS	EACH	$340.00	1	$340.00
6243 ADJUST VALVE BOX	EACH	$180.00	6	$1,080.00
CONTRACT SUBTOTAL				$376,040.85
WASHINGTON STATE SALES TAX		8.10%		$30,459.31
PROJECT SUBTOTAL				$406,500.16
ENGINEERING (Same as PCCP)				$112,518.26
TOTAL ESTIMATED COST				**$519,018.42**

Table A-9. SR 291, Division Street and Francis Avenue ACP inlay construction cost estimate.

Contract 5132 SR 2 Division Street and Francis Avenue **ACP Inlay Construction Cost**			**Construction Year: 1997** **0.20' Inlay**		
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of all items)	L.S.		L.S.	$10,200.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.20	3,316	$663.20
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200	2	$400.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$1,305.00	1	$1,305.00
	ASPHALT CONCRETE PAVEMENT				
8840	PLANING BITUMINOUS PAVEMENT	M2	$2.50	8,603	$21,507.50
8870	ASPHALT CONC. PAVEMENT CL. A	TONNE	$42.00	1,305	$54,810.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$1,644.30	1	$1,644.30
5835	COMPACTION PRICE ADJUSTMENT	DOL	$1,096.20	1	$1,096.20
	TRAFFIC				
9249	PAINT STRIPE	M	$0.35	1,880	$658.00
9251	PLASTIC STRIPE	M	$2.15	2,215	$4,762.25
9257	PLASTIC GORE STRIPE	M	$3.75	525	$1,968.75
9289	PLASTIC CROSSWALK STRIP	M2	$30.00	74	$2,220.00
9273	PLASTIC STOP BAR	M	$17.00	74	$1,258.00
6833	PLASTIC TRAFFIC ARROWS	EACH	$50.00	6	$300.00
6871	PLASTIC TRAFFIC LETTERS	EACH	$25.00	16	$400.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.35	3,316	$1,160.60
6956	SEQUENTIAL ARROWS SIGNS	HOUR	$3.00	120	$360.00
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	180	$5,040.00
6968	TRAFFIC CONTROL VEHICLES	DAY	$100.00	3	$300.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$35.00	30	$1,050.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$65.00	5	$325.00

	OTHER ITEMS				
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00
	CONTRACT SUBTOTAL				$111,928.80
	WASHINGTON STATE SALES TAX		8.10%		$9,066.23
	PROJECT SUBTOTAL				$120,995.03
	ENGINEERING		20.00%		$24,199.01
	CONTINGENCIES		5.00%		$6,049.75
	TOTAL ESTIMATED COST				**$151,243.79**

Table A-10. SR 291, Francis Avenue with Maple and Ash Streets initial PCCP construction cost estimate.

Contract 5132
SR 291
Francis Avenue with Maple and Ash Streets

Construction Year: 1997
0.75' PCCP

Initial Cost of PCCP Construction

STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Same as ACP)	L.S.		L.S.	$24,000.00
585	REMOVING TRAFFIC ISLAND	M2	$5.25	285	$1,496.25
590	REMOVING TRAFFIC CURB	M	$16.25	257	$4,176.25
	REMOVING MONUMENT CASE AND COVER	EACH	$105.00	1	$105.00
	GRADING				
2955	ROADWAY EXCAVATION INCL. HAUL	M3	$11.00	3,364	$37,004.00
	STORM SEWER				
6387	DUCTILE IRON PIPE 200 MM DIAM.	M	$80.00	5	$400.00
	CONNECT 200MM DIAM. PIPE TO EX. CB	EACH	$135.00	1	$135.00
	CATCH BASIN TYPE 2	EACH	$1,700.00	1	$1,700.00
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$17.00	1,185	$20,145.00
	CEMENT CONCRETE PAVEMENT				
	MODIFIED CONC. CLASS 28 1 DAY 225 MM SECTION	M2	$41.50	5,061	$210,031.50
	ASPHALT CONCRETE PAVEMENT				
8915	LONGITUDINAL JOINT SEAL	M	$2.45	234	$573.30
	TRAFFIC				
9216	CEMENT CONC BARRIER CURB	M	$25.15	73	$1,835.95
9229	EXTRUDED CURB	M	$15.65	203	$3,176.95
	DELINEATORS	EACH	$36.00	1	$36.00
9249	PAINT STRIPE	M	$0.25	2,170	$542.50

9251 PLASTIC STRIPE	M	$2.15	32	$68.80
9257 PLASTIC GORE STRIPE	M	$3.75	33	$123.75
9289 PLASTIC CROSSWALK STRIP	M2	$20.50	71	$1,455.50
9273 PLASTIC STOP BAR	M	$10.50	85	$892.50
6833 PLASTIC TRAFFIC ARROWS	EACH	$43.00	7	$301.00
6871 PLASTIC TRAFFIC LETTERS	EACH	$17.00	16	$272.00
9310 TEMPORARY PAVEMENT MARKING	M	$0.35	2,170	$759.50
6890 PERMANENT SIGNING	L.S.	$1,600.00	L.S.	$1,600.00
INDUCTION LOOP DETECTORS	EACH	$800.00	2	$1,600.00
TRAFFIC SIGNAL CONTROL SYSTEM.	L.S.	$12,700.00	L.S.	$12,700.00
TRAFFIC COMMUNICATION SYSTEM.	L.S.	$1,200.00	L.S.	$1,200.00
TEMP TRAFFIC SIGNAL SYSTEM MAPLE ST.	L.S.	$5,000.00	L.S.	$5,000.00
TEMP TRAFFIC SIGNAL SYSTEM ASH ST.	L.S.	$1,000.00	L.S.	$1,000.00
6956 SEQUENTIAL ARROWS SIGNS	HOUR	$2.75	600	$1,650.00
9380 TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$200.00	L.S.	$200.00
6979 TRAFFIC CONTROL LABOR	HOUR	$27.50	300	$8,250.00
6968 TRAFFIC CONTROL VEHICLES	DAY	$50.00	29	$1,450.00
6969 TRAFFIC CONTROL SUPERVISOR	HOUR	$33.00	232	$7,656.00
9398 CONSTRUCTION SIGNS CLASS A	M2	$65.00	13	$845.00
OTHER ITEMS				
QUALITY CONTROL PROGRAM	L.S.	$500.00	L.S.	$500.00
3080 ADJUST MANHOLE	EACH	$340.00	8	$2,720.00
6243 ADJUST VALVE BOX	EACH	$180.00	7	$1,260.00
C.O. #7 - PERMANENT SIGNS AT MAPLE/ASH I/S	L.S.	$2,872.26	L.S.	$2,872.26
CONTRACT SUBTOTAL				$359,734.01
WASHINGTON STATE SALES TAX		8.00%		$28,778.72
PROJECT SUBTOTAL				$388,512.73
ENGINEERING		20.00%		$77,702.55
TOTAL ESTIMATED COST				**$466,215.28**

Table A-11. SR 291, Francis Avenue with Maple and Ash Streets initial ACP construction cost estimate.

Contract 5132 SR 291 Francis Avenue with Maple and Ash Streets **Initial Cost of ACP Construction**		Construction Year: 1997 0.70' ACP			
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10%)	L.S.		L.S.	$24,000.00
0048	REMOVING CATCH BASIN	EACH	$400.00	1	$400.00
0540	REMOVING CEMENT CONCRETE SIDEWALK	M2	$8.50	171	$1,453.50
0590	REMOVING CEMENT CONCRETE CURB	M	$16.25	82	$1,332.50
0585	REMOVING TRAFFIC ISLAND	M2	$5.25	285	$1,496.25
0590	REMOVING TRAFFIC CURB	M	$16.25	257	$4,176.25
	REMOVING MONUMENT CASE AND COVER	EACH	$105.00	1	$105.00
	GRADING				
2955	ROADWAY EXCAVATION INCL. HAUL	M3	$11.00	2,313	$25,443.00
	STORM SEWER				
6387	DUCTILE IRON PIPE 200 MM DIAM.	M	$80.00	5	$400.00
	CONNECT 200MM DIAM. PIPE TO EXIST. CATCH BASIN	EACH	$135.00	1	$135.00
3090	CATCH BASIN TYPE 2	EACH	$1,700.00	1	$1,700.00
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$17.00	1,354	$23,018.00
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE		2.3	$460.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$2,633.00	1	$2,633.00
	ASPHALT CONCRETE PAVEMENT				
8870	ASPHALT CONC. PAVEMENT CL. A	TONNE	$42.00	2727	$110,586.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$3,317.58	1	$3,317.58
5835	COMPACTION PRICE ADJUSTMENT	DOL	$2,211,72	1	$2,211.72

TRAFFIC

9216	CEMENT CONC BARRIER CURB	M	$25.15	73	$1,835.95
9229	EXTRUDED CURB	M	$15.65	203	$3,176.95
	DELINEATORS	EACH	$36.00	1	$36.00
9249	PAINT STRIPE	M	$0.25	2,170	$542.50
9251	PLASTIC STRIPE	M	$2.15	32	$68.80
9257	PLASTIC GORE STRIPE	M	$3.75	33	$123.75
9289	PLASTIC CROSSWALK STRIP	M2	$20.50	71	$1,455.50
9273	PLASTIC STOP BAR	M	$10.50	85	$892.50
6833	PLASTIC TRAFFIC ARROWS	EACH	$43.00	7	$301.00
6871	PLASTIC TRAFFIC LETTERS	EACH	$17.00	16	$272.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.35	2,170	$759.50
6890	PERMANENT SIGNING	L.S.	$1,600.00	L.S.	$1,600.00
	INDUCTION LOOP DETECTORS	EACH	$800.00	2	$1,600.00
	TRAFFIC SIGNAL CONTROL SYS	L.S.	$12,700.00	L.S.	$12,700.00
	TRAFFIC COMMUNICATION SYSTEM	L.S.	$1,200.00	L.S.	$1,200.00
	TEMP TRAFFIC SIGNAL SYS MAPLE ST	L.S.	$5,000.00	L.S.	$5,000.00
	TEMP TRAFFIC SIGNAL SYS ASH ST	L.S.	$1,000.00	L.S.	$1,000.00
6956	SEQUENTIAL ARROWS SIGNS	HOUR	$2.75	600	$1,650.00
9380	TEMP TRAFFIC CONTROL DEVICES	L.S.	$200.00	L.S.	$200.00
6979	TRAFFIC CONTROL LABOR	HOUR	$27.50	300	$8,250.00
6968	TRAFFIC CONTROL VEHICLES	DAY	$50.00	29	$1,450.00
6969	TRAFFIC CONTROL SUPERVISOR	HOUR	$33.00	232	$7,656.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$65.00	13	$845.00

OTHER ITEMS

	QUALITY CONTROL PROGRAM	L.S.	$500.00	L.S.	$500.00
3080	ADJUST MANHOLE	EACH	$340.00	8	$2,720.00
6243	ADJUST VALVE BOX	EACH	$180.00	7	$1,260.00
	C.O. #7 - PERMANENT SIGNS AT MAPLE/ASH I/S	L.S.	$2,872.26	L.S.	$2,872.26
	CONTRACT SUBTOTAL				$262,835.51
	WASHINGTON STATE SALES TAX		8.10%		$21,289.68
	PROJECT SUBTOTAL				$284,125.19
	ENGINEERING (Same as PCCP)				$77,702.55
	TOTAL ESTIMATED COST				**$361,827.64**

Table A-12. SR 2, Francis Avenue with Maple and Ash Streets ACP inlay construction cost estimate.

Contract 5132			Construction Year: 1997		
SR 291			0.20' Inlay		
Francis Avenue with Maple and Ash Streets					
ACP Inlay Construction Cost					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of all items)	L.S.		L.S.	$6,200.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.20	496	$99.20
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200.00	1.2	$240.00
5334	ANTI-STRIPPING ADDITIVE	EST	$780.00	DOL	$780.00
	ASPHALT CONCRETE PAVEMENT				
8840	PLANING BITUMINOUS PAVEMENT	M2	$2.50	5,061	$12,652.50
8870	ASPHALT CONC. PAVEMENT CL. A	TONNE	$42.00	780	$32,760.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$982.80	1	$982.80
5835	COMPACTION PRICE ADJUSTMENT	DOL	$655.20	1	$655.20
	TRAFFIC				
9249	PAINT STRIPE	M	0.35	2,170	$759.50
9251	PLASTIC STRIPE	M	$6.00	32	$192.00
9257	PLASTIC GORE STRIPE	M	$3.75	33	$123.75
9289	PLASTIC CROSSWALK STRIP	M2	$30	71	$2,130.00
9273	PLASTIC STOP BAR	M	$17.00	85	$1,445.00
6833	PLASTIC TRAFFIC ARROWS	EACH	$50.00	7	$350.00
6871	PLASTIC TRAFFIC LETTERS	EACH	$25.00	16	$400.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.35	496	$173.60
6956	SEQUENTIAL ARROWS SIGNS	HOUR	$3.00	120	$360.00
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	180	$5,040.00
6968	TRAFFIC CONTROL VEHICLES	DAY	$100.00	3	$300.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$35.00	30	$1,050.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$65.00	13	$845.00
	OTHER ITEMS				
7840	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00

CONTRACT SUBTOTAL		$68,038.55
WASHINGTON STATE SALES TAX	8.10%	$5,511.12
PROJECT SUBTOTAL		$73,549.67
ENGINEERING	20.00%	$14,709.93
CONTINGENCIES	5.00%	$3,677.48
TOTAL ESTIMATED COST		$91,937.08

Table A-13. SR 27, Pines Road and Broadway Avenue initial PCCP construction cost estimate.

Contract 5298 SR 27 Pines Road and Broadway Avenue			Construction Year: 1998 0.83' PCCP		
Initial Cost of PCCP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (same as ACP)	L.S.		L.S.	$25,000.00
0590	REMOVING TRAFFIC CURB	M	$4.50	253	$1,138.50
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.15	1,237.0	$185.55
	REMOVE MONUMENT CASE AND COVER	EACH	$60.00	1.0	$60.00
	GRADING				
2945	ROADWAY EXCAVATION INCL. HAUL	M3	$15.00	1,825	$27,375.00
	SURFACING				
8677	CRUSHED SURFACING TOP COURSE	TONNE	$18.00	1,343	$24,174.00
	CEMENT CONCRETE PAVEMENT				
	MODIFIED CONC. CLASS 28 1 DAY	M2	$45.00	4,808	$216,360.00
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	T	$200.00	0.1	$20.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$53.00	1	$53.00
	ASPHALT CONCRETE PAVEMENT				
8840	PLANING BITUMIOUS PAVEMENT	M2	$1.10	397	$436.70
	MODIFIED ASPHALT CONC. PAVEMENT CL. A	TONNE	$30.80	53	$1,632.40
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$49.00	1	$49.00
5835	COMPACTION PRICE ADJUSTMENT	DOL	$33.00	1	$33.00

TRAFFIC

9310	TEMPORARY PAVEMENT MARKING	M	$0.16	3,000	$480.00
9249	PAINT STRIPE	M	$0.18	3,000	$540.00
9355	PAINTED GORE STRIPE	M	$0.45	168	$75.60
9289	PLASTIC CROSSWALK STRIPE	M2	$28.50	44	$1,254.00
9273	PLASTIC STOP BAR	M	$15.80	24	$379.20
	PLASTIC TRAFFIC ARROW	EACH	$60.00	4	$240.00
6890	PERMANENT SIGNING	L.S.	$2,000.00	L.S.	$2,000.00
6956	SEQUENTIAL ARROW SIGN	HOUR	$5.00	369	$1,845.00
9380	TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$100.00	L.S.	$100.00
6968	TRAFFIC CONTROL VEHICLE	DAY	$50.00	30	$1,500.00
6979	TRAFFIC CONTROL LABOR	HOUR	$29.00	300	$8,700.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$32.00	240	$7,680.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$50.00	10	$500.00
	PREFORMED INDUCTION LOOPS-ROUND AND TYPE 1	L.S.	$21,000.00	L.S.	$21,000.00

OTHER ITEMS

6243	ADJUST VALVE BOX	EACH	$180.00	14	$2,520.00
3080	ADJUST MANHOLE	EACH	$360.00	2	$720.00
3100	ADJUST CATCH BASIN	EACH	$360.00	2	$720.00
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00
7490	TRIMMING AND CLEANUP	L.S.	$500.00	L.S.	$500.00
	C.O.#4 -EXTRUDED CURB	M	$15.00	222	$3,330.00

CONTRACT SUBTOTAL		$351,100.95
WASHINGTON STATE SALES TAX	8.10%	$28,439.18
PROJECT SUBTOTAL		$379,540.13
ENGINEERING	20.00%	$75,908.03
PROJECT ESTIMATED COST		$455,448.16

Table A-14. SR 27, Pines Road and Broadway Avenue initial ACP construction cost estimate.

Contract 5298 SR 27 Pines Road and Broadway Avenue			Construction Year: 1998 0.70' ACP		
Initial Cost of ACP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of Subtotal)	L.S.		L.S.	25,000.00
0590	REMOVING TRAFFIC CURB	M	4.50	253.0	$1,138.50
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.15	1,237	$185.55
	REMOVE MONUMENT CASE AND COVER	EACH	$60.00	1.0	$60.00
	GRADING				
2945	ROADWAY EXCAVATION INCL. HAUL	M3	$15.00	1,825	$27,375.00
	SURFACING				
8677	CRUSHED SURFACING TOP COURSE	TONNE	$18.00	1,761	$31,698.00
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200.00	2.2	$440.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$2,502.00	1	$2,502.00
	ASPHALT CONCRETE PAVEMENT				
8870	ASPHALT CONC PAVEMENT CL. A	TONNE	$42.00	2,502	$105,084.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$3,152.52	1	$3,152.52
5835	COMPACTION PRICE ADJUSTMENT	DOL	$2,101.68	1	$2,101.68
	TRAFFIC				
9310	TEMPORARY PAVEMENT MARKING	M	$0.16	3,000	$480.00
9249	PAINT STRIPE	M	$0.18	3000	$540.00
9355	PAINTED GORE STRIPE	M	$0.45	168	$75.60
9289	PLASTIC CROSSWALK STRIPE	M2	$28.50	44	$1,254.00
9273	PLASTIC STOP BAR	M	$15.80	24	$379.20
	PLASTIC TRAFFIC ARROW	EACH	$60.00	4	$240.00
6890	PERMANENT SIGNING	L.S.	$2,000.00	L.S.	$2,000.00
6956	SEQUENTIAL ARROW SIGN	HOUR	$5.00	369	$1,845.00
9380	TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$100.00	L.S.	$100.00

6968	TRAFFIC CONTROL VEHICLE	DAY	$50.00	30	$1,500.00
6979	TRAFFIC CONTROL LABOR	HOUR	$29.00	300	$8,700.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$32.00	240	$7,680.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$50.00	10	$500.00
	PREFORMED INDUCTION LOOPS ROUND AND TYPE 1	L.S.	$21,000.00	L.S.	$21,000.00
	OTHER ITEMS				
6243	ADJUST VALVE BOX	EACH	$180.00	14	$2,520.00
3080	ADJUST MANHOLE	EACH	$360.00	2	$720.00
3100	ADJUST CATCH BASIN	EACH	$360.00	2	$720.00
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00
7490	TRIMMING AND CLEANUP	L.S.	$500.00	L.S.	$500.00
	EXTRUDED CURB	M	$15.00	222	$3,330.00
	CONTRACT SUBTOTAL				$253,321.05
	WASHINGTON STATE SALES TAX		8.10%		$20,519.01
	PROJECT SUBTOTAL				$273,840.06
	ENGINEERING (Same as PCCP)				$75,908.03
	TOTAL ESTIMATED COST				$349,748.09

Table A-15. SR 27, Pines Road and Broadway Avenue ACP inlay construction cost estimate.

Contract 5298
SR 27
Pines Road and Broadway Avenue

Construction Year: 1998
0.20' Inlay

ACP Inlay Construction Cost

STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of all items)	L.S.		L.S.	$6,000.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.20	1,770	$354.00
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200.00	1.1	$220.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$803.00	1	$803.00
	ASPHALT CONCRETE PAVEMENT				
8840	PLANING BITUMIOUS PAVEMENT	M2	$2.50	4,808	$12,020.00
8870	ASPHALT CONC PAVEMENT CL A	TONNE	$42.00	803	$33,726.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$1,011.78	1	$1,011.78
5835	COMPACTION PRICE ADJUSTMENT	DOL	$674.52	1	$674.52
	TRAFFIC				
9249	PAINT STRIPE	M	$0.35	3,000	$1,050.00
9355	PAINTED GORE STRIPE	M	$0.45	168	$75.60
9289	PLASTIC CROSSWALK STRIPE	M2	$30.00	44	$1,320.00
9273	PLASTIC STOP BAR	M	$17.00	24	$408.00
6833	PLASTIC TRAFFIC ARROW	EACH	$50.00	4	$200.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.35	1,770	$619.50
6956	SEQUENTIAL ARROW SIGN	HOUR	$3.00	120	$360.00
6968	TRAFFIC CONTROL VEHICLE	DAY	$100.00	3	$300.00
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	180	$5,040.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$35.00	30	$1,050.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$65.00	10	$650.00

	OTHER ITEMS				
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00
	CONTRACT SUBTOTAL				$66,382.40
	WASHINGTON STATE SALES TAX		8.10%		$5,376.97
	PROJECT SUBTOTAL				$71,759.37
	ENGINEERING		20.00%		$14,351.87
	CONTINGENCIES		5.00%		$3,587.97
	TOTAL ESTIMATED COST				$89,699.21

Table A-16. SR 2, Division Street and Third Avenue initial PCCP construction cost estimate.

Contract 5400			Construction Year: 1998		
SR 2			0.83' PCCP		
Division Street and Third Avenue					
Initial Cost of PCCP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Same as ACP)	L.S.		L.S.	$11,000.00
0049	REMOVING DRAINAGE STRUCTURE	EACH	$350.00	1	$350.00
0535	REMOVING CEMENT CONCRETE PAVEMENT	M2	$17.00	1,423	$24,191.00
0565	REMOVING ASPHALT CONCRETE PAVEMENT	M2	$6.00	1,638	$9,828.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.15	220	$33.00
	REMOVING MONUMENT CASE AND COVER	EACH	$150.00	1	$150.00
	GRADING				
2945	ROADWAY EXCAVATION INCL. HAUL	M3	$18.50	397	$7,344.50
	STORM SEWER				
3091	CATCH BASIN TYPE 1	EACH	$1,500.00	1	$1,500.00
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$16.00	718	$11,488.00
	CEMENT CONCRETE PAVEMENT				
	MODIFIED CONC. CLASS 28 1 DAY 250 MM SECTION	M2	$50.00	1,638	$81,900.00

ASPHALT CONCRETE PAVEMENT				
8915 LONGITUDINAL JOINT SEAL	M	$23.00	47	$1,081.00
TRAFFIC				
9216 CEMENT CONC. BARRIER CURB	M	$31.00	35	$1,085.00
9249 PAINT STRIPE	M	$0.30	621	$186.30
9289 PLASTIC CROSSWALK STRIPE	M2	$18.50	14	$259.00
9310 TEMPORARY PAVEMENT MARKING	M	$0.15	220	$33.00
6956 SEQUENTIAL ARROW SIGN	HOUR	$3.00	168	$504.00
6964 TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$500.00	L.S.	$500.00
6979 TRAFFIC CONTROL LABOR	HOUR	$29.00	200	$5,800.00
6968 TRAFFIC CONTROL VEHICLE	DAY	$30.00	5	$150.00
6972 TRAFFIC CONTROL SUPERVISOR	HOUR	$30.00	40	$1,200.00
9398 CONSTRUCTION SIGNS CLASS A	M2	$80.00	14	$1,120.00
OTHER ITEMS				
9216 STRUCTURE EXCAVATION. CLASS B INCL. HAUL	M3	$100.00	4	$400.00
9475 CEMENT CONC. SIDEWALK	M2	$33.00	5	$165.00
3080 ADJUST MANHOLE	EACH	$400.00	1	$400.00
7480 ROADSIDE CLEANUP	DOL	$100.00	1	$100.00

CONTRACT SUBTOTAL		$160,767.80
WASHINGTON STATE SALES TAX	8.10%	$13,022.19
PROJECT SUBTOTAL		$173,789.99
ENGINEERING	20.00%	$34,758.00
TOTAL ESTIMATED COST		**$208,547.99**

Table A-17. SR 2, Division Street and Third Avenue initial ACP construction cost estimate.

Contract 5400			Construction Year: 1998		
SR 2			0.70' ACP		
Division Street and Third Avenue					
Initial Cost of ACP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of Subtotal)	L.S.		L.S.	$11,000.00
0049	REMOVING DRAINAGE STRUCTURE	EACH	$350.00	1	$350.00
0535	REMOVING CEMENT CONCRETE PAVEMENT	M2	$17.00	1423	$24,191.00
0565	REMOVING ASPHALT CONCRETE PAVEMENT	M2	$6.00	1638	$9,828.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.15	220	$33.00
	REMOVING MONUMENT CASE AND COVER	EACH	$150.00	1	$150.00
	GRADING				
2945	ROADWAY EXCAVATION INCL. HAUL	M3	$18.50	397	$7,344.50
	STORM SEWER				
3091	CATCH BASIN TYPE 1	EACH	$1,500.00	1	$1,500.00
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$16.00	844	$13,504.00
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200.00	1	$200.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$891.00	1	$891.00
	ASPHALT CONCRETE PAVEMENT				

8870 ASPHALT CONC. PAVEMENT CL. A	TONNE	$42.00	891	$37,422.00
5830 JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$1,122.66	1	$1,122.66
5835 COMPACTION PRICE ADJUSTMENT	DOL	$748.44	1	$748.44
TRAFFIC				
9216 CEMENT CONC. BARRIER CURB	M	$31.00	35	$1,085.00
9249 PAINT STRIPE	M	$0.30	621	$186.30
9289 PLASTIC CROSSWALK STRIPE	M2	$18.50	14	$259.00
9310 TEMPORARY PAVEMENT MARKING	M	$0.15	220	$33.00
6956 SEQUENTIAL ARROW SIGN	HOUR	$3.00	168	$504.00
6964 TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$500.00	L.S.	$500.00
6979 TRAFFIC CONTROL LABOR	HOUR	$29.00	200	$5,800.00
6968 TRAFFIC CONTROL VEHICLE	DAY	$30.00	5	$150.00
6972 TRAFFIC CONTROL SUPERVISOR	HOUR	$30.00	40	$1,200.00
9398 CONSTRUCTION SIGNS CLASS A	M2	$80.00	14	$1,120.00
OTHER ITEMS				
9216 STRUCTURE EXCAVATION CLASS B INCL. HAUL	M3	$100.00	4	$400.00
9475 CEMENT CONC. SIDEWALK	M2	$33.00	5	$165.00
3080 ADJUST MANHOLE	EACH	$400.00	1	$400.00
7480 ROADSIDE CLEANUP	DOL	$100.00	1	$100.00
CONTRACT SUBTOTAL				$120,186.90
WASHINGTON STATE SALES TAX		8.10%		$9,735.14
PROJECT SUBTOTAL				$129,922.04
ENGINEERING (SAME AS PCCP)				$34,767.91
TOTAL ESTIMATED COST				**$164,680.04**

Table A-18. SR 2, Division Street and Third Avenue ACP inlay construction cost estimate.

Contract 5400			Construction Year: 1998		
SR 2			0.20' Inlay		
Division Street and Third Avenue					
ACP INLAY CONSTRUCTION COST					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10 % of all items)	L.S.	10.00%	L.S.	$1,900.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.20	220	$44.00
	LIQUID ASPHALT				
8770	ASHALT FOR TACK COAT	TONNE	$200.00	0.50	$100.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$250.00	DOL	$250.00
	ASPHALT CONCRETE PAVEMENT				
8840	PLANING BITUMINOUS PAVEMENT	M2	$2.50	1,638	$4,095.00
8822	ASPHALT CONC. PAVEMENT CL. A	TONNE	$42.00	253	$10,626.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$300.00	1	$300.00
5835	COMPACTION PRICE ADJUSTMENT	DOL	$200.00	1	$200.00
	TRAFFIC				
9249	PAINT STRIPE	M	$0.35	621	$217.35
9289	PLASTIC CROSSWALK STRIPE	M2	$30.00	13.5	$405.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.35	220	$77.00
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	40	$1,120.00
6968	TRAFFIC CONTROL VEHICLE	DAY	$100.00	1	$100.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$35.00	10	$350.00
9398	CONSTRUCTION SIGNS CLASS A	M2	$65.00	3.87	$251.55

OTHER ITEMS

7480	ROADSIDE CLEANUP	DOL	$500.00	DOL.	$500.00
	CONTRACT SUBTOTAL				$20,535.90
	WASHINGTON STATE SALES TAX		8.00%		$1,642.87
	PROJECT SUBTOTAL				$22,178.77
	ENGINEERING		20.00%		$4,435.75
	CONTINGENCIES		5.00%		$1,108.94
	TOTAL ESTIMATED COST				**$27,723.48**

Table A-19. SR 395, SR 395 and 19th Avenue initial PCCP construction cost estimate.

Contract 5445 SR 395 SR 395 and 19th Avenue			Construction Year: 1998 1.0' PCCP		
Initial Cost of PCCP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Actual)	L.S.	$36,130.00	L.S.	$36,130.00
0050	REMOVING STRUCTURE AND OBSTRUCTION	L.S.	$180.00	L.S.	$180.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.30	2,910	$873.00
0902	REMOVING PAINT STRIPE	M	$1.30	372	$483.60
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$16.30	0	$0.00
	CEMENT CONCRETE PAVEMENT				
	MODIFIED CONC. PAVEMENT CL. 28 1 DAY 300 MM SECTION	M2	$50.50	5,322	$268,761.00
	LIQUID ASPHALT				
5325	ASPHALT FOR TACK COAT	TONNE	$200.00	0.1	$20.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$85.00	DOL.	$85.00
	ASPHALT CONCRETE PAVEMENT				
	PLANING BIT. PAVEMENT 300 MM DEPTH	M2	$3.55	5,322	$18,893.10
	SPECIAL ASPHALT CONC. PAVEMENT	TONNE	$40.50	85	$3,442,50
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$103.28	1	$103.28
5835	COMPACTION PRICE ADJUSTMENT	DOL	$68.85	1	$68.85
	TRAFFIC				
6832	FLEXIBLE GUIDE POST	EACH	$25.00	15	$375.00
9249	PAINT STRIPE	M	$0.29	4,430	$1,284.70
9257	PLASTIC GORE STRIPE	M	$4.76	227	$1,080.52
9289	PLASTIC CROSSWALK STRIPE	M2	$45.75	78	$3,568.50
9273	PLASTIC STOP BAR	M	$20.87	60	$1,252.20
6833	PLASTIC TRAFFIC ARROW	EACH	$55.00	6	$330.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.25	1,960	$490.00

6890	PERMANENT SIGNING	L.S.	$2,320.31	L.S.	$2,320.31
6911	TRAFFIC SIGNAL DISPLAY AND DETECTION SYSTEM	L.S.	$28,534.96	L.S.	$28,534.96
6954	TRAFFIC SAFETY DRUM	EACH	$30.00	123	$3,690.00
6956	SEQUENTIAL ARROW SIGN	HOUR	$3.50	361	$1,263.50
6994	PORTABLE CHANGEABLE MESSAGE SIGN	EACH	$7,000.00	2	$14,000.00
6995	OPERATION OF PORTABLE CHANGEABLE MESSAGE SIGN	HOUR	$5.00	177	$885.00
6958	TYPE III BARRICADE	EACH	$75.00	4	$300.00
9380	TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$170.00	L.S.	$170.00
6979	TRAFFIC CONTROL LABOR	HOUR	$29.00	495	$14,355.00
6968	TRAFFIC CONTROL VEHICLE	DAY	$40.00	20	$800.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$30.00	160	$4,800.00
	RESETTING IMPACT ATTENUATOR	EACH	$1,200.00	3	$3,600.00
	OTHER ITEMS				
9433	CONTROLLED DENSITY FILL	M3	$69.08	128	$8,842.24
7480	ROADSIDE CLEANUP	EST.	$500.00	500	$500.00
7491	TRIMMING AND CLEANUP	L.S.	$875.00	L.S.	$875.00
	REMOVING AND RESETTING MONUMENT CASE AND COVER	EACH	$450.00	1	$450.00
	CONTRACT SUBTOTAL				$422,807.26
	WASHINGTON STATE SALES TAX		7.70%		$32,556.16
	PROJECT SUBTOTAL				$455,363.42
	ENGINEERING		20.00%		$91,072.68
	TOTAL ESTIMATED COST				**$546,436.10**

Table A-20. SR 395, SR 395 and 19th Avenue initial ACP construction cost estimate.

Contract 5445 SR 395 SR 395 and 19th Avenue			Construction Year: 1998 0.80' ACP		
Initial Cost of ACP Construction					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (Same as PCCP)	L.S.		L.S.	$36,130.00
0050	REMOVING STRUCTURE AND OBSTRUCTION	L.S.	$180.00	L.S.	$180.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.30	2,910	$873.00
0902	REMOVING PAINT STRIPE	M	$1.30	372	$483.60
	SURFACING				
8673	CRUSHED SURFACING BASE COURSE	TONNE	$16.30	712	$11,605.60
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200.00	2.4	$480.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$3,282.00	1	$3,844.00
	ASPHALT CONCRETE PAVEMENT				
	PLANING BIT. PAVEMENT 300 MM DEPTH	M2	$3.55	6,613	$23,476.15
8870	ASPHALT CONC. PAVEMENT CL. A	TONNE	$40.50	3,844	$155,682.00
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$4,670.46	DOL.	$4,670.46
5835	COMPACTION PRICE ADJUSTMENT	DOL	$3,113.64	DOL.	$3,113.64
	TRAFFIC				
6832	FLEXIBLE GUIDE POST	EACH	$25.00	15	375.00
9249	PAINT STRIPE	M	$0.29	4,430	$1,284.70
9257	PLASTIC GORE STRIPE	M	$4.76	227	$1,080.52
9289	PLASTIC CROSSWALK STRIPE	M2	$45.75	78	$3,568.50
9273	PLASTIC STOP BAR	M	$20.87	60	$1,252.20
6833	PLASTIC TRAFFIC ARROW	EACH	$55.00	6	$330.00
9310	TEMPORARY PAVEMENT MARKING	M	$0.25	1,960	$490.00
6890	PERMANENT SIGNING	L.S.	$2,320.31	L.S.	$2,320.31
6911	TRAFFIC SIGNAL DISPLAY AND DETECTION SYSTEM	L.S.	$28,534.96	L.S.	$28,534.96

6954	TRAFFIC SAFETY DRUM	EACH	$30.00	123	$3,690.00
6956	SEQUENTIAL ARROW SIGN	HOUR	$3.50	361	$1,263.50
6994	PORTABLE CHANGEABLE MESSAGE SIGN	EACH	$7,000.00	2	$14,000.00
6995	OPERATION OF PORTABLE CHANGEABLE MESSAGE SIGN	HOUR	$5.00	177	$885.00
6958	TYPE III BARRICADE	EACH	$75.00	4	$300.00
9380	TEMPORARY TRAFFIC CONTROL DEVICES	L.S.	$170.00	L.S.	$170.00
6979	TRAFFIC CONTROL LABOR	HOUR	$29.00	495	$14,355.00
6968	TRAFFIC CONTROL VEHICLE	DAY	$40.00	20	$800.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$30.00	160	$4,800.00
	RESETTING IMPACT ATTENUATOR	EACH	$1200.00	3	$3,600.00
	OTHER ITEMS				
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00
7491	TRIMMING AND CLEANUP	L.S.	$875.00	L.S.	$875.00
	REMOVING AND RESETTING MONUMENT CASE AND COVER	EACH	$450.00	1	$450.00
	CONTRACT SUBTOTAL				$325,463.14
	WASHINGTON STATE SALES TAX		7.70%		$25,060.66
	PROJECT SUBTOTAL				$350,523.80
	ENGINEERING (SAME AS PCCP)				$91,072.68
	TOTAL ESTIMATED COST				**$441,596.48**

Table A-21. SR 395, SR 395 and 19th Avenue ACP inlay construction cost estimate.

Contract 5445 SR 395 SR 395 and 19th Avenue			Construction Year: 1998 0.20' Inlay		
ACP Inlay Construction Cost					
STD. ITEM NO.	ITEM	UNITS	UNIT PRICE	QUANTITY	AMOUNT
	PREPARATION				
0001	MOBILIZATION (10% of all items)	L.S.		L.S.	$6,200.00
0900	REMOVING TEMPORARY PAVEMENT MARKING	M	$0.20	2,126	$425.20
	LIQUID ASPHALT				
8722	ASPHALT FOR TACK COAT	TONNE	$200.00	1.2	$240.00
5334	ANTI-STRIPPING ADDITIVE	DOL	$791.00	1	$791.00
	ASPHALT CONCRETE PAVEMENT				
8840	PLANING BITUMINOUS PAVEMENT	M2	$2.50	5,322	$13,305.00
8870	ASPHALT CONC. PAVEMENT CL. A	TONNE	$40.50	791	$32,035.50
5830	JOB MIX COMPLIANCE PRICE ADJUSTMENT	DOL	$961	1	$961.00
5835	COMPACTION PRICE ADJUSTMENT	DOL	$641	1	$641.00
	TRAFFIC				
9249	PAINT STRIPE	M	$0.35	4,430	$1,550.50
9257	PLASTIC GORE STRIPE	M	$3.75	227	$851.25
9289	PLASTIC CROSSWALK STRIPE	M2	$30.00	78	$2,340.00
9273	PLASTIC STOP BAR	M	$17.00	60	$1,020.00
6833	PLASTIC TRAFFIC ARROW	EACH	$50.00	6	$300.00
9310	TEMPORARY PAVEMENT MARKINGS	M	$0.35	2,126	$744.10
6979	TRAFFIC CONTROL LABOR	HOUR	$28.00	180	$5,040.00
6968	TRAFFIC CONTROL VEHICLE	DAY	$100.00	3	$300.00
6972	TRAFFIC CONTROL SUPERVISOR	HOUR	$35.00	30	$1,050.00

	OTHER ITEMS				
7480	ROADSIDE CLEANUP	DOL	$500.00	1	$500.00
	CONTRACT SUBTOTAL				$68,294.55
	WASHINGTON STATE SALES TAX		7.70%		$5,258.68
	PROJECT SUBTOTAL				$73,553.23
	ENGINEERING		20.00%		$14,710.65
	CONTINGENCIES		5.00%		$3,677.66
	TOTAL ESTIMATED COST				**$91,941.54**

APPENDIX B – LIFE CYCLE COST ANALYSIS

Tables B-1 to B-28 show summaries of the Life Cycle Cost Analysis for the following comparisons:

Tables	**Comparison**
B-1 to B-7	PCCP reconstruction vs. ACP reconstruction with inlays at four year cycles – life cycle cost analysis.
B-8 to B-14	PCCP reconstruction vs. ACP reconstruction with inlays at six year cycles – life cycle cost analysis.
B-15 to B-21	PCCP reconstruction vs. ACP reconstruction with inlays at six year cycles – life cycle cost analysis.
B-22 to B-28	PCCP reconstruction vs. ACP inlays with four year inlay cycles – life cycle cost analysis.
B-29 to B-35	PCCP reconstruction vs. ACP inlays with six year inlay cycles – life cycle cost analysis.
B-36 to B-42	PCCP reconstruction vs. ACP inlays with eight year inlay cycles – life cycle cost analysis.

Table B-1. SR 27, Pines Road and Sprague Avenue PCCP reconstruction versus ACP reconstruction with inlays at four-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Sprague Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	403,890	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	1,059,630
PW (no user cost)	403,890	62,281	53,238	45,508	38,901	33,252	28,424	24,297	20,769	17,754	728,315
Construction Total	403,890	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	1,059,630
User Costs	121,941	8,308	8,991	9,732	10,531	11,405	12,337	13,368	14,468	15,649	226,730
PW (with user costs)	525,831	69,383	59,808	51,587	44,523	38,457	33,237	28,755	24,894	21,567	898,041

40 Year Annualized Costs: Excluding User Costs: 36,800
Including User Costs: 45,400

PCCP											
Year	**Year 0**										**Total**
Construction Total	531,270										531,270
PW (no user cost)	531,270										531,270
Construction Total	531,270										531,270
User Costs	121,941										121,941
PW (with user costs)	653,211										653,211

40 Year Annualized Costs: Excluding User Costs: 26,800
Including User Costs: 33,000

Table B-2. SR 27, Pines Road and Broadway Avenue PCCP reconstruction versus ACP reconstruction with inlays at four-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Broadway Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	349,750	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	1,157,050
PW (no user cost)	349,750	76,676	65,543	56,026	47,892	40,938	34,994	29,913	25,570	21,857	749,158
Construction Total	349,750	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	1,157,050
User Costs	222,241	6,513	7,051	7,654	8,273	8,957	9,698	10,485	11,359	12,291	304,522
PW (with user costs)	571,991	82,243	70,695	60,807	52,309	45,026	38,777	33,409	28,808	24,852	1,008,917

40 Year Annualized Costs:

Excluding User Costs: 37,900
Including User Costs: 51,000

PCCP											
Year	**Year 0**										**Total**
Construction Total	455,450										455,450
PW (no user cost)	455,450										455,450
Construction Total	455,450										455,450
User Costs	222,241										222,241
PW (with user costs)	677,691										677,691

40 Year Annualized Costs:

Excluding User Costs: 23,000
Including User Costs: 34,200

Table B-3. SR 2, Division Street and Francis Avenue PCCP reconstruction versus ACP reconstruction with inlays at four-year cycles - life cycle cost analysis.

SR 2 - Division Street and Francis Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	519,020	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	1,880,180
PW (no user cost)	519,020	129,281	110,510	94,464	80,748	69,024	59,002	50,435	43,112	36,852	1,192,448
Construction Total	519,020	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	1,880,180
User Costs	752,156	11,349	12,283	13,304	14,388	15,582	16,868	18,257	19,769	21,388	895,344
PW (w/ user costs)	1,271,176	138,982	119,485	102,774	88,430	76,135	65,583	56,523	48,747	42,064	2,009,889

40 Year Annualized Costs: Excluding User Costs: 60,200
Including User Costs: 101,500

PCCP											
Year	**Year 0**										**Total**
Construction Total	675,110										675,110
PW (no user cost)	675,110										675,110
Construction Total	675,110										675,110
User Costs	752,156										752,156
PW (w/ user costs)	1,427,266										1,427,266

40 Year Annualized Costs: Excluding User Costs: 34,100
Including User Costs: 72,100

Table B-4. SR 291, Francis Avenue with Maple and Ash Streets PCCP reconstruction versus ACP reconstruction with inlays at four-year cycles - life cycle cost analysis.

SR 291 - Francis Avenue with Maple and Ash Streets

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	361,830	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	1,189,290
PW (no user cost)	361,830	78,591	67,180	57,425	49,088	41,960	35,868	30,660	26,208	22,403	771,212
Construction Total	361,830	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	1,189,290
User Costs	185,354	8,602	9,317	10,090	10,914	11,813	12,782	13,849	14,979	16,230	293,930
PW (w/ user costs)	547,184	85,944	73,987	63,728	54,915	47,352	40,854	35,278	30,478	26,358	1,006,077

40 Year Annualized Costs: Excluding User Costs: 39,000
Including User Costs: 50,800

PCCP											
Year	**Year 0**										**Total**
Construction Total	466,220										466,220
PW (no user cost)	466,220										466,220
Construction Total	466,220										466,220
User Costs	185,354										185,354
PW (w/ user costs)	651,574										651,574

40 Year Annualized Costs: Excluding User Costs: 23,600
Including User Costs: 32,900

Table B-5. SR 395, SR 395 and 19th Avenue PCCP reconstruction versus ACP reconstruction with inlays at four-year cycles - life cycle cost analysis.

SR 395 - SR 395 and 19th Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	441,600	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	1,269,060
PW (no user cost)	441,600	78,591	67,180	57,425	49,088	41,960	35,868	30,660	26,208	22,403	850,982
Construction Total	441,600	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	1,269,060
User Costs	49,454	4,108	4,439	4,812	5,208	5,646	6,106	6,613	7,161	7,743	101,290
PW (w/ user costs)	491,054	82,102	70,423	60,431	51,868	44,537	38,250	32,865	28,250	24,290	924,070

40 Year Annualized Costs: Excluding User Costs: 43,000
Including User Costs: 46,700

PCCP											
Year	**Year 0**										**Total**
Construction Total	546,440										546,440
PW (no user cost)	546,440										546,440
Construction Total	546,440										546,440
User Costs	49,454										49,454
PW (w/ user costs)	595,894										595,894

40 Year Annualized Costs: Excluding User Costs: 27,600
Including User Costs: 30,100

Table B-6. SR 90, Broadway Avenue and Thierman Street PCCP reconstruction versus ACP reconstruction with inlays at four-year cycles - life cycle cost analysis.

SR 90 - Broadway Avenue and Thierman Street

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	728,600	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	1,592,060
PW (no user cost)	728,600	82,010	70,102	59,924	51,223	43,786	37,428	31,994	27,348	23,378	1,155,793
Construction Total	728,600	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	1,592,060
User Costs	95,856	3,538	3,831	4,135	4,480	4,856	5,266	5,687	6,162	6,659	140,470
PW (w/ user costs)	824,856	85,034	72,902	62,507	53,615	46,002	39,483	33,890	29,105	25,000	1,271,994

40 Year Annualized Costs:

Excluding User Costs: 58,400
Including User Costs: 64,300

PCCP											
Year	**Year 0**										**Total**
Construction Total	982,180										982,180
PW (no user cost)	982,180										982,180
Construction Total	982,180										982,180
User Costs	95,856										95,856
PW (w/ user costs)	1,078,036										1,078,036

40 Year Annualized Costs:

Excluding User Costs: 49,600
Including User Costs: 54,500

Table B-7. SR 2, Division Street and Third Avenue PCCP reconstruction versus ACP reconstruction with inlays at four-year cycles - life cycle cost analysis.

SR 2 - Division Street and Third Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	164,680	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	414,170
PW (no user costs)	164,680	23,695	20,255	17,314	14,800	12,651	10,814	9,244	7,902	6,754	288,109
Construction Total	164,680	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	414,160
User Costs	63,942	980	1,079	1,160	1,252	1,355	1,477	1,592	1,719	1,857	76,413
PW (w/ user costs)	228,123	24,533	21,043	18,038	15,468	13,269	11,390	9,775	8,392	7,207	357,738

40 Year Annualized Costs: Excluding User Costs: 14,600
Including User Costs: 18,100

PCCP											
Year	**Year 0**										**Total**
Construction Total	208,540										208,540
PW (no user cost)	208,540										208,540
Construction Total	208,540										208,540
User Costs	63,942										63,942
PW (w/ user costs)	272,482										272,482

40 Year Annualized Costs: Excluding User Costs: 10,500
Including User Costs: 13,800

Table B-8. SR 27, Pines Road and Sprague Avenue PCCP reconstruction versus ACP reconstruction with inlays at six-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Sprague Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Year 40**	**Total**
Construction Total	403,890	72,860	72,860	72,860	72,860	72,860	72,860	-24,287	816,763
PW (no user costs)	403,890	57,582	45,508	35,966	28,424	22,464	17,754	-5,059	606,530
Construction Total	403,890	72,860	72,860	72,860	72,860	72,860	72,860	-24,287	816,763
User Costs	121,941	8,644	9,732	10,966	12,337	13,907	15,649		193,176
PW (w/ user costs)	525,831	64,414	51,587	41,379	33,237	26,752	21,567	-5,059	759,708

40 Year Annualized Costs: Excluding User Costs: 30,600
Including User Costs: 38,400

PCCP									
Year	**Year 0**								**Total**
Construction Total	531,270								531,270
PW (no user costs)	531,270								531,270
Construction Total	531,270								531,270
User Costs	121,941								121,941
PW (w/ user costs)	653,211								653,211

40 Year Annualized Costs: Excluding User Costs: 26,800
Including User Costs: 33,000

Table B-9. SR 27, Pines Road and Broadway Avenue PCCP reconstruction versus ACP reconstruction with inlays at six-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Broadway Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Year 40**	**Total**
Construction Total	349,750	89,700	89,700	89,700	89,700	89,700	89,700	-29,900	858,050
PW (no user costs)	349,750	70,891	56,026	44,278	34,994	27,656	21,857	-6,228	599,225
Construction Total	349,750	89,700	89,700	89,700	89,700	89,700	89,700	-29,900	858,050
User Costs	222,241	6,791	7,654	8,609	9,698	10,913	12,291		278,197
PW (w/ user costs)	571,991	76,258	60,807	48,528	38,777	31,021	24,852	-6,228	846,007

40 Year Annualized Costs: Excluding User Costs: 30,300
Including User Costs: 42,700

PCCP									
Year	**Year 0**								**Total**
Construction Total	455,450								455,450
PW (no user costs)	455,450								455,450
Construction Total	455,450								455,450
User Costs	222,241								222,241
PW (w/ user costs)	677,691								677,691

40 Year Annualized Costs: Excluding User Costs: 23,000
Including User Costs: 34,200

Table B-10. SR 2, Division Street and Francis Avenue PCCP reconstruction versus ACP reconstruction with inlays at six-year cycles - life cycle cost analysis.

SR 2 - Division Street and Francis Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Year 40**	**Total**
Construction Total	519,020	151,240	151,240	151,240	151,240	151,240	151,240	-50,413	1,376,047
PW (no user costs)	519,020	119,527	94,464	74,656	59,002	46,630	36,852	-10,501	939,652
Construction Total	519,020	151,240	151,240	151,240	151,240	151,240	151,240	-50,413	1,376,047
User Costs	752,156	11,804	13,304	14,988	16,868	18,996	21,388		849,504
PW (w/ user costs)	1,271,716	128,856	102,774	82,055	65,583	52,487	42,064	-10,501	1,734,494

40 Year Annualized Costs: Excluding User Costs: 47,500
Including User Costs: 87,600

PCCP									
Year	**Year 0**								**Total**
Construction Total	675,110								675,110
PW (no user costs)	675,110								675,110
Construction Total	675,110								675,110
User Costs	752,156								752,156
PW (w/ user costs)	1,427,266								1,427,266

40 Year Annualized Costs: Excluding User Costs: 34,100
Including User Costs: 72,100

Table B-11. SR 291, Francis Avenue/Maple and Ash Streets PCCP reconstruction versus ACP reconstruction with inlays at six-year cycles - life cycle cost analysis.

SR 291 - Francis Avenue with Maple and Ash Streets

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Year 40**	**Total**
Construction Total	361,830	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	882,823
PW (no user costs)	361,830	72,662	57,425	45,384	35,868	28,347	22,403	-6,383	617,535
Construction Total	361,830	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	882,823
User Costs	185,354	8,954	10,090	11,346	12,782	14,408	16,230		259,164
PW (w/ user costs)	547,184	79,738	63,728	50,985	40,854	32,789	26,358	-6,383	835,252

40 Year Annualized Costs: Excluding User Costs: 31,200
Including User Costs: 42,200

PCCP									
Year	**Year 0**								**Total**
Construction Total	466,220								466,220
PW (no user costs)	466,220								466,220
Construction Total	466,220								466,220
User Costs	185,354								185,354
PW (w/ user costs)	651,574								651,574

40 Year Annualized Costs: Excluding User Costs: 23,600
Including User Costs: 32,900

Table B-12. SR 395, SR 395 and 19th Avenue PCCP reconstruction versus ACP reconstruction with inlays at six-year cycles - life cycle cost analysis.

SR 395 - SR 395 and 19th Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Year 40**	**Total**
Construction Total	441,600	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	962,593
PW (no user costs)	441,600	72,662	57,425	45,384	35,868	28,347	22,403	-6,383	697,305
Construction Total	441,600	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	962,593
User Costs	49,454	4,283	4,812	5,425	6,106	6,875	7,743		84,698
PW (w/ user costs)	491,054	76,046	60,431	48,062	38,250	30,467	24,290	-6,383	762,216

40 Year Annualized Costs: Excluding User Costs: 35,200
Including User Costs: 38,500

PCCP									
Year	**Year 0**								**Total**
Construction Total	546,440								546,440
PW (no user costs)	546,440								546,440
Construction Total	546,440								546,440
User Costs	49,454								49,454
PW (w/ user costs)	595,894								595,894

40 Year Annualized Costs: Excluding User Costs: 27,600
Including User Costs: 30,100

Table B-13. SR 90, Broadway Avenue and Thierman Street PCCP reconstruction versus ACP reconstruction with inlays at six-year cycles - life cycle cost analysis.

SR 90 - Broadway Avenue and Thierman Street

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Year 40**	**Total**
Construction Total	728,600	95,940	95,940	95,940	95,940	95,940	95,940	-31,980	1,272,260
PW (no user costs)	728,600	75,823	59,924	47,359	37,428	29,580	23,378	-6,661	995,430
Construction Total	728,600	95,940	95,940	95,940	95,940	95,940	95,940	-31,980	1,272,260
User Costs	95,856	3,690	4,135	4,662	5,266	5,915	6,659		126,183
PW (w/ user costs)	824,456	78,739	62,507	49,660	39,483	31,404	25,000	-6,661	1,104,587

40 Year Annualized Costs: Excluding User Costs: 50,300
Including User Costs: 55,800

PCCP									
Year	**Year 0**								**Total**
Construction Total	982,180								982,180
PW (no user costs)	982,180								982,180
Construction Total	982,180								982,180
User Costs	95,856								95,856
PW (w/ user costs)	1,078,036								1,078,036

40 Year Annualized Costs: Excluding User Costs: 49,600
Including User Costs: 54,500

Table B-14. SR 2, Division Street and Third Avenue PCCP reconstruction versus ACP reconstruction with inlays at six-year cycles - life cycle cost analysis.

SR 2 – Division Street and Third Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Year 40**	**Total**
Construction Total	164,680	27,720	27,720	27,720	27,720	27,720	27,720	-9,240	321,760
PW (no user costs)	164,680	21,908	17,314	13,683	10,814	8,547	6,754	-1,925	241,775
Construction Total	164,680	27,720	27,720	27,720	27,720	27,720	27,720	-9,240	321,760
User Costs	63,443	1,015	1,160	1,298	1,477	1,650	1,857		71,900
PW (w/ user costs)	228,123	22,710	18,038	14,324	11,390	9,055	7,207	-1,925	308,923

40 Year Annualized Costs: Excluding User Costs: 12,200
Including User Costs: 15,600

PCCP									
Year	**Year 0**								**Total**
Construction Total	208,540								208,540
PW (no user costs)	208,540								208,540
Construction Total	208,540								208,540
User Costs	63,443								63,443
PW (w/ user costs)	271,983								271,983

40 Year Annualized Costs: Excluding User Costs: 10,500
Including User Costs: 13,800

Table B-15. SR 27, Pines Road and Sprague Avenue PCCP reconstruction versus ACP reconstruction with inlays at eight-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Sprague Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	403,890	72,860	72,860	72,860	72,860	695,330
PW (no user cost)	403,890	53,238	38,901	28,424	20,769	545,222
Construction Total	403,890	72,860	72,860	72,860	72,860	695,330
User Costs	121,941	8,991	10,531	12,337	14,468	168,268
PW (with user costs)	525,831	59,808	44,523	33,237	24,894	688,293

40 Year Annualized Costs:	Excluding User Costs:	27,500
	Including User Costs:	34,800

PCCP						
Year	**Year 0**					**Total**
Construction Total	531,270					531,270
PW (no user cost)	531,270					531,270
Construction Total	531,270					531,270
User Costs	121,941					121,941
PW (with user costs)	653,211					653,211

40 Year Annualized Costs:	Excluding User Costs:	26,800
	Including User Costs:	33,000

Table B-16. SR 27, Pines Road and Broadway Avenue PCCP reconstruction versus ACP reconstruction with inlays at eight-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Broadway Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	349,750	89,700	89,700	89,700	89,700	708,550
PW (no user cost)	349,750	65,543	47,892	34,994	25,570	523,748
Construction Total	349,750	89,700	89,700	89,700	89,700	708,550
User Costs	222,241	7,051	8,273	9,698	11,359	258,622
PW (with user costs)	571,991	70,695	52,309	38,777	28,808	762,580

40 Year Annualized Costs:	Excluding User Costs:	26,500
	Including User Costs:	38,500

PCCP						
Year	**Year 0**					**Total**
Construction Total	455,450					455,450
PW (no user cost)	455,450					455,450
Construction Total	455,450					455,450
User Costs	222,241					222,241
PW (with user costs)	677,691					677,691

40 Year Annualized Costs:	Excluding User Costs:	23,000
	Including User Costs:	34,200

Table B-17. SR 2, Divisions Street and Francis Avenue PCCP reconstruction versus ACP reconstruction with inlays at eight-year cycles - life cycle cost analysis.

SR 2 - Division Street and Francis Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	519,020	151,240	151,240	151,240	151,240	1,123,980
PW (no user cost)	519,020	110,510	80,748	59,002	43,112	812,392
Construction Total	519,020	151,240	151,240	151,240	151,240	1,123,980
User Costs	752,156	12,283	14,388	16,868	19,769	815,464
PW (with user costs)	1,271,176	119,485	88,430	65,583	48,747	1,593,421

Excluding User Costs: 41,000
Including User Costs: 80,500

PCCP						
Year	**Year 0**					**Total**
Construction Total	675,110					675,110
PW (no user cost)	675,110					675,110
Construction Total	675,110					675,110
User Costs	752,156					752,156
PW (with user costs)	1,427,266					1,427,266

40 Year Annualized Costs: Excluding User Costs: 34,100
Including User Costs: 72,100

Table B-18. SR 27, Francis Avenue with Maple and Ash Streets PCCP reconstruction versus ACP reconstruction with inlays at eight-year cycles - life cycle cost analysis.

SR 291 - Francis Avenue with Maple and Ash Streets

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	316,830	91,940	91,940	91,940	91,940	684,590
PW (no user cost)	316,830	67,180	49,088	35,868	26,208	495,173
Construction Total	316,830	91,940	91,940	91,940	91,940	684,590
User Costs	185,354	9,317	10,914	12,782	14,979	233,346
PW (with user costs)	502,184	73,987	54,915	40,854	30,478	702,419

40 Year Annualized Costs:	Excluding User Costs:	25,000
	Including User Costs:	35,500

PCCP						
Year	**Year 0**					**Total**
Construction Total	466,220					466,220
PW (no user cost)	466,220					466,220
Construction Total	466,220					466,220
User Costs	185,354					185,354
PW (with user costs)	651,574					651,574

40 Year Annualized Costs:	Excluding User Costs:	23,600
	Including User Costs:	32,900

Table B-19. SR 395, SR 395 and 19th Avenue PCCP reconstruction versus ACP reconstruction with inlays at eight-year cycles - life cycle cost analysis.

SR 395 - SR 395 and 19th Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	441,600	91,940	91,940	91,940	91,940	809,360
PW (no user cost)	441,600	67,180	49,088	35,868	26,208	619,943
Construction Total	441,600	91,940	91,940	91,940	91,940	809,360
User Costs	49,454	4,439	5,208	6,106	7,161	72,368
PW (with user costs)	491,054	70,423	51,868	38,250	28,250	679,845

40 Year Annualized Costs: Excluding User Costs: 31,300
Including User Costs: 34,300

PCCP						
Year	**Year 0**					**Total**
Construction Total	546,440					546,440
PW (no user cost)	546,440					546,440
Construction Total	546,440					546,440
User Costs	49,454					49,454
PW (with user costs)	595,894					595,894

40 Year Annualized Costs: Excluding User Costs: 27,600
Including User Costs: 30,100

Table B-20. SR 90, Broadway Avenue and Thierman Street PCCP reconstruction versus ACP reconstruction with inlays at eight-year cycles - life cycle cost analysis.

SR 90 - Broadway Avenue and Thierman Street

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	728,600	95,940	95,940	95,940	95,940	1,112,360
PW (no user cost)	728,600	70,102	51,223	37,428	27,348	914,702
Construction Total	728,600	95,940	95,940	95,940	95,940	1,112,360
User Costs	95,856	3,831	4,480	5,266	6,162	115,595
PW (with user costs)	824,456	72,902	53,615	39,483	29,105	1,019,560

40 Year Annualized Costs: Excluding User Costs: 46,200
Including User Costs: 51,500

PCCP						
Year	**Year 0**					**Total**
Construction Total	982,180					982,180
PW (no user cost)	982,180					982,180
Construction Total	982,180					982,180
User Costs	95,856					95,856
PW (with user costs)	1,078,036					1,078,036

40 Year Annualized Costs: Excluding User Costs: 49,600
Including User Costs: 54,500

Table B-21. SR 2, Division Street and Third Avenue PCCP reconstruction versus ACP reconstruction with inlays at eight-year cycles - life cycle cost analysis.

SR 2 - Division Street and Third Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	164,680	27,720	27,720	27,720	27,720	275,560
PW (no user cost)	164,680	20,255	14,800	10,814	7,902	218,451
Construction Total	164,680	27,720	27,720	27,720	27,720	275,560
User Costs	63,443	1,061	1,252	1,459	1,719	68,934
PW (with user costs)	228,123	21,030	15,468	11,383	8,392	284,397

40 Year Annualized Costs: Excluding User Costs: 11,000
Including User Costs: 14,400

PCCP						
Year	**Year 0**					**Total**
Construction Total	208,540					208,540
PW (no user cost)	208,540					208,540
Construction Total	208,540					208,540
User Costs	63,443					63,443
PW (with user costs)	271,983					271,983

40 Year Annualized Costs: Excluding User Costs: 10,500
Including User Costs: 13,800

Table B-22. SR 27, Pines Road and Sprague Avenue PCCP reconstruction versus ACP inlays with four-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Sprague Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	728,600
PW (no user cost)	72,860	62,281	53,238	45,508	38,901	33,252	28,424	24,297	20,769	17,754	397,285
Construction Total	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	72,860	758,600
User Costs	7,677	8,308	8,991	9,732	10,531	11,405	12,337	13,368	14,468	15,649	112,466
PW (with user costs)	80,537	69,383	59,808	51,587	44,523	38,457	33,237	28,755	24,894	21,567	452,747

40 Year Annualized Costs: Excluding Delay Costs: 20,100
Including Delay Costs: 22,900

PCCP											
Year	**Year 0**										**Total**
Construction Total	531,270										531,270
PW (no user cost)	531,270										531,270
Construction Total	531,270										531,270
User Costs	121,941										121,941
PW (with user costs)	653,211										653,211

40 Year Annualized Costs: Excluding Delay Costs: 26,800
Including Delay Costs: 33,000

Table B-23. SR 27, Pines Road and Broadway Avenue PCCP reconstruction versus ACP inlays with four-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Broadway Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	897,000
PW (no user cost)	89,700	76,676	65,543	56,026	47,892	40,938	34,994	29,913	25,570	21,857	489,108
Construction Total	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	89,700	897,000
User Costs	6,027	6,513	7,051	7,654	8,273	8,957	9,698	10,485	11,359	12,291	88,308
PW (with user costs)	95,727	82,243	70,695	60,807	52,309	45,026	38,777	33,409	28,808	24,852	532,653

40 Year Annualized Costs:

Excluding Delay Costs: 24,700
Including Delay Costs: 26,900

PCCP											
Year	**Year 0**										**Total**
Construction Total	455,450										455,450
PW (no user cost)	455,450										455,450
Construction Total	455,450										455,450
User Costs	222,241										222,241
PW (with user costs)	677,691										677,691

Excluding Delay Costs: 23,000
Including Delay Costs: 34,200

Table B-24. SR 2, Division Street and Francis Avenue PCCP reconstruction versus ACP inlays with four-year cycles - life cycle cost analysis.

SR 2 - Division Street and Francis Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	1,512,400
PW (no user cost)	151,240	129,281	110,510	94,464	80,748	69,024	59,002	50,435	43,112	36,852	824,668
Construction Total	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	151,240	1,512,400
User Costs	10,484	11,349	12,283	13,304	14,388	15,582	16,868	18,257	19,769	21,388	153,672
PW (with user costs)	161,724	138,982	119,485	102,774	88,430	76,135	65,583	56,523	48,747	42,064	900,447

40 Year Annualized Costs: Excluding Delay Costs: 41,700
Including Delay Costs: 45,500

PCCP											
Year	**Year 0**										**Total**
Construction Total	675,110										675,110
PW (no user cost)	675,110										675,110
Construction Total	675,110										675,110
User Costs	752,156										752,156
PW (with user costs)	1,427,266										1,427,266

40 Year Annualized Costs: Excluding Delay Costs: 34,100
Including Delay Costs: 72,100

Table B-25. SR 291, Francis Avenue with Maple and Ash Streets PCCP reconstruction versus ACP inlays with four-year cycles - life cycle cost analysis.

SR 291 - Francis Avenue with Maple and Ash Streets

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	919,400
PW (no user cost)	91,940	78,591	67,180	57,425	49,088	41,960	35,868	30,660	26,208	22,403	501,322
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	919,400
User Costs	7,951	8,602	9,317	10,090	10,914	11,813	12,782	13,849	14,979	16,230	116,527
PW (with user costs)	99,891	85,944	73,987	63,728	54,915	47,352	40,854	35,278	30,478	26,358	558,784

40 Year Annualized Costs:	Excluding Delay Costs:	25,300
	Including Delay Costs:	28,200

PCCP											
Year	**Year 0**										**Total**
Construction Total	466,220										466,220
PW (no user cost)	466,220										466,220
Construction Total	466,220										466,220
User Costs	185,354										185,354
PW (with user costs)	651,574										651,574

40 Year Annualized Costs:	Excluding Delay Costs:	23,600
	Including Delay Costs:	32,900

Table B-26. SR 395, SR 395 and 19th Avenue PCCP reconstruction versus ACP inlays with four-year cycles - life cycle cost analysis.

SR 395 - SR 395 and 19th Avenue

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	919,400
PW (no user cost)	91,940	78,591	67,180	57,425	49,088	41,960	35,868	30,660	26,208	22,403	501,322
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	91,940	919,400
User Costs	3,799	4,108	4,439	4,812	5,208	5,646	6,106	6,613	7,161	7,743	55,635
PW (with user costs)	95,739	82,102	70,423	60,431	51,868	44,537	38,250	32,865	28,250	24,290	528,755

40 Year Annualized Costs:

Excluding Delay Costs: 25,300
Including Delay Costs: 26,700

PCCP											
Year	**Year 0**										**Total**
Construction Total	546,440										546,440
PW (no user cost)	546,440										546,440
Construction Total	546,440										546,440
User Costs	49,454										49,454
PW (with user costs)	595,894										595,894

Excluding Delay Costs: 27,600
Including Delay Costs: 30,100

Table B-27. SR 90, Broadway Avenue and Thierman Street PCCP reconstruction versus ACP inlays with four-year cycles - life cycle cost analysis.

SR 90 - Broadway Avenue and Thierman Street

ACP											
Year	**Year 0**	**Year 4**	**Year 8**	**Year 12**	**Year 16**	**Year 20**	**Year 24**	**Year 28**	**Year 32**	**Year 36**	**Total**
Construction Total	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	959,400
PW (no user cost)	95,940	82,010	70,102	59,924	51,223	43,786	37,428	31,994	27,348	23,378	523,133
Construction Total	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	95,940	959,400
User Costs	3,269	3,538	3,831	4,135	4,480	4,856	5,266	5,687	6,162	6,659	47,883
PW (with user costs)	99,209	85,034	72,902	62,507	53,615	46,002	39,483	33,890	29,105	25,000	546,747

40 Year Annualized Costs: Excluding Delay Costs: 26,400
Including Delay Costs: 27,600

PCCP											
Year	**Year 0**										**Total**
Construction Total	982,180										982,180
PW (no user cost)	982,180										982,180
Construction Total	982,180										982,180
User Costs	95,856										95,856
PW (with user costs)	1,078,036										1,078,036

40 Year Annualized Costs: Excluding Delay Costs: 49,600
Including Delay Costs: 54,500

Table B-28. SR 2, Division Street and Third Avenue PCCP reconstruction versus ACP inlays with four-year cycles - life cycle cost analysis.

SR 2 - Division Street and Third Avenue

ACP

Year	Year 0	Year 4	Year 8	Year 12	Year 16	Year 20	Year 24	Year 28	Year 32	Year 36	Total
Construction Total	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	277,200
PW (no user cost)	27,720	23,695	20,255	17,314	14,800	12,651	10,814	9,244	7,902	6,754	151,149
Construction Total	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	27,720	277,200
User Costs	911	980	1,079	1,160	1,252	1,355	1,477	1,592	1,719	1,857	13,382
PW (with user costs)	28,631	24,533	21,043	18,038	15,468	13,269	11,390	9,775	8,392	7,207	157,747

40 Year Annualized Costs: Excluding Delay Costs: 7,600
Including Delay Costs: 8,000

PCCP

Year	Year 0										Total
Construction Total	208,540										208,540
PW (no user cost)	208,540										208,540
Construction Total	208,540										208,540
User Costs	63,942										63,942
PW (with user costs)	272,482										272,482

40 Year Annualized Costs: Excluding Delay Costs: 10,500
Including Delay Costs: 13,800

Table B-29. SR 27, Pines Road and Sprague Avenue PCCP reconstruction versus ACP inlays with six-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Sprague Avenue

ACP

Year	Year 0	Year 6	Year 12	Year 18	Year 24	Year 30	Year 36	Salvage	Total
Construction Total	72,860	72,860	72,860	72,860	72,860	72,860	72,860	-24,287	485,733
PW (no user cost)	72,860	57,582	45,508	35,966	28,424	22,464	17,754	-5,059	275,500
Construction Total	72,860	72,860	72,860	72,860	72,860	72,860	72,860	-24,287	485,733
User Costs	7,677	8,644	9,732	10,966	12,337	13,907	15,649		78,912
PW (with user costs)	80,537	64,414	51,587	41,379	33,237	26,752	21,567	-5,059	314,414

40 Year Annualized Cost: Excluding User Costs: 13,900
Including User Costs: 15,900

PCCP

Year	Year 0								Total
Construction Total	531,270								531,270
PW (no user cost)	531,270								531,270
Construction Total	531,270								531,270
User Costs	121,941								121,941
PW (with user costs)	653,211								653,211

40 Year Annualized Cost: Excluding User Costs: 26,800
Including User Costs: 33,000

Table B-30. SR 27, Pines Road and Broadway Avenue PCCP reconstruction versus ACP inlays with six-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Broadway Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Salvage**	**Total**
Construction Total	89,700	89,700	89,700	89,700	89,700	89,700	89,700	-29,900	627,900
PW (no user cost)	89,700	70,891	56,026	44,278	34,994	27,656	21,857	-6,228	339,175
Construction Total	89,700	89,700	89,700	89,700	89,700	89,700	89,700	-29,900	627,900
User Costs	6,027	6,791	7,654	8,609	9,698	10,913	12,291		61,983
PW (with user costs)	95,727	76,258	60,807	48,528	38,777	31,021	24,852	-6,228	369,743

40 Year Annualized Cost: Excluding User Costs: 17,100
Including User Costs: 18,700

PCCP									
Year	**Year 0**								**Total**
Construction Total	455,450								455,450
PW (no user cost)	455,450								455,450
Construction Total	455,450								455,450
User Costs	222,241								222,241
PW (with user costs)	677,691								677,691

40 Year Annualized Cost: Excluding User Costs: 23,000
Including User Costs: 34,200

Table B-31. SR 2, Division Street and Francis Avenue PCCP reconstruction versus ACP inlays with six-year cycles - life cycle cost analysis.

SR 2 - Division Street and Francis Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Salvage**	**Total**
Construction Total	151,240	151,240	151,240	151,240	151,240	151,240	151,240	-50,413	1,058,680
PW (no user cost)	151,240	119,527	94,464	74,656	59,002	46,630	36,852	-10,501	571,872
Construction Total	151,240	151,240	151,240	151,240	151,240	151,240	151,240	-50,413	1,058,680
User Costs	10,484	11,804	13,304	14,988	16,868	18,996	21,388		107,832
PW (with user costs)	161,154	128,856	102,774	82,055	65,583	52,487	42,064	-10,501	625,042

40 Year Annualized Cost:	Excluding User Costs:	28,900
	Including User Costs:	31,600

PCCP									
Year	**Year 0**								**Total**
Construction Total	675,110								675,110
PW (no user cost)	675,110								675,110
Construction Total	675,110								675,110
User Costs	752,156								752,156
PW (with user costs)	1,427,266								1,427,266

40 Year Annualized Cost:	Excluding User Costs:	34,100
	Including User Costs:	72,100

Table B-32. SR 291, Francis Avenue with Maple and Ash Streets PCCP reconstruction versus ACP inlays with six-year cycles - life cycle cost analysis.

SR 291 - Francis Avenue with Maple and Ash Streets

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Salvage**	**Total**
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	643,580
PW (no user cost)	91,940	72,662	57,425	45,384	35,868	28,347	22,403	-6,383	347,645
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	643,580
User Costs	7,951	8,954	10,090	11,346	12,782	14,408	16,230		81,761
PW (with user costs)	99,891	79,738	63,728	50,985	40,854	32,789	26,358	-6,383	387,959

40 Year Annualized Cost:	Excluding User Costs:	17,600
	Including User Costs:	19,600

PCCP									
Year	**Year 0**								**Total**
Construction Total	466,220								466,220
PW (no user cost)	466,220								466,220
Construction Total	466,220								466,220
User Costs	185,354								185,354
PW (with user costs)	651,574								651,574

40 Year Annualized Cost:	Excluding User Costs:	23,600
	Including User Costs:	32,900

Table B-33. SR 395, SR 395 and 19th Avenue PCCP reconstruction versus ACP inlays with six-year cycles - life cycle cost analysis.

SR 395 - SR 395 and 19th Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Salvage**	**Total**
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	643,580
PW (no user cost)	91,940	72,662	57,425	45,384	35,868	28,347	22,403	-6,383	347,645
Construction Total	91,940	91,940	91,940	91,940	91,940	91,940	91,940	-30,647	643,580
User Costs	3,799	4,283	4,812	5,425	6,106	6,875	7,743		39,043
PW (with user costs)	95,739	76,046	60,431	48,062	38,250	30,467	24,290	-6,383	366,901

40 Year Annualized Cost: Excluding User Costs: 17,600
Including User Costs: 18,500

PCCP									
Year	**Year 0**								**Total**
Construction Total	546,440								546,440
PW (no user cost)	546,440								546,440
Construction Total	546,440								546,440
User Costs	49,454								49,454
PW (with user costs)	595,894								595,894

40 Year Annualized Cost: Excluding User Costs: 27,600
Including User Costs: 30,100

Table B-34. SR 90, Broadway Avenue and Thierman Street PCCP reconstruction versus ACP inlays with six-year cycles - life cycle cost analysis.

SR 90 - Broadway Avenue and Thierman Street

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Salvage**	**Total**
Construction Total	95,940	95,940	95,940	95,940	95,940	95,940	95,940	-31,980	671,580
PW (no user cost)	95,940	75,823	59,924	47,359	37,428	29,580	23,378	-6,661	362,770
Construction Total	95,940	95,940	95,940	95,940	95,940	95,940	95,940	-31,980	671,580
User Costs	3,269	3,690	4,135	4,662	5,266	5,915	6,659		33,596
PW (with user costs)	99,209	78,739	62,507	49,660	39,483	31,404	25,000	-6,661	379,340

40 Year Annualized Cost:	Excluding User Costs:	18,300
	Including User Costs:	19,200

PCCP									
Year	**Year 0**								**Total**
Construction Total	982,180								982,180
PW (no user cost)	982,180								982,180
Construction Total	982,180								982,180
User Costs	95,856								95,856
PW (with user costs)	1,078,036								1,078,036

40 Year Annualized Cost:	Excluding User Costs:	49,600
	Including User Costs:	54,500

Table B-35. SR 2, Division Street and Third Avenue PCCP reconstruction versus ACP inlays with six-year cycles - life cycle cost analysis.

SR 2 - Division and Third Avenue

ACP									
Year	**Year 0**	**Year 6**	**Year 12**	**Year 18**	**Year 24**	**Year 30**	**Year 36**	**Salvage**	**Total**
Construction Total	27,720	27,720	27,720	27,720	27,720	27,720	27,720	-9,240	194,040
PW (no user cost)	27,720	21,908	17,314	13,683	10,814	8,547	6,754	-1,925	104,815
Construction Total	27,720	27,720	27,720	27,720	27,720	27,720	27,720	-9,240	194,040
User Costs	911	1,015	1,160	1,298	1,477	1,650	1,857		9,368
PW (with user costs)	28,631	22,710	18,038	14,324	11,390	9,055	7,207	-1,925	109,431

40 Year Annualized Cost: Excluding User Costs: 5,300
Including User Costs: 5,500

PCCP									
Year	**Year 0**								**Total**
Construction Total	208,540								208,540
PW (no user cost)	208,540								208,540
Construction Total	208,540								208,540
User Costs	63,942								63,942
PW (with user costs)	272,482								272,482

40 Year Annualized Cost: Excluding User Costs: 10,500
Including User Costs: 13,800

Table B-36. SR 27, Pines Road and Sprague Avenue PCCP reconstruction versus ACP inlays with eight-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Sprague Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	72,860	72,860	72,860	72,860	72,860	364,300
PW (no user cost)	72,860	53,238	38,901	28,424	20,769	214,192
Construction Total	72,860	72,860	72,860	72,860	72,860	364,300
User Costs	7,677	8,991	10,531	12,337	14,468	54,004
PW (with user costs)	80,537	59,808	44,523	33,237	24,894	242,999

40 Year Annualized Cost — Excluding User Costs: 10,800
Including User Costs: 12,300

PCCP						
Year	**Year 0**					**Total**
Construction Total	531,270					531,270
PW (no user cost)	531,270					531,270
Construction Total	531,270					531,270
User Costs	121,941					121,941
PW (with user costs)	653,211					653,211

40 Year Annualized Cost — Excluding User Costs: 26,800
Including User Costs: 33,000

Table B-37. SR 2, Pines Road and Broadway Avenue PCCP reconstruction versus ACP inlays with eight-year cycles - life cycle cost analysis.

SR 27 - Pines Road and Broadway Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	89,700	89,700	89,700	89,700	89,700	448,500
PW (no user cost)	89,700	65,543	47,892	34,994	25,570	263,698
Construction Total	89,700	89,700	89,700	89,700	89,700	448,500
User Costs	6,027	7,051	8,273	9,698	11,359	42,408
PW (with user costs)	95,727	70,695	52,309	38,777	28,808	286,316

40 Year Annualized Cost	Excluding User Costs:	13,300
	Including User Costs:	14,500

PCCP						
Year	**Year 0**					**Total**
Construction Total	455,450					455,450
PW (no user cost)	455,450					455,450
Construction Total	455,450					455,450
User Costs	222,241					222,241
PW (with user costs)	677,691					677,691

40 Year Annualized Cost	Excluding User Costs:	23,000
	Including User Costs:	34,200

Table B-38. SR 27, Division Street and Francis Avenue PCCP reconstruction versus ACP inlays with eight-year cycles - life cycle cost analysis.

SR 2 - Division Street and Francis Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	151,240	151,240	151,240	151,240	151,240	756,200
PW (no user cost)	151,240	110,510	80,748	59,002	43,112	444,612
Construction Total	151,240	151,240	151,240	151,240	151,240	756,200
User Costs	10,484	12,283	14,388	16,868	19,769	73,792
PW (with user costs)	161,724	119,485	88,430	65,583	48,747	483,969

40 Year Annualized Cost	Excluding User Costs:	22,500
	Including User Costs:	24,500

PCCP						
Year	**Year 0**					**Total**
Construction Total	675,110					675,110
PW (no user cost)	675,110					675,110
Construction Total	675,110					675,110
User Costs	752,156					752,156
PW (with user costs)	1,427,266					1,427,266

40 Year Annualized Cost	Excluding User Costs:	34,100
	Including User Costs:	72,100

Table B-39. SR 291, Francis Avenue with Maple and Ash Streets PCCP reconstruction versus ACP inlays with eight-year cycles - life cycle cost analysis.

SR 291 - Francis Avenue with Maple and Ash Streets

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	91,940	91,940	91,940	91,940	91,940	459,700
PW (no user cost)	91,940	67,180	49,088	35,868	26,208	270,283
Construction Total	91,940	91,940	91,940	91,940	91,940	459,700
User Costs	7,951	9,317	10,914	12,782	14,979	55,943
PW (with user costs)	99,891	73,987	54,915	40,854	30,478	300,126

40 Year Annualized Cost	Excluding User Costs:	13,700
	Including User Costs:	15,200

PCCP						
Year	**Year 0**					**Total**
Construction Total	466,220					466,220
PW (no user cost)	466,220					466,220
Construction Total	466,220					466,220
User Costs	185,354					185,354
PW (with user costs)	651,574					651,574

40 Year Annualized Cost	Excluding User Costs:	23,600
	Including User Costs:	32,900

Table B-40. SR 395, SR 395 and 19th Avenue PCCP reconstruction versus ACP inlays with eight-year cycles - life cycle cost analysis.

SR 395 - SR 395 and 19th Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	91,940	91,940	91,940	91,940	91,940	459,700
PW (no user cost)	91,940	67,180	49,088	35,868	26,208	270,283
Construction Total	91,940	91,940	91,940	91,940	91,940	459,700
User Costs	3,799	4,439	5,208	6,106	7,161	26,713
PW (with user costs)	95,739	70,423	51,868	38,250	28,250	284,530

40 Year Annualized Cost	Excluding User Costs:	13,700
	Including User Costs:	14,400

PCCP						
Year	**Year 0**					**Total**
Construction Total	546,440					546,440
PW (no user cost)	546,440					546,440
Construction Total	546,440					546,440
User Costs	49,454					49,454
PW (with user costs)	595,894					595,894

40 Year Annualized Cost	Excluding User Costs:	27,600
	Including User Costs:	30,100

Table B-41. SR 90, Broadway Avenue and Thierman Street PCCP reconstruction versus ACP inlays with eight-year cycles - life cycle cost analysis.

SR 90 - Broadway Avenue and Thierman Street

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	95,940	95,940	95,940	95,940	95,940	479,700
PW (no user cost)	95,940	70,102	51,223	37,428	27,348	282,042
Construction Total	95,940	95,940	95,940	95,940	95,940	479,700
User Costs	3,269	3,831	4,480	5,266	6,162	23,008
PW (with user costs)	99,209	72,902	53,615	39,483	29,105	294,313

40 Year Annualized Cost	Excluding User Costs:	14,200
	Including User Costs:	14,900

PCCP						
Year	**Year 0**					**Total**
Construction Total	982,180					982,180
PW (no user cost)	982,180					982,180
Construction Total	982,180					982,180
User Costs	95,856					95,856
PW (with user costs)	1,078,036					1,078,036

40 Year Annualized Cost	Excluding User Costs:	49,600
	Including User Costs:	54,500

Table B-42. SR 2, Division Street and Third Avenue PCCP reconstruction versus ACP inlays with eight-year cycles - life cycle cost analysis.

SR 2 - Division and Third Avenue

ACP						
Year	**Year 0**	**Year 8**	**Year 16**	**Year 24**	**Year 32**	**Total**
Construction Total	27,720	27,720	27,720	27,720	27,720	138,600
PW (no user cost)	27,720	20,255	14,800	10,814	7,902	81,491
Construction Total	27,720	27,720	27,720	27,720	27,720	138,600
User Costs	911	1,061	1,252	1,459	1,719	6,402
PW (with user costs)	28,631	21,030	15,468	11,383	8,392	84,905

40 Year Annualized Cost	Excluding User Costs:	4,100
	Including User Costs:	4,300

PCCP						
Year	**Year 0**					**Total**
Construction Total	208,540					208,540
PW (no user cost)	208,540					208,540
Construction Total	208,540					208,540
User Costs	63,942					63,942
PW (with user costs)	272,482					272,482

40 Year Annualized Cost	Excluding User Costs:	10,500
	Including User Costs:	13,800

APPENDIX C – USER DELAY TIME SUMMARY AND CALCULATIONS

Tables C-1 to C-62 show the calculations used to compute total delay time at each intersection:

Tables	**Calculation**
C-1	Calculation of total delay time at each intersection for PCCP reconstruction or ACP reconstruction.
C-2 to C-27	Calculation of daily delay time at each intersection for PCCP or ACP reconstruction. Calculations were based on day or night construction.
C-28 to C-34	Calculation of total delay time at each intersection for ACP inlays at four year cycles.
C-35 to C-41	Calculation of total delay time at each intersection for ACP inlays at six year cycles.
C-42 to C-48	Calculation of total delay time at each intersection for ACP inlays at eight year cycles.
C-49 to C-62	Calculation of total daily time at each intersection for ACP inlays. Calculations we based on night construction.

Table C-1. Calculation of total delay time at each intersection for PCCP or ACP reconstruction.

SR 27 – Pines Road and Sprague Avenue

Approach	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road	840	5	4200	6.5	273.0	3927.0
SR 27 - Pines Road	60	15	900	6.5	58.5	841.5
Sprague Avenue	840	5	4200	6.5	273.0	3927.0
Sprague Avenue	60	15	900	6.5	58.5	841.5
Total Delay (hours)			**10,200**		**663**	**9,537**

SR 27 – Pines Road and Broadway Avenue

Approach	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road	219	10	2190	6.5	142.4	2047.7
SR 27 - Pines Road	437	20	8740	6.5	568.1	8171.9
Broadway Avenue	328	10	3280	6.5	213.2	3066.8
Broadway Avenue	219	20	4380	6.5	284.7	4095.3
Total Delay (hours)			**18,590**		**1,208**	**17,382**

SR 2 - Division Street and Francis Avenue

Approach	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 - Division Street	314	10	3140	2.6	81.6	3058.4
SR 2 - Division Street	1255	25	31375	2.6	815.8	30559.3
SR 291 - Francis Ave.	271	10	2710	2.8	75.9	2634.1
SR 291 - Francis Ave.	1085	25	27125	2.8	759.5	26365.5
Total Delay (hours)			**64,350**		**1,733**	**62,617**

Table C-1 (cont.). Calculation of total delay time at each intersection for PCCP or ACP reconstruction.

SR 291 - Francis Avenue with Maple and Ash Streets

Approach	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 291 - Francis Ave.	814	5	4070	2.8	114.0	3956.0
SR 291 - Francis Ave.	271	24	6504	2.8	182.1	6321.9
Ash & Maple Streets	407	5	2035	2.0	40.7	1994.3
Ash & Maple Streets	136	24	3264	2.0	65.3	3198.7
Total Delay (hours)			**15,873**		**402**	**15,471**

SR 395 - SR 395 and 19th Avenue

Approach	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 395	228	5	1140	19.0	216.6	923.4
SR 395	114	10	1140	19.0	216.6	923.4
19^{th} Avenue	171	5	855	5.0	42.8	812.3
19^{th} Avenue	85	10	850	5.0	42.5	807.5
Total Delay (hours)			**3,985**		**518**	**3,467**

SR 90 - Broadway Avenue and Thierman Street

Approach	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
Broadway Avenue	290	15	4350	17.0	739.5	3610.5
Broadway Avenue	145	15	2175	17.0	369.8	1805.2
City Streets	43	15	645	30.0	193.5	451.5
City Streets	21	15	315	30.0	94.5	220.5
Total Delay (hours)			**7,485**		**1,397**	**6,088**

Table C-1 (cont.). Calculation of total delay time at each intersection for PCCP or ACP reconstruction.

SR 2 - Division Street and Third Avenue

Approach	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 – Division Street	1025	5	5125	5.5	282	4843
Third Avenue	51	5	255	5.5	14	241
Total Delay (hours)			**5,380**		**296**	**5,084**

Table C-2. Daily delay time for PCCP construction on SR 27, Pines Road and Sprague Avenue – Pines Road approaches.

SR 27- Pines Road and Sprague Avenue Intersection

Pines Road Approach

ADT = 24,596

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	155	0	0	0.0
1-2	0.5	86	0	0	0.0
2-3	0.4	69	0	0	0.0
3-4	0.4	69	0	0	0.0
4-5	0.6	103	0	0	0.0
5-6	1.8	310	0	0	0.0
6-7	4.4	758	4	3032	50.5
7-8	6.2	1,067	4	4268	71.1
8-9	5.7	981	4	3924	65.4
9-10	5.1	878	4	3512	58.5
10-11	5.2	895	4	3580	59.7
11-12	5.6	964	4	3856	64.3
12-13	6.0	1,033	4	4132	68.9
13-14	5.9	1,016	4	4064	67.7
14-15	6.4	1,102	4	4408	73.5
15-16	7.4	1,274	4	5096	84.9
16-17	7.8	1,343	4	5372	89.5
17-18	7.5	1,291	4	5164	86.1
18-19	5.9	1,016	0	0	0.0
19-20	4.8	826	0	0	0.0
20-21	4.0	689	0	0	0.0
21-22	3.3	568	0	0	0.0
22-23	2.4	413	0	0	0.0
23-24	1.7	293	0	0	0.0
Totals		**17,200**		**50,408**	**840**

Table C-3. Nightly delay time for PCCP construction on SR 27, Pines Road and Sprague Avenue – Pines Road approaches.

SR 27 - Pines Road and Sprague Avenue

Pines Road Approaches

ADT = 24,596

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	155	1	155	2.6
1-2	0.5	86	1	86	1.4
2-3	0.4	69	1	69	1.1
3-4	0.4	69	1	69	1.1
4-5	0.6	103	1	103	1.7
5-6	1.8	310	1	310	5.2
6-7	4.4	758	0	0	0.0
7-8	6.2	1,067	0	0	0.0
8-9	5.7	981	0	0	0.0
9-10	5.1	878	0	0	0.0
10-11	5.2	895	0	0	0.0
11-12	5.6	964	0	0	0.0
12-13	6.0	1,033	0	0	0.0
13-14	5.9	1,016	0	0	0.0
14-15	6.4	1,102	0	0	0.0
15-16	7.4	1,274	0	0	0.0
16-17	7.8	1,343	0	0	0.0
17-18	7.5	1,291	0	0	0.0
18-19	5.9	1,016	0	0	0.0
19-20	4.8	826	1	826	13.8
20-21	4.0	689	1	689	11.5
21-22	3.3	568	1	568	9.5
22-23	2.4	413	1	413	6.9
23-24	1.7	293	1	293	4.9
Totals		**17,200**		**3,581**	**60**

Table C-4. Daily delay time for PCCP construction on SR 27, Pines Road and Sprague Avenue – Sprague Avenue approaches.

SR 27 - Pines Road and Sprague Avenue

Sprague Avenue Approaches

ADT = 24,596

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	155	0	0	0.0
1-2	0.5	86	0	0	0.0
2-3	0.4	69	0	0	0.0
3-4	0.4	69	0	0	0.0
4-5	0.6	103	0	0	0.0
5-6	1.8	310	0	0	0.0
6-7	4.4	758	4	3032	50.5
7-8	6.2	1,067	4	4268	71.1
8-9	5.7	981	4	3924	65.4
9-10	5.1	878	4	3512	58.5
10-11	5.2	895	4	3580	59.7
11-12	5.6	964	4	3856	64.3
12-13	6.0	1,033	4	4132	68.9
13-14	5.9	1,016	4	4064	67.7
14-15	6.4	1,102	4	4408	73.5
15-16	7.4	1,274	4	5096	84.9
16-17	7.8	1,343	4	5372	89.5
17-18	7.5	1,291	4	5164	86.1
18-19	5.9	1,016	0	0	0.0
19-20	4.8	826	0	0	0.0
20-21	4.0	689	0	0	0.0
21-22	3.3	568	0	0	0.0
22-23	2.4	413	0	0	0.0
23-24	1.7	293	0	0	0.0
Totals		**17,200**		**50,412**	**840**

Table C-5. Nightly delay time for PCCP construction on SR 27, Pines Road and Sprague Avenue – Sprague Avenue approaches.

SR 27 - Pines Road and Sprague Avenue

Sprague Avenue Approaches

ADT = 24,596

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	155	1	155	2.6
1-2	0.5	86	1	86	1.4
2-3	0.4	69	1	69	1.1
3-4	0.4	69	1	69	1.1
4-5	0.6	103	1	103	1.7
5-6	1.8	310	1	310	5.2
6-7	4.4	758	0	0	0.0
7-8	6.2	1,067	0	0	0.0
8-9	5.7	981	0	0	0.0
9-10	5.1	878	0	0	0.0
10-11	5.2	895	0	0	0.0
11-12	5.6	964	0	0	0.0
12-13	6.0	1,033	0	0	0.0
13-14	5.9	1,016	0	0	0.0
14-15	6.4	1,102	0	0	0.0
15-16	7.4	1,274	0	0	0.0
16-17	7.8	1,343	0	0	0.0
17-18	7.5	1,291	0	0	0.0
18-19	5.9	1,016	0	0	0.0
19-20	4.8	826	1	826	13.8
20-21	4.0	689	1	689	11.5
21-22	3.3	568	1	568	9.5
22-23	2.4	413	1	413	6.9
23-24	1.7	293	1	293	4.9
Totals		**17,200**		**3,581**	**60**

Table C-6. Daily delay time for PCCP construction on SR 27, Pines Road and Broadway Avenue – Pines Road approaches.

SR 27 - Pines Road and Broadway Avenue

Pines Road Approach

ADT = 25,608

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	161	0	0	0.0
1-2	0.5	90	0	0	0.0
2-3	0.4	72	0	0	0.0
3-4	0.4	72	0	0	0.0
4-5	0.6	108	0	0	0.0
5-6	1.8	323	0	0	0.0
6-7	4.4	789	2	1578	26.3
7-8	6.2	1,111	2	2222	37.0
8-9	5.7	1,022	2	2044	34.1
9-10	5.1	914	2	1828	30.5
10-11	5.2	932	2	1864	31.1
11-12	5.6	1,004	2	2008	33.5
12-13	6.0	1,076	2	2152	35.9
13-14	5.9	1,058	2	2116	35.3
14-15	6.4	1,147	2	2294	38.2
15-16	7.4	1,326	2	2652	44.2
16-17	7.8	1,398	2	2796	46.6
17-18	7.5	1,344	2	2688	44.8
18-19	5.9	1,058	0	0	0.0
19-20	4.8	860	0	0	0.0
20-21	4.0	717	0	0	0.0
21-22	3.3	592	0	0	0.0
22-23	2.4	430	0	0	0.0
23-24	1.7	305	0	0	0.0
Totals		**17,908**		**26,242**	**437**

Table C-7. Nightly delay time for PCCP construction on SR 27, Pines Road and Broadway Avenue – Pines Road approaches.

SR 27 - Pines Road and Broadway Avenue

Pines Road Approach

ADT = 25,608

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	161	0	0	0.0
1-2	0.5	90	0	0	0.0
2-3	0.4	72	0	0	0.0
3-4	0.4	72	0	0	0.0
4-5	0.6	108	0	0	0.0
5-6	1.8	323	0	0	0.0
6-7	4.4	789	1	789	13.1
7-8	6.2	1,111	1	1,111	18.5
8-9	5.7	1,022	1	1,022	17.0
9-10	5.1	914	1	914	15.2
10-11	5.2	932	1	932	15.5
11-12	5.6	1,004	1	1,004	16.7
12-13	6.0	1,076	1	1,076	17.9
13-14	5.9	1,058	1	1,058	17.6
14-15	6.4	1,147	1	1,147	19.1
15-16	7.4	1,326	1	1,326	22.1
16-17	7.8	1,398	1	1,398	23.3
17-18	7.5	1,344	1	1,344	22.4
18-19	5.9	1,058	0	0	0.0
19-20	4.8	860	0	0	0.0
20-21	4.0	717	0	0	0.0
21-22	3.3	592	0	0	0.0
22-23	2.4	430	0	0	0.0
23-24	1.7	305	0	0	0.0
Totals		**17,908**		**13,121**	**219**

Table C-8. Daily delay time for PCCP construction on SR 27, Pines Road and Broadway Avenue – Broadway Avenue approaches.

SR 27 - Pines Road and Broadway Avenue

Broadway Avenue Approaches

ADT = 12,804

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	81	0	0	0.0
1-2	0.5	45	0	0	0.0
2-3	0.4	36	0	0	0.0
3-4	0.4	36	0	0	0.0
4-5	0.6	54	0	0	0.0
5-6	1.8	161	0	0	0.0
6-7	4.4	394	3	1182	19.7
7-8	6.2	556	3	1668	27.8
8-9	5.7	511	3	1533	25.6
9-10	5.1	457	3	1371	22.9
10-11	5.2	466	3	1398	23.3
11-12	5.6	502	3	1506	25.1
12-13	6.0	538	3	1614	26.9
13-14	5.9	529	3	1587	26.5
14-15	6.4	574	3	1722	28.7
15-16	7.4	663	3	1989	33.2
16-17	7.8	699	3	2097	35.0
17-18	7.5	672	3	2016	33.6
18-19	5.9	529	0	0	0.0
19-20	4.8	430	0	0	0.0
20-21	4.0	359	0	0	0.0
21-22	3.3	296	0	0	0.0
22-23	2.4	215	0	0	0.0
23-24	1.7	152	0	0	0.0
Totals		**8,954**		**19,683**	**328**

Table C-9. Nightly delay time for PCCP construction on SR 27, Pines Road and Broadway Avenue – Broadway Avenue approaches.

SR 27 - Pines Road and Broadway Avenue

Broadway Avenue Approaches

ADT = 12,804

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	81	0	0	0.0
1-2	0.5	45	0	0	0.0
2-3	0.4	36	0	0	0.0
3-4	0.4	36	0	0	0.0
4-5	0.6	54	0	0	0.0
5-6	1.8	161	0	0	0.0
6-7	4.4	394	2	788	13.1
7-8	6.2	556	2	1112	18.5
8-9	5.7	511	2	1022	17.0
9-10	5.1	457	2	914	15.2
10-11	5.2	466	2	932	15.5
11-12	5.6	502	2	1004	16.7
12-13	6.0	538	2	1076	17.9
13-14	5.9	529	2	1058	17.6
14-15	6.4	574	2	1148	19.1
15-16	7.4	663	2	1326	22.1
16-17	7.8	699	2	1398	23.3
17-18	7.5	672	2	1344	22.4
18-19	5.9	529	0	0	0.0
19-20	4.8	430	0	0	0.0
20-21	4.0	359	0	0	0.0
21-22	3.3	296	0	0	0.0
22-23	2.4	215	0	0	0.0
23-24	1.7	152	0	0	0.0
Totals		**8,954**		**13,122**	**219**

Table C-10. Daily delay time for PCCP construction on SR 2, Division Street and Francis Avenue – Division Street approaches.

SR 2 – Division Street and Francis Avenue

Division Street Approaches

ADT = 36,726

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	231	0	0	0.0
1-2	0.5	129	0	0	0.0
2-3	0.4	103	0	0	0.0
3-4	0.4	103	0	0	0.0
4-5	0.6	154	0	0	0.0
5-6	1.8	463	0	0	0.0
6-7	4.4	1,131	4	4,524	75.4
7-8	6.2	1,594	4	6,376	106.3
8-9	5.7	1,465	4	5,860	97.7
9-10	5.1	1,311	4	5,244	87.4
10-11	5.2	1,337	4	5,348	89.1
11-12	5.6	1,440	4	5,760	96.0
12-13	6.0	1,542	4	6,168	102.8
13-14	5.9	1,517	4	6,068	101.1
14-15	6.4	1,645	4	6,580	109.7
15-16	7.4	1,902	4	7,608	126.8
16-17	7.8	2,005	4	8,020	133.7
17-18	7.5	1,928	4	7,712	128.5
18-19	5.9	1,517	0	0	0.0
19-20	4.8	1,234	0	0	0.0
20-21	4.0	1,028	0	0	0.0
21-22	3.3	848	0	0	0.0
22-23	2.4	617	0	0	0.0
23-24	1.7	437	0	0	0.0
Totals		**25,682**		**75,268**	**1,255**

Table C-11. Nightly delay time for PCCP construction on SR 2, Division Street and Francis Avenue – Division Street approaches.

SR 2 – Division Street and Francis Avenue

Division Street Approaches

ADT = 36,726

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	231	0	0	0.0
1-2	0.5	129	0	0	0.0
2-3	0.4	103	0	0	0.0
3-4	0.4	103	0	0	0.0
4-5	0.6	154	0	0	0.0
5-6	1.8	463	0	0	0.0
6-7	4.4	1,131	1	1,131	18.9
7-8	6.2	1,594	1	1,594	26.6
8-9	5.7	1,465	1	1,465	24.4
9-10	5.1	1,311	1	1,311	21.9
10-11	5.2	1,337	1	1,337	22.3
11-12	5.6	1,440	1	1,440	24.0
12-13	6.0	1,542	1	1,542	25.7
13-14	5.9	1,517	1	1,517	25.3
14-15	6.4	1,645	1	1,645	27.4
15-16	7.4	1,902	1	1,902	31.7
16-17	7.8	2,005	1	2,005	33.4
17-18	7.5	1,928	1	1,928	32.1
18-19	5.9	1,517	0	0	0.0
19-20	4.8	1,234	0	0	0.0
20-21	4.0	1,028	0	0	0.0
21-22	3.3	848	0	0	0.0
22-23	2.4	617	0	0	0.0
23-24	1.7	437	0	0	0.0
Totals		**25,682**		**18,817**	**314**

Table C-12. Daily delay time for PCCP construction on SR 2, Division Street and Francis Avenue – Francis Avenue approaches.

SR 2 – Division Street and Francis Avenue

Francis Avenue Approaches

ADT = 31,768

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	200	0	0	0.0
1-2	0.5	111	0	0	0.0
2-3	0.4	89	0	0	0.0
3-4	0.4	89	0	0	0.0
4-5	0.6	133	0	0	0.0
5-6	1.8	400	0	0	0.0
6-7	4.4	978	4	3,912	65.2
7-8	6.2	1,379	4	5,516	91.9
8-9	5.7	1,268	4	5,072	84.5
9-10	5.1	1,134	4	4,536	75.6
10-11	5.2	1,156	4	4,624	77.1
11-12	5.6	1,245	4	4,980	83.0
12-13	6.0	1,334	4	5,336	89.0
13-14	5.9	1,312	4	5,248	87.5
14-15	6.4	1,423	4	5,692	94.9
15-16	7.4	1,646	4	6,584	109.7
16-17	7.8	1,735	4	6,940	115.6
17-18	7.5	1,668	4	6,672	111.2
18-19	5.9	1,312	0	0	0.0
19-20	4.8	1,067	0	0	0.0
20-21	4.0	890	0	0	0.0
21-22	3.3	734	0	0	0.0
22-23	2.4	534	0	0	0.0
23-24	1.7	378	0	0	0.0
Totals		**22,215**		**65,112**	**1,085**

Table C-13. Nightly delay time for PCCP construction on SR 2 Division Street and Francis Avenue – Francis Avenue approaches.

SR 2 – Division Street and Francis Avenue

Francis Avenue Approaches

ADT = 31,768

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	200	0	0	0.0
1-2	0.5	111	0	0	0.0
2-3	0.4	89	0	0	0.0
3-4	0.4	89	0	0	0.0
4-5	0.6	133	0	0	0.0
5-6	1.8	400	0	0	0.0
6-7	4.4	978	1	978	16.3
7-8	6.2	1,379	1	1,379	23.0
8-9	5.7	1,268	1	1,268	21.1
9-10	5.1	1,134	1	1,134	18.9
10-11	5.2	1,156	1	1,156	19.3
11-12	5.6	1,245	1	1,245	20.8
12-13	6.0	1,334	1	1,334	22.2
13-14	5.9	1,312	1	1,312	21.9
14-15	6.4	1,423	1	1,423	23.7
15-16	7.4	1,646	1	1,646	27.4
16-17	7.8	1,735	1	1,735	28.9
17-18	7.5	1,668	1	1,668	27.8
18-19	5.9	1,312	0	0	0.0
19-20	4.8	1,067	0	0	0.0
20-21	4.0	890	0	0	0.0
21-22	3.3	734	0	0	0.0
22-23	2.4	534	0	0	0.0
23-24	1.7	378	0	0	0.0
Totals		**22,215**		**16,278**	**271**

Table C-14. Daily delay time for PCCP construction on SR 291, Division Street with Maple and Ash Streets – Francis Avenue approaches.

SR 291 - Francis Avenue with Maple and Ash Streets

Francis Avenue Approaches

ADT = 31,768

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	200	0	0	0.0
1-2	0.5	111	0	0	0.0
2-3	0.4	89	0	0	0.0
3-4	0.4	89	0	0	0.0
4-5	0.6	133	0	0	0.0
5-6	1.8	400	0	0	0.0
6-7	4.4	978	3	2,934	48.9
7-8	6.2	1,379	3	4,137	69.0
8-9	5.7	1,268	3	3,804	63.4
9-10	5.1	1,134	3	3,402	56.7
10-11	5.2	1,156	3	3,468	57.8
11-12	5.6	1,245	3	3,735	62.3
12-13	6.0	1,334	3	4,002	66.7
13-14	5.9	1,312	3	3,936	65.6
14-15	6.4	1,423	3	4,269	71.2
15-16	7.4	1,646	3	4,938	82.3
16-17	7.8	1,735	3	5,205	86.8
17-18	7.5	1,668	3	5,004	83.4
18-19	5.9	1,312	0	0	0.0
19-20	4.8	1,067	0	0	0.0
20-21	4.0	890	0	0	0.0
21-22	3.3	734	0	0	0.0
22-23	2.4	534	0	0	0.0
23-24	1.7	378	0	0	0.0
Totals		**22,215**		**48,834**	**814**

Table C-15. Nightly delay time for PCCP construction on SR 291, Division Street with Maple and Ash Streets – Francis Avenue approaches.

SR 291 - Francis Avenue with Maple and Ash Streets

Francis Avenue Approaches

ADT = 31,768

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	200	0	0	0.0
1-2	0.5	111	0	0	0.0
2-3	0.4	89	0	0	0.0
3-4	0.4	89	0	0	0.0
4-5	0.6	133	0	0	0.0
5-6	1.8	400	0	0	0.0
6-7	4.4	978	1	978	16.3
7-8	6.2	1,379	1	1,379	23.0
8-9	5.7	1,268	1	1,268	21.1
9-10	5.1	1,134	1	1,134	18.9
10-11	5.2	1,156	1	1,156	19.3
11-12	5.6	1,245	1	1,245	20.8
12-13	6.0	1,334	1	1,334	22.2
13-14	5.9	1,312	1	1,312	21.9
14-15	6.4	1,423	1	1,423	23.7
15-16	7.4	1,646	1	1,646	27.4
16-17	7.8	1,735	1	1,735	28.9
17-18	7.5	1,668	1	1,668	27.8
18-19	5.9	1,312	0	0	0.0
19-20	4.8	1,067	0	0	0.0
20-21	4.0	890	0	0	0.0
21-22	3.3	734	0	0	0.0
22-23	2.4	534	0	0	0.0
23-24	1.7	378	0	0	0.0
Totals		**22,215**		**16,278**	**271**

Table C-16. Daily delay time for PCCP construction on SR 291 Division Street with Maple and Ash Streets – city streets approaches.

SR 291 - Francis Avenue with Maple and Ash Streets

City Streets Approaches

ADT = 15,884

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	100	0	0	0.0
1-2	0.5	56	0	0	0.0
2-3	0.4	44	0	0	0.0
3-4	0.4	44	0	0	0.0
4-5	0.6	67	0	0	0.0
5-6	1.8	200	0	0	0.0
6-7	4.4	489	3	1,467	24.5
7-8	6.2	689	3	2,067	34.5
8-9	5.7	634	3	1,902	31.7
9-10	5.1	567	3	1,701	28.4
10-11	5.2	578	3	1,734	28.9
11-12	5.6	623	3	1,869	31.2
12-13	6.0	667	3	2,001	33.4
13-14	5.9	656	3	1,968	32.8
14-15	6.4	712	3	2,136	35.6
15-16	7.4	823	3	2,469	41.2
16-17	7.8	867	3	2,601	43.4
17-18	7.5	834	3	2,502	41.7
18-19	5.9	656	0	0	0.0
19-20	4.8	534	0	0	0.0
20-21	4.0	445	0	0	0.0
21-22	3.3	367	0	0	0.0
22-23	2.4	267	0	0	0.0
23-24	1.7	189	0	0	0.0
Totals		**11,108**		**24,417**	**407**

Table C-17. Nightly delay time for PCCP construction on SR 291 Division Street with Maple and Ash Streets – city streets approaches.

SR 291 - Francis Avenue with Maple and Ash Streets

City Streets Approaches

ADT = 15,884

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	100	0	0	0.0
1-2	0.5	56	0	0	0.0
2-3	0.4	44	0	0	0.0
3-4	0.4	44	0	0	0.0
4-5	0.6	67	0	0	0.0
5-6	1.8	200	0	0	0.0
6-7	4.4	489	1	489	8.2
7-8	6.2	689	1	689	11.5
8-9	5.7	634	1	634	10.6
9-10	5.1	567	1	567	9.5
10-11	5.2	578	1	578	9.6
11-12	5.6	623	1	623	10.4
12-13	6.0	667	1	667	11.1
13-14	5.9	656	1	656	10.9
14-15	6.4	712	1	712	11.9
15-16	7.4	823	1	823	13.7
16-17	7.8	867	1	867	14.5
17-18	7.5	834	1	834	13.9
18-19	5.9	656	0	0	0.0
19-20	4.8	534	0	0	0.0
20-21	4.0	445	0	0	0.0
21-22	3.3	367	0	0	0.0
22-23	2.4	267	0	0	0.0
23-24	1.7	189	0	0	0.0
Totals		**11,108**		**8,139**	**136**

Table C-18. Daily delay time for PCCP construction on SR 395, SR 395 and 19th Avenue – SR 395 approaches.

SR 395 - SR 395 and 19th Avenue

SR 395 Approach Legs

ADT = 13,370

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	84	0	0	0.0
1-2	0.5	47	0	0	0.0
2-3	0.4	37	0	0	0.0
3-4	0.4	37	0	0	0.0
4-5	0.6	56	0	0	0.0
5-6	1.8	168	0	0	0.0
6-7	4.4	412	2	824	13.7
7-8	6.2	580	2	1,160	19.3
8-9	5.7	533	2	1,066	17.8
9-10	5.1	477	2	954	15.9
10-11	5.2	487	2	974	16.2
11-12	5.6	524	2	1,048	17.5
12-13	6.0	562	2	1,124	18.7
13-14	5.9	552	2	1,104	18.4
14-15	6.4	599	2	1,198	20.0
15-16	7.4	693	2	1,386	23.1
16-17	7.8	730	2	1,460	24.3
17-18	7.5	702	2	1,404	23.4
18-19	5.9	552	0	0	0.0
19-20	4.8	449	0	0	0.0
20-21	4.0	374	0	0	0.0
21-22	3.3	309	0	0	0.0
22-23	2.4	225	0	0	0.0
23-24	1.7	159	0	0	0.0
Totals		**9,350**		**13,702**	**228**

Table C-19. Daily delay time for PCCP construction on SR 395 SR 395 and 19th Avenue – SR 395 approaches.

SR 395 - SR 395 and 19th Avenue

SR 395 Approach Legs

ADT = 13,370

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	84	0	0	0.0
1-2	0.5	47	0	0	0.0
2-3	0.4	37	0	0	0.0
3-4	0.4	37	0	0	0.0
4-5	0.6	56	0	0	0.0
5-6	1.8	168	0	0	0.0
6-7	4.4	412	1	412	6.9
7-8	6.2	580	1	580	9.7
8-9	5.7	533	1	533	8.9
9-10	5.1	477	1	477	8.0
10-11	5.2	487	1	487	8.1
11-12	5.6	524	1	524	8.7
12-13	6.0	562	1	562	9.4
13-14	5.9	552	1	552	9.2
14-15	6.4	599	1	599	10
15-16	7.4	693	1	693	11.6
16-17	7.8	730	1	730	12.2
17-18	7.5	702	1	702	11.7
18-19	5.9	552	0	0	0.0
19-20	4.8	449	0	0	0.0
20-21	4.0	374	0	0	0.0
21-22	3.3	309	0	0	0.0
22-23	2.4	225	0	0	0.0
23-24	1.7	159	0	0	0.0
Totals		**9,350**		**6,851**	**114**

Table C-20. Nightly delay time for PCCP construction on SR 395, SR 395 and 19th Avenue – 19th Avenue approaches.

SR 395 - SR 395 and 19th Avenue

19th Avenue Approach Legs

ADT = 10,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	63	0	0	0.0
1-2	0.5	35	0	0	0.0
2-3	0.4	28	0	0	0.0
3-4	0.4	28	0	0	0.0
4-5	0.6	42	0	0	0.0
5-6	1.8	126	0	0	0.0
6-7	4.4	308	2	616	10.3
7-8	6.2	434	2	868	14.5
8-9	5.7	399	2	798	13.3
9-10	5.1	357	2	714	11.9
10-11	5.2	364	2	728	12.1
11-12	5.6	392	2	784	13.1
12-13	6.0	420	2	840	14.0
13-14	5.9	413	2	826	13.8
14-15	6.4	448	2	896	14.9
15-16	7.4	518	2	1,036	17.3
16-17	7.8	546	2	1,092	18.2
17-18	7.5	525	2	1,050	17.5
18-19	5.9	413	0	0	0.0
19-20	4.8	336	0	0	0.0
20-21	4.0	280	0	0	0.0
21-22	3.3	231	0	0	0.0
22-23	2.4	168	0	0	0.0
23-24	1.7	119	0	0	0.0
Totals		**6,993**		**10,248**	**171**

Table C-21. Nightly delay time for PCCP construction on SR 395
SR 395 and 19th Avenue – 19th Avenue approaches.

SR 395 - SR 395 and 19th Avenue

19th Avenue Approach Legs

ADT = 10,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	63	0	0	0.0
1-2	0.5	35	0	0	0.0
2-3	0.4	28	0	0	0.0
3-4	0.4	28	0	0	0.0
4-5	0.6	42	0	0	0.0
5-6	1.8	126	0	0	0.0
6-7	4.4	308	1	308	5.1
7-8	6.2	434	1	434	7.2
8-9	5.7	399	1	399	6.7
9-10	5.1	357	1	357	6.0
10-11	5.2	364	1	364	6.1
11-12	5.6	392	1	392	6.5
12-13	6.0	420	1	420	7.0
13-14	5.9	413	1	413	6.9
14-15	6.4	448	1	448	7.5
15-16	7.4	518	1	518	8.6
16-17	7.8	546	1	546	9.1
17-18	7.5	525	1	525	8.8
18-19	5.9	413	0	0	0.0
19-20	4.8	336	0	0	0.0
20-21	4.0	280	0	0	0.0
21-22	3.3	231	0	0	0.0
22-23	2.4	168	0	0	0.0
23-24	1.7	119	0	0	0.0
Totals		**6,993**		**5,124**	**85**

Table C-22. Daily delay time for PCCP construction on SR 90, Broadway Avenue and Thierman Street – Broadway Avenue approaches.

SR 90 - Broadway Avenue and Thierman Road

Broadway Avenue Approaches

ADT = 17,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	107	0	0	0.0
1-2	0.5	60	0	0	0.0
2-3	0.4	48	0	0	0.0
3-4	0.4	48	0	0	0.0
4-5	0.6	71	0	0	0.0
5-6	1.8	214	0	0	0.0
6-7	4.4	524	2	1,048	17.5
7-8	6.2	738	2	1,476	24.6
8-9	5.7	678	2	1,356	22.6
9-10	5.1	607	2	1,214	20.2
10-11	5.2	619	2	1,238	20.6
11-12	5.6	666	2	1,332	22.2
12-13	6.0	714	2	1,428	23.8
13-14	5.9	702	2	1,404	23.4
14-15	6.4	762	2	1,524	25.4
15-16	7.4	881	2	1,762	29.4
16-17	7.8	928	2	1,856	30.9
17-18	7.5	893	2	1,786	29.8
18-19	5.9	702	0	0	0.0
19-20	4.8	571	0	0	0.0
20-21	4.0	476	0	0	0.0
21-22	3.3	393	0	0	0.0
22-23	2.4	286	0	0	0.0
23-24	1.7	202	0	0	0.0
Totals		**11,888**		**17,424**	**290**

Table C-23. Nightly delay time for PCCP construction on SR 90 Broadway Avenue and Thierman Road – Broadway Avenue approaches.

SR 90 - Broadway Avenue and Thierman Road

Broadway Avenue Approaches

ADT = 17,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	107	0	0	0.0
1-2	0.5	60	0	0	0.0
2-3	0.4	48	0	0	0.0
3-4	0.4	48	0	0	0.0
4-5	0.6	71	0	0	0.0
5-6	1.8	214	0	0	0.0
6-7	4.4	524	1	524	8.7
7-8	6.2	738	1	738	12.3
8-9	5.7	678	1	678	11.3
9-10	5.1	607	1	607	10.1
10-11	5.2	619	1	619	10.3
11-12	5.6	666	1	666	11.1
12-13	6.0	714	1	714	11.9
13-14	5.9	702	1	702	11.7
14-15	6.4	762	1	762	12.7
15-16	7.4	881	1	881	14.7
16-17	7.8	928	1	928	15.5
17-18	7.5	893	1	893	14.9
18-19	5.9	702	0	0	0.0
19-20	4.8	571	0	0	0.0
20-21	4.0	476	0	0	0.0
21-22	3.3	393	0	0	0.0
22-23	2.4	286	0	0	0.0
23-24	1.7	202	0	0	0.0
Totals		**11,888**		**8,712**	**145**

Table C-24. Daily delay time for PCCP construction on SR 90, Broadway Avenue and Thierman Road – city street approaches.

SR 90 - Broadway Avenue and Thierman Road

City Street Approaches

ADT = 2,500

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	16	0	0	0.0
1-2	0.5	9	0	0	0.0
2-3	0.4	7	0	0	0.0
3-4	0.4	7	0	0	0.0
4-5	0.6	11	0	0	0.0
5-6	1.8	32	0	0	0.0
6-7	4.4	77	2	154	2.6
7-8	6.2	109	2	218	3.6
8-9	5.7	100	2	200	3.3
9-10	5.1	89	2	178	3.0
10-11	5.2	91	2	182	3.0
11-12	5.6	98	2	196	3.3
12-13	6.0	105	2	210	3.5
13-14	5.9	103	2	206	3.4
14-15	6.4	112	2	224	3.7
15-16	7.4	130	2	260	4.3
16-17	7.8	137	2	274	4.6
17-18	7.5	131	2	262	4.4
18-19	5.9	103	0	0	0.0
19-20	4.8	84	0	0	0.0
20-21	4.0	70	0	0	0.0
21-22	3.3	58	0	0	0.0
22-23	2.4	42	0	0	0.0
23-24	1.7	30	0	0	0.0
Totals		**1,748**		**2,562**	**43**

Table C-25. Nightly delay time for PCCP construction on SR 90, Broadway Avenue and Thierman Road – city street approaches.

SR 90 - Broadway Avenue and Thierman Road

City Street Approaches

ADT = 2,500

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	16	0	0	0.0
1-2	0.5	9	0	0	0.0
2-3	0.4	7	0	0	0.0
3-4	0.4	7	0	0	0.0
4-5	0.6	11	0	0	0.0
5-6	1.8	32	0	0	0.0
6-7	4.4	77	1	77	1.3
7-8	6.2	109	1	109	1.8
8-9	5.7	100	1	100	1.7
9-10	5.1	89	1	89	1.5
10-11	5.2	91	1	91	1.5
11-12	5.6	98	1	98	1.6
12-13	6.0	105	1	105	1.8
13-14	5.9	103	1	103	1.7
14-15	6.4	112	1	112	1.9
15-16	7.4	130	1	130	2.2
16-17	7.8	137	1	137	2.3
17-18	7.5	131	1	131	2.2
18-19	5.9	103	0	0	0.0
19-20	4.8	84	0	0	0.0
20-21	4.0	70	0	0	0.0
21-22	3.3	58	0	0	0.0
22-23	2.4	42	0	0	0.0
23-24	1.7	30	0	0	0.0
Totals		**1,748**		**1,281**	**21**

Table C-26. Daily delay time for PCCP construction on SR 2, Division Street and Third Avenue – Division Street approaches.

SR 2 – Division Street and Third Avenue

Division Approach Leg

ADT = 12,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	76	0	0	0.0
1-2	0.5	42	0	0	0.0
2-3	0.4	34	0	0	0.0
3-4	0.4	34	0	0	0.0
4-5	0.6	50	0	0	0.0
5-6	1.8	151	0	0	0.0
6-7	4.4	370	10	3,700	61.7
7-8	6.2	521	10	5,210	86.8
8-9	5.7	479	10	4,790	79.8
9-10	5.1	428	10	4,280	71.3
10-11	5.2	437	10	4,370	72.8
11-12	5.6	470	10	4,700	78.3
12-13	6.0	504	10	5,040	84.0
13-14	5.9	496	10	4,960	82.7
14-15	6.4	538	10	5,380	89.7
15-16	7.4	622	10	6,220	103.7
16-17	7.8	655	10	6,550	109.2
17-18	7.5	630	10	6,300	105.0
18-19	5.9	496	0	0	0.0
19-20	4.8	403	0	0	0.0
20-21	4.0	336	0	0	0.0
21-22	3.3	277	0	0	0.0
22-23	2.4	202	0	0	0.0
23-24	1.7	143	0	0	0.0
Totals		**8,392**		**61,500**	**1,025**

Table C-27. Nightly delay time for PCCP construction on SR 2, Division Street and Third Avenue – Third Avenue approach.

SR 2 – Division Street and Third Avenue

Third Avenue Approach

ADT = 6,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	38	0	0	0.0
1-2	0.5	21	0	0	0.0
2-3	0.4	17	0	0	0.0
3-4	0.4	17	0	0	0.0
4-5	0.6	25	0	0	0.0
5-6	1.8	76	0	0	0.0
6-7	4.4	185	1	185	3.1
7-8	6.2	260	1	260	4.3
8-9	5.7	239	1	239	4.0
9-10	5.1	214	1	214	3.6
10-11	5.2	218	1	218	3.6
11-12	5.6	235	1	235	3.9
12-13	6.0	252	1	252	4.2
13-14	5.9	248	1	248	4.1
14-15	6.4	269	1	269	4.5
15-16	7.4	311	1	311	5.2
16-17	7.8	328	1	328	5.5
17-18	7.5	315	1	315	5.3
18-19	5.9	248	0	0	0.0
19-20	4.8	202	0	0	0.0
20-21	4.0	168	0	0	0.0
21-22	3.3	139	0	0	0.0
22-23	2.4	101	0	0	0.0
23-24	1.7	71	0	0	0.0
Totals		**4,196**		**3,074**	**51**

Table C-28. Calculation of delay time on SR 27, Pines Road and Sprague Avenue with four-year ACP inlay cycles.

SR 27 - Pines Road and Sprague Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road							
Year 0	24,596	107.0	3	321	6.5	20.9	300.1
Year 4	26,624	115.8	3	347	6.5	22.6	324.9
Year 8	28,818	125.4	3	376	6.5	24.4	351.7
Year 12	31,194	135.7	3	407	6.5	26.5	380.6
Year 16	33,765	146.9	3	441	6.5	28.6	412.0
Year 20	36,548	159.0	3	477	6.5	31.0	446.0
Year 24	39,561	172.1	3	516	6.5	33.6	482.7
Year 28	42,822	186.3	3	559	6.5	36.3	522.5
Year 32	46,352	201.6	3	605	6.5	39.3	565.6
Year 36	50,173	218.3	3	655	6.5	42.6	612.2
Sprague Avenue							
Year 0	24,596	107.0	3	321	6.5	20.9	300.1
Year 4	26,624	115.8	3	347	6.5	22.6	324.9
Year 8	28,818	125.4	3	376	6.5	24.4	351.7
Year 12	31,194	135.7	3	407	6.5	26.5	380.6
Year 16	33,765	146.9	3	441	6.5	28.6	412.0
Year 20	36,548	159.0	3	477	6.5	31.0	446.0
Year 24	39,561	172.1	3	516	6.5	33.6	482.7
Year 28	42,822	186.3	3	559	6.5	36.3	522.5
Year 32	46,352	201.6	3	605	6.5	39.3	565.6
Year 36	50,173	218.3	3	655	6.5	42.6	612.2
Total Delay (Both Legs)							
Year 0				642		42	600
Year 4				695		45	650
Year 8				752		49	703
Year 12				814		53	761
Year 16				881		57	824
Year 20				954		62	892
Year 24				1033		67	965
Year 28				1118		73	1045
Year 32				1210		79	1131
Year 36				1310		85	1224

Table C-29. Calculation of delay time on SR 27, Pines Road and Broadway Avenue with four-year ACP inlay cycles.

SR 27 - Pines Road and Broadway Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road							
Year 0	25,608	112.0	3	336	6.5	21.8	314.2
Year 4	27,719	121.2	3	364	6.5	23.6	340.1
Year 8	30,004	131.2	3	394	6.5	25.6	368.1
Year 12	32,477	142.0	3	426	6.5	27.7	398.4
Year 16	35,154	153.8	3	461	6.5	30.0	431.3
Year 20	38,052	166.4	3	499	6.5	32.5	466.8
Year 24	41,189	180.1	3	540	6.5	35.1	505.3
Year 28	44,584	195.0	3	585	6.5	38.0	547.0
Year 32	48,259	211.1	3	633	6.5	41.2	592.0
Year 36	52,237	228.5	3	685	6.5	44.6	640.9
Broadway Avenue							
Year 0	12,804	56.0	3	168	6.5	10.9	157.1
Year 4	13,859	60.6	3	182	6.5	11.8	170.0
Year 8	15,002	65.6	3	197	6.5	12.8	184.0
Year 12	16,239	71.0	3	213	6.5	13.8	199.2
Year 16	17,577	76.9	3	231	6.5	15.0	215.6
Year 20	19,026	83.2	3	250	6.5	16.2	233.4
Year 24	20,594	90.1	3	270	6.5	17.6	252.7
Year 28	22,292	97.5	3	292	6.5	19.0	273.5
Year 32	24,130	105.5	3	317	6.5	20.6	296.0
Year 36	26,119	114.2	3	343	6.5	22.3	320.4
Total Delay (Both Legs)							
Year 0				504		33	471
Year 4				546		35	510
Year 8				591		38	552
Year 12				639		42	598
Year 16				692		45	647
Year 20				749		49	700
Year 24				811		53	758
Year 28				877		57	820
Year 32				950		62	888
Year 36				1028		67	961

Table C-30. Calculation of delay time on SR 2, Division Street and Francis Avenue with four-year ACP inlay cycles.

SR 2 - Division Street and Francis Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 - Division Street							
Year 0	36,726	160.0	3	480	2.6	12.5	467.5
Year 4	39,753	173.2	3	520	2.6	13.5	506.1
Year 8	43,030	187.5	3	562	2.6	14.6	547.8
Year 12	46,577	202.9	3	609	2.6	15.8	592.9
Year 16	50,417	219.6	3	659	2.6	17.1	641.8
Year 20	54,573	237.8	3	713	2.6	18.5	694.7
Year 24	59,071	257.3	3	772	2.6	20.1	752.0
Year 28	63,941	278.6	3	836	2.6	21.7	814.0
Year 32	69,212	301.5	3	905	2.6	23.5	881.1
Year 36	74,917	326.4	3	979	2.6	25.5	953.7
SR 291 - Francis Ave.							
Year 0	31,768	139.0	3	417	2.8	11.7	405.3
Year 4	34,387	150.5	3	451	2.8	12.6	438.7
Year 8	37,221	162.9	3	489	2.8	13.7	474.9
Year 12	40,290	176.3	3	529	2.8	14.8	514.0
Year 16	43,611	190.8	3	572	2.8	16.0	556.4
Year 20	47,206	206.5	3	620	2.8	17.3	602.3
Year 24	51,097	223.6	3	671	2.8	18.8	651.9
Year 28	55,309	242.0	3	726	2.8	20.3	705.7
Year 32	59,868	262.0	3	786	2.8	22.0	763.8
Year 36	64,803	283.5	3	851	2.8	23.8	826.8
Total Delay (Both Legs)							
Year 0				897		24	873
Year 4				971		26	945
Year 8				1051		28	1023
Year 12				1138		31	1107
Year 16				1231		33	1198
Year 20				1333		36	1297
Year 24				1443		39	1404
Year 28				1562		42	1520
Year 32				1690		46	1645
Year 36				1830		49	1781

Table C-31. Calculation of delay time on SR 291, Francis Avenue with Maple and Ash Streets with four-year ACP inlay cycles.

SR 291 - Francis Avenue with Maple and Ash Streets

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 291 - Francis Ave.							
Year 0	31,768	139.0	3	417	2.8	11.7	405.3
Year 4	34,387	150.5	3	451	2.8	12.6	438.7
Year 8	37,221	162.9	3	489	2.8	13.7	474.9
Year 12	40,290	176.3	3	529	2.8	14.8	514.0
Year 16	43,611	190.8	3	572	2.8	16.0	556.4
Year 20	47,206	206.5	3	620	2.8	17.3	602.3
Year 24	51,097	223.6	3	671	2.8	18.8	651.9
Year 28	55,309	242.0	3	726	2.8	20.3	705.7
Year 32	59,868	262.0	3	786	2.8	22.0	763.8
Year 36	64,803	283.5	3	851	2.8	23.8	826.8
Ash & Maple Streets							
Year 0	15,884	88.0	3	264	2.0	5.3	258.7
Year 4	17,193	95.3	3	286	2.0	5.7	280.0
Year 8	18,611	103.1	3	309	2.0	6.2	303.1
Year 12	20,145	111.6	3	335	2.0	6.7	328.1
Year 16	21,805	120.8	3	362	2.0	7.2	355.2
Year 20	23,603	130.8	3	392	2.0	7.8	384.4
Year 24	25,548	141.5	3	425	2.0	8.5	416.1
Year 28	27,654	153.2	3	460	2.0	9.2	450.4
Year 32	29,934	165.8	3	498	2.0	10.0	487.6
Year 36	32,402	179.5	3	539	2.0	10.8	527.8
Total Delay (Both Legs)							
Year 0				681		17	664
Year 4				737		18	719
Year 8				798		20	778
Year 12				864		22	842
Year 16				935		23	912
Year 20				1012		25	987
Year 24				1095		27	1068
Year 28				1186		30	1156
Year 32				1283		32	1251
Year 36				1389		35	1355

Table C-32. Calculation of delay time on SR 395, SR 395 and 19th Avenue with four-year ACP inlay cycles.

SR 395 - SR 395 and 19th Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 395							
Year 0	13,370	58.0	3	174	19.0	33.1	140.9
Year 4	14,472	62.8	3	188	19.0	35.8	152.6
Year 8	15,665	68.0	3	204	19.0	38.7	165.1
Year 12	16,956	73.6	3	221	19.0	41.9	178.7
Year 16	18,354	79.6	3	239	19.0	45.4	193.5
Year 20	19,867	86.2	3	259	19.0	49.1	209.4
Year 24	21,505	93.3	3	280	19.0	53.2	226.7
Year 28	23,277	101.0	3	303	19.0	57.6	245.4
Year 32	25,196	109.3	3	328	19.0	62.3	265.6
Year 36	27,273	118.3	3	355	19.0	67.4	287.5
19th Avenue							
Year 0	10,000	44.0	3	132	5.0	6.6	125.4
Year 4	10,824	47.6	3	143	5.0	7.1	135.7
Year 8	11,717	51.6	3	155	5.0	7.7	146.9
Year 12	12,682	55.8	3	167	5.0	8.4	159.0
Year 16	13,728	60.4	3	181	5.0	9.1	172.1
Year 20	14,859	65.4	3	196	5.0	9.8	186.3
Year 24	16,084	70.8	3	212	5.0	10.6	201.7
Year 28	17,410	76.6	3	230	5.0	11.5	218.3
Year 32	18,845	82.9	3	249	5.0	12.4	236.3
Year 36	20,399	89.8	3	269	5.0	13.5	255.8
Total Delay (Both Legs)							
Year 0				306		40	266
Year 4				331		43	288
Year 8				359		46	312
Year 12				388		50	338
Year 16				420		54	366
Year 20				455		59	396
Year 24				492		64	428
Year 28				533		69	464
Year 32				577		75	502
Year 36				624		81	543

Table C-33. Calculation of delay time on SR 90, Broadway Avenue and Thierman Street with four-year ACP inlay cycles.

SR 90 - Broadway Avenue and Thierman Street

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
Broadway Avenue							
Year 0	17,000	74.0	3	222	17.0	37.7	184.3
Year 4	18,401	80.1	3	240	17.0	40.9	199.4
Year 8	19,918	86.7	3	260	17.0	44.2	215.9
Year 12	21,560	93.8	3	282	17.0	47.9	233.7
Year 16	23,337	101.6	3	305	17.0	51.8	252.9
Year 20	25,261	110.0	3	330	17.0	56.1	273.8
Year 24	27,343	119.0	3	357	17.0	60.7	296.4
Year 28	29,597	128.8	3	387	17.0	65.7	320.8
Year 32	32,037	139.5	3	418	17.0	71.1	347.2
Year 36	34,678	151.0	3	453	17.0	77.0	375.9
City Streets							
Year 0	2,500	11.0	3	33	30.0	9.9	23.1
Year 4	2,706	11.9	3	36	30.0	10.7	25.0
Year 8	2,929	12.9	3	39	30.0	11.6	27.1
Year 12	3,171	14.0	3	42	30.0	12.6	29.3
Year 16	3,432	15.1	3	45	30.0	13.6	31.7
Year 20	3,715	16.3	3	49	30.0	14.7	34.3
Year 24	4,021	17.7	3	53	30.0	15.9	37.2
Year 28	4,353	19.2	3	57	30.0	17.2	40.2
Year 32	4,711	20.7	3	62	30.0	18.7	43.5
Year 36	5,100	22.4	3	67	30.0	20.2	47.1
Total Delay (Both Legs)							
Year 0				255		48	207
Year 4				276		52	224
Year 8				299		56	243
Year 12				323		60	263
Year 16				350		65	285
Year 20				379		71	308
Year 24				410		77	334
Year 28				444		83	361
Year 32				481		90	391
Year 36				520		97	423

Table C-34. Calculation of delay time on SR 2, Division Street and Third Avenue with four-year ACP inlay cycles.

SR 2 - Division Street and Third Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 - Division							
Year 0	12,000	52.0	1	52	2.8	1.5	50.5
Year 4	12,989	56.3	1	56	2.8	1.6	54.7
Year 8	14,060	60.9	1	61	2.8	1.7	59.2
Year 12	15,219	65.9	1	66	2.8	1.8	64.1
Year 16	16,473	71.4	1	71	2.8	2.0	69.4
Year 20	17,831	77.3	1	77	2.8	2.2	75.1
Year 24	19,301	83.6	1	84	2.8	2.3	81.3
Year 28	20,892	90.5	1	91	2.8	2.5	88.0
Year 32	22,614	98.0	1	98	2.8	2.7	95.3
Year 36	24,479	106.1	1	106	2.8	3.0	103.1
Third Avenue							
Year 0	6,000	26.0	1	26	2.8	0.7	25.3
Year 4	6,495	28.1	1	28	2.8	0.8	27.4
Year 8	7,030	30.5	1	30	2.8	0.9	29.6
Year 12	7,609	33.0	1	33	2.8	0.9	32.1
Year 16	8,237	35.7	1	36	2.8	1.0	34.7
Year 20	8,916	38.6	1	39	2.8	1.1	37.6
Year 24	9,651	41.8	1	42	2.8	1.2	40.6
Year 28	10,446	45.3	1	45	2.8	1.3	44.0
Year 32	11,307	49.0	1	49	2.8	1.4	47.6
Year 36	12,239	53.0	1	53	2.8	1.5	51.6
Total Delay (Both Legs)							
Year 0				78		2	76
Year 4				84		2	82
Year 8				91		3	89
Year 12				99		3	96
Year 16				107		3	104
Year 20				116		3	113
Year 24				125		4	122
Year 28				136		4	132
Year 32				147		4	143
Year 36				159		4	155

Table C-35. Calculation of delay time on SR 27, Pines Road and Sprague Avenue with six-year ACP inlay cycles.

SR 27 - Pines Road and Sprague Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road							
Year 0	24,596	107.0	3	321	6.5	20.9	300.1
Year 6	27,699	120.5	3	361	6.5	23.5	338.0
Year 12	31,194	135.7	3	407	6.5	26.5	380.6
Year 18	35,129	152.8	3	458	6.5	29.8	428.7
Year 24	39,561	172.1	3	516	6.5	33.6	482.7
Year 30	44,552	193.8	3	581	6.5	37.8	543.7
Year 36	50,173	218.3	3	655	6.5	42.6	612.2
Sprague Avenue							
Year 0	24,596	107.0	3	321	6.5	20.9	300.1
Year 6	27,699	120.5	3	361	6.5	23.5	338.0
Year 12	31,194	135.7	3	407	6.5	26.5	380.6
Year 18	35,129	152.8	3	458	6.5	29.8	428.7
Year 24	39,561	172.1	3	516	6.5	33.6	482.7
Year 30	44,552	193.8	3	581	6.5	37.8	543.7
Year 36	50,173	218.3	3	655	6.5	42.6	612.2
Total Delay (Both Legs)							
Year 0				642		42	600
Year 6				723		47	676
Year 12				814		53	761
Year 18				917		60	857
Year 24				1033		67	965
Year 30				1163		76	1087
Year 36				1310		85	1224

Table C-36. Calculation of delay time on SR 27, Pines Road and Broadway Avenue with six-year ACP inlay cycles.

SR 27 - Pines Road and Broadway Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road							
Year 0	25,608	112.0	3	336	6.5	21.8	314.2
Year 6	28,839	126.1	3	378	6.5	24.6	353.8
Year 12	32,477	142.0	3	426	6.5	27.7	398.4
Year 18	36,575	160.0	3	480	6.5	31.2	448.7
Year 24	41,189	180.1	3	540	6.5	35.1	505.3
Year 30	46,385	202.9	3	609	6.5	39.6	569.1
Year 36	52,237	228.5	3	685	6.5	44.6	640.9
Broadway Avenue							
Year 0	12,804	56.0	3	168	6.5	10.9	157.1
Year 6	14,419	63.1	3	189	6.5	12.3	176.9
Year 12	16,239	71.0	3	213	6.5	13.8	199.2
Year 18	18,287	80.0	3	240	6.5	15.6	224.3
Year 24	20,594	90.1	3	270	6.5	17.6	252.7
Year 30	23,193	101.4	3	304	6.5	19.8	284.5
Year 36	26,119	114.2	3	343	6.5	22.3	320.4
Total Delay (Both Legs)							
Year 0				504		33	471
Year 6				568		37	531
Year 12				639		42	598
Year 18				720		47	673
Year 24				811		53	758
Year 30				913		59	854
Year 36				1028		67	961

Table C-37. Calculation of delay time on SR 2, Division Street and Francis Avenue with six-year ACP inlay cycles.

SR 2 - Division Street and Francis Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 - Division Street							
Year 0	36,726	160.0	3	480	2.6	12.5	467.5
Year 6	41,359	180.2	3	541	2.6	14.1	526.5
Year 12	46,577	202.9	3	609	2.6	15.8	592.9
Year 18	52,454	228.5	3	686	2.6	17.8	667.7
Year 24	59,071	257.3	3	772	2.6	20.1	752.0
Year 30	66,524	289.8	3	869	2.6	22.6	846.8
Year 36	74,917	326.4	3	979	2.6	25.5	953.7
SR 291 - Francis Ave.							
Year 0	31,768	139.0	3	417	2.8	11.7	405.3
Year 6	35,776	156.5	3	470	2.8	13.1	456.5
Year 12	40,290	176.3	3	529	2.8	14.8	514.0
Year 18	45,373	198.5	3	596	2.8	16.7	578.9
Year 24	51,097	223.6	3	671	2.8	18.8	651.9
Year 30	57,543	251.8	3	755	2.8	21.1	734.2
Year 36	64,803	283.5	3	851	2.8	23.8	826.8
Total Delay (Both Legs)							
Year 0				897		24	873
Year 6				1010		27	983
Year 12				1138		31	1107
Year 18				1281		35	1247
Year 24				1443		39	1404
Year 30				1625		44	1581
Year 36				1830		49	1781

Table C-38. Calculation of delay time on SR 291, Francis Avenue with Maple and Ash Streets with six-year ACP inlay cycles.

SR 291 - Francis Avenue with Maple and Ash Streets

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 291 - Francis Ave.							
Year 0	31,768	139.0	3	417	2.8	11.7	405.3
Year 6	35,776	156.5	3	470	2.8	13.1	456.5
Year 12	40,290	176.3	3	529	2.8	14.8	514.0
Year 18	45,373	198.5	3	596	2.8	16.7	578.9
Year 24	51,097	223.6	3	671	2.8	18.8	651.9
Year 30	57,543	251.8	3	755	2.8	21.1	734.2
Year 36	64,803	283.5	3	851	2.8	23.8	826.8
Ash & Maple Streets							
Year 0	15,884	88.0	3	264	2.0	5.3	258.7
Year 6	17,888	99.1	3	297	2.0	5.9	291.4
Year 12	20,145	111.6	3	335	2.0	6.7	328.1
Year 18	22,686	125.7	3	377	2.0	7.5	369.5
Year 24	25,548	141.5	3	425	2.0	8.5	416.1
Year 30	28,772	159.4	3	478	2.0	9.6	468.6
Year 36	32,402	179.5	3	539	2.0	10.8	527.8
Total Delay (Both Legs)							
Year 0				681		17	664
Year 6				767		19	748
Year 12				864		22	842
Year 18				973		24	948
Year 24				1095		27	1068
Year 30				1234		31	1203
Year 36				1389		35	1355

Table C-39. Calculation of delay time on SR 395, SR 395 and 19th Avenue with six-year ACP inlay cycles.

SR 395 - SR 395 and 19th Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 395							
Year 0	13,370	58.0	3	174	19.0	33.1	140.9
Year 6	15,057	65.3	3	196	19.0	37.2	158.7
Year 12	16,956	73.6	3	221	19.0	41.9	178.7
Year 18	19,096	82.8	3	249	19.0	47.2	201.3
Year 24	21,505	93.3	3	280	19.0	53.2	226.7
Year 30	24,218	105.1	3	315	19.0	59.9	255.3
Year 36	27,273	118.3	3	355	19.0	67.4	287.5
19th Avenue							
Year 0	10,000	44.0	3	132	5.0	6.6	125.4
Year 6	11,262	49.6	3	149	5.0	7.4	141.2
Year 12	12,682	55.8	3	167	5.0	8.4	159.0
Year 18	14,282	62.8	3	189	5.0	9.4	179.1
Year 24	16,084	70.8	3	212	5.0	10.6	201.7
Year 30	18,114	79.7	3	239	5.0	12.0	227.1
Year 36	20,399	89.8	3	269	5.0	13.5	255.8
Total Delay (Both Legs)							
Year 0				306		40	266
Year 6				345		45	300
Year 12				388		50	338
Year 18				437		57	380
Year 24				492		64	428
Year 30				554		72	482
Year 36				624		81	543

Table C-40. Calculation of delay time on SR 90, Broadway Avenue and Thierman Road with six-year ACP inlay cycles.

SR 90 - Broadway Avenue and Thierman Street

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
Broadway Avenue							
Year 0	17,000	74.0	3	222	17.0	37.7	184.3
Year 6	19,145	83.3	3	250	17.0	42.5	207.5
Year 12	21,560	93.8	3	282	17.0	47.9	233.7
Year 18	24,280	105.7	3	317	17.0	53.9	263.2
Year 24	27,343	119.0	3	357	17.0	60.7	296.4
Year 30	30,793	134.0	3	402	17.0	68.4	333.8
Year 36	34,678	151.0	3	453	17.0	77.0	375.9
City Streets							
Year 0	2,500	11.0	3	33	30.0	9.9	23.1
Year 6	2,815	12.4	3	37	30.0	11.1	26.0
Year 12	3,171	14.0	3	42	30.0	12.6	29.3
Year 18	3,571	15.7	3	47	30.0	14.1	33.0
Year 24	4,021	17.7	3	53	30.0	15.9	37.2
Year 30	4,528	19.9	3	60	30.0	17.9	41.8
Year 36	5,100	22.4	3	67	30.0	20.2	47.1
Total Delay (Both Legs)							
Year 0				255		48	207
Year 6				287		54	234
Year 12				323		60	263
Year 18				364		68	296
Year 24				410		77	334
Year 30				462		86	376
Year 36				520		97	423

Table C-41. Calculation of delay time on SR 2, Division Street and Third Avenue with six-year ACP inlay cycles.

SR 2 - Division Street and Third Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 - Division							
Year 0	12,000	52.0	1	52	2.8	1.5	50.5
Year 6	13,514	58.6	1	59	2.8	1.6	56.9
Year 12	15,219	65.9	1	66	2.8	1.8	64.1
Year 18	17,139	74.3	1	74	2.8	2.1	72.2
Year 24	19,301	83.6	1	84	2.8	2.3	81.3
Year 30	21,736	94.2	1	94	2.8	2.6	91.6
Year 36	24,479	106.1	1	106	2.8	3.0	103.1
Third Avenue							
Year 0	6,000	26.0	1	26	2.8	0.7	25.3
Year 6	6,757	29.3	1	29	2.8	0.8	28.5
Year 12	7,609	33.0	1	33	2.8	0.9	32.1
Year 18	8,569	37.1	1	37	2.8	1.0	36.1
Year 24	9,651	41.8	1	42	2.8	1.2	40.6
Year 30	10,868	47.1	1	47	2.8	1.3	45.8
Year 36	12,239	53.0	1	53	2.8	1.5	51.6
Total Delay (Both Legs)							
Year 0				78		2	76
Year 6				88		2	85
Year 12				99		3	96
Year 18				111		3	108
Year 24				125		4	122
Year 30				141		4	137
Year 36				159		4	155

Table C-42. Calculation of delay time on SR 27, Pines Road and Sprague Avenue with eight-year ACP inlay cycles.

SR 27 - Pines Road and Sprague Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road							
Year 0	24,596	107.0	3	321	6.5	20.9	300.1
Year 8	28,818	125.4	3	376	6.5	24.4	351.7
Year 16	33,765	146.9	3	441	6.5	28.6	412.0
Year 24	39,561	172.1	3	516	6.5	33.6	482.7
Year 32	46,352	201.6	3	605	6.5	39.3	565.6
Sprague Avenue							
Year 0	24,596	107.0	3	321	6.5	20.9	300.1
Year 8	28,818	125.4	3	376	6.5	24.4	351.7
Year 16	33,765	146.9	3	441	6.5	28.6	412.0
Year 24	39,561	172.1	3	516	6.5	33.6	482.7
Year 32	46,352	201.6	3	605	6.5	39.3	565.6
Total Delay (Both Legs)							
Year 0				642		42	600
Year 8				752		49	703
Year 16				881		57	824
Year 24				1033		67	965
Year 32				1210		79	1131

Table C-43. Calculation of delay time on SR 27, Pines Road and Broadway Avenue with eight-year ACP inlay cycles.

SR 27 - Pines Road and Broadway Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 27 - Pines Road							
Year 0	25,608	112.0	3	336	6.5	21.8	314.2
Year 8	30,004	131.2	3	394	6.5	25.6	368.1
Year 16	35,154	153.8	3	461	6.5	30.0	431.3
Year 24	41,189	180.1	3	540	6.5	35.1	505.3
Year 32	48,259	211.1	3	633	6.5	41.2	592.0
Broadway Avenue							
Year 0	12,804	56.0	3	168	6.5	10.9	157.1
Year 8	15,002	65.6	3	197	6.5	12.8	184.0
Year 16	17,577	76.9	3	231	6.5	15.0	215.6
Year 24	20,594	90.1	3	270	6.5	17.6	252.7
Year 32	24,130	105.5	3	317	6.5	20.6	296.0
Total Delay (Both Legs)							
Year 0				504		33	471
Year 8				591		38	552
Year 16				692		45	647
Year 24				811		53	758
Year 32				950		62	888

Table C-44. Calculation of delay time on SR 2, Division Street and Francis Avenue with eight-year ACP inlay cycles.

SR 2 - Division Street and Francis Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 - Division Street							
Year 0	36,726	160.0	3	480	2.6	12.5	467.5
Year 8	43,030	187.5	3	562	2.6	14.6	547.8
Year 16	50,417	219.6	3	659	2.6	17.1	641.8
Year 24	59,071	257.3	3	772	2.6	20.1	752.0
Year 32	69,212	301.5	3	905	2.6	23.5	881.1
SR 291 - Francis Ave.							
Year 0	31,768	139.0	3	417	2.8	11.7	405.3
Year 8	37,221	162.9	3	489	2.8	13.7	474.9
Year 16	43,611	190.8	3	572	2.8	16.0	556.4
Year 24	51,097	223.6	3	671	2.8	18.8	651.9
Year 32	59,868	262.0	3	786	2.8	22.0	763.8
Total Delay (Both Legs)							
Year 0				897		24	873
Year 8				1051		28	1023
Year 16				1231		33	1198
Year 24				1443		39	1404
Year 32				1690		46	1645

Table C-45. Calculation of delay time on SR 291, Francis Avenue with Maple and Ash Streets with eight-year ACP inlay cycles.

SR 291 - Francis Avenue with Maple and Ash Streets

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 291 - Francis Ave.							
Year 0	31,768	139.0	3	417	2.8	11.7	405.3
Year 8	37,221	162.9	3	489	2.8	13.7	474.9
Year 16	43,611	190.8	3	572	2.8	16.0	556.4
Year 24	51,097	223.6	3	671	2.8	18.8	651.9
Year 32	59,868	262.0	3	786	2.8	22.0	763.8
Ash & Maple Streets							
Year 0	15,884	88.0	3	264	2.0	5.3	258.7
Year 8	18,611	103.1	3	309	2.0	6.2	303.1
Year 16	21,805	120.8	3	362	2.0	7.2	355.2
Year 24	25,548	141.5	3	425	2.0	8.5	416.1
Year 32	29,934	165.8	3	498	2.0	10.0	487.6
Total Delay (Both Legs)							
Year 0				681		17	664
Year 8				798		20	778
Year 16				935		23	912
Year 24				1095		27	1068
Year 32				1283		32	1251

Table C-46. Calculation of delay time on SR 395, SR 395 and 19th Avenue with eight-year ACP inlay cycles.

SR 395 - SR 395 and 19th Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 395							
Year 0	13,370	58.0	3	174	19.0	33.1	140.9
Year 8	15,665	68.0	3	204	19.0	38.7	165.1
Year 16	18,354	79.6	3	239	19.0	45.4	193.5
Year 24	21,505	93.3	3	280	19.0	53.2	226.7
Year 32	25,196	109.3	3	328	19.0	62.3	265.6
19th Avenue							
Year 0	10,000	44.0	3	132	5.0	6.6	125.4
Year 8	11,717	51.6	3	155	5.0	7.7	146.9
Year 16	13,728	60.4	3	181	5.0	9.1	172.1
Year 24	16,084	70.8	3	212	5.0	10.6	201.7
Year 32	18,845	82.9	3	249	5.0	12.4	236.3
Total Delay (Both Legs)							
Year 0				306		40	266
Year 8				359		46	312
Year 16				420		54	366
Year 24				492		64	428
Year 32				577		75	502

Table C-47. Calculation of delay time on SR 90, Broadway Avenue and Thierman Street with eight-year ACP inlay cycles.

SR 90 - Broadway Avenue and Thierman Street

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
Broadway Avenue							
Year 0	17,000	74.0	3	222	17.0	37.7	184.3
Year 8	19,918	86.7	3	260	17.0	44.2	215.9
Year 16	23,337	101.6	3	305	17.0	51.8	252.9
Year 24	27,343	119.0	3	357	17.0	60.7	296.4
Year 32	32,037	139.5	3	418	17.0	71.1	347.2
City Streets							
Year 0	2,500	11.0	3	33	30.0	9.9	23.1
Year 8	2,929	12.9	3	39	30.0	11.6	27.1
Year 16	3,432	15.1	3	45	30.0	13.6	31.7
Year 24	4,021	17.7	3	53	30.0	15.9	37.2
Year 32	4,711	20.7	3	62	30.0	18.7	43.5
Total Delay (Both Legs)							
Year 0				255		48	207
Year 8				299		56	243
Year 16				350		65	285
Year 24				410		77	334
Year 32				481		90	391

Table C-48. Calculation of delay time on SR 2, Division Street and Third Avenue with eight-year ACP inlay cycles.

SR 2 - Division Street and Third Avenue

Approach	Average Daily Traffic	Delay per Day (hours)	Number of Days	Total Delay (hours)	Percent Trucks (%)	Truck Delay (hours)	Auto Delay (hours)
SR 2 - Division							
Year 0	12,000	52.0	1	52	2.8	1.5	50.5
Year 8	14,060	60.9	1	61	2.8	1.7	59.2
Year 16	16,473	71.4	1	71	2.8	2.0	69.4
Year 24	19,301	83.6	1	84	2.8	2.3	81.3
Year 32	22,614	98.0	1	98	2.8	2.7	95.3
Third Avenue							
Year 0	6,000	26.0	1	26	2.0	0.5	25.5
Year 8	7,030	30.5	1	30	2.0	0.6	29.9
Year 16	8,237	35.7	1	36	2.0	0.7	35.0
Year 24	9,651	41.8	1	42	2.0	0.8	41.0
Year 32	11,307	49.0	1	49	2.0	1.0	48.0
Total Delay (Both Legs)							
Year 0				78		2	76
Year 8				91		2	89
Year 16				107		3	104
Year 24				125		3	122
Year 32				147		4	143

Table C-49. Nightly delay time for ACP inlay on SR 27, Pines Road and Sprague Avenue – Pines Road approaches.

SR 27 - Pines Road and Sprague Avenue

Pines Road Approaches

ADT = 24,596

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	155	1	155	2.6
1-2	0.5	86	1	86	1.4
2-3	0.4	69	1	69	1.2
3-4	0.4	69	1	69	1.2
4-5	0.6	103	1	103	1.7
5-6	1.8	310	1	310	5.2
6-7	4.4	758	0	0	0.0
7-8	6.2	1,067	0	0	0.0
8-9	5.7	981	0	0	0.0
9-10	5.1	878	0	0	0.0
10-11	5.2	895	0	0	0.0
11-12	5.6	964	0	0	0.0
12-13	6.0	1,033	0	0	0.0
13-14	5.9	1,016	0	0	0.0
14-15	6.4	1,102	0	0	0.0
15-16	7.4	1,274	0	0	0.0
16-17	7.8	1,343	0	0	0.0
17-18	7.5	1,291	0	0	0.0
18-19	5.9	1,016	2	2032	33.9
19-20	4.8	826	2	1652	27.5
20-21	4.0	689	1	689	11.5
21-22	3.3	568	1	568	9.5
22-23	2.4	413	1	413	6.9
23-24	1.7	293	1	293	4.9
Totals		**17,200**		**6,439**	**107**

Table C-50. Nightly delay time for ACP inlay on SR 27, Pines Road and Sprague Avenue – Sprague Avenue approaches.

SR 27 - Pines Road and Sprague Avenue

Sprague Avenue Approaches

ADT = 24,596

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	155	1	155	2.6
1-2	0.5	86	1	86	1.4
2-3	0.4	69	1	69	1.2
3-4	0.4	69	1	69	1.2
4-5	0.6	103	1	103	1.7
5-6	1.8	310	1	310	5.2
6-7	4.4	758	0	0	0.0
7-8	6.2	1,067	0	0	0.0
8-9	5.7	981	0	0	0.0
9-10	5.1	878	0	0	0.0
10-11	5.2	895	0	0	0.0
11-12	5.6	964	0	0	0.0
12-13	6.0	1,033	0	0	0.0
13-14	5.9	1,016	0	0	0.0
14-15	6.4	1,102	0	0	0.0
15-16	7.4	1,274	0	0	0.0
16-17	7.8	1,343	0	0	0.0
17-18	7.5	1,291	0	0	0.0
18-19	5.9	1,016	2	2032	33.9
19-20	4.8	826	2	1652	27.5
20-21	4.0	689	1	689	11.5
21-22	3.3	568	1	568	9.5
22-23	2.4	413	1	413	6.9
23-24	1.7	293	1	293	4.9
Totals		**17,200**		**6,439**	**107**

Table C-51. Nightly delay time for ACP inlay on SR 27, Pines Road and Broadway Avenue – Pines Road approaches.

SR 27 - Pines Road and Broadway Avenue

Pines Road Approach

ADT = 25,608

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	161	1	161	2.7
1-2	0.5	90	1	90	1.5
2-3	0.4	72	1	72	1.2
3-4	0.4	72	1	72	1.2
4-5	0.6	108	1	108	1.8
5-6	1.8	323	1	323	5.4
6-7	4.4	789	0	0	0.0
7-8	6.2	1,111	0	0	0.0
8-9	5.7	1,022	0	0	0.0
9-10	5.1	914	0	0	0.0
10-11	5.2	932	0	0	0.0
11-12	5.6	1,004	0	0	0.0
12-13	6.0	1,076	0	0	0.0
13-14	5.9	1,058	0	0	0.0
14-15	6.4	1,147	0	0	0.0
15-16	7.4	1,326	0	0	0.0
16-17	7.8	1,398	0	0	0.0
17-18	7.5	1,344	0	0	0.0
18-19	5.9	1,058	2	2116	35.3
19-20	4.8	860	2	1720	28.7
20-21	4.0	717	1	717	12.0
21-22	3.3	592	1	592	9.9
22-23	2.4	430	1	430	7.2
23-24	1.7	305	1	305	5.1
Totals		**17,908**		**6,706**	**112**

Table C-52. Nightly delay time for ACP inlay on SR 27, Pines Road and Broadway Avenue – Broadway Avenue approaches.

SR 27 - Pines Road and Broadway Avenue

Broadway Avenue Approaches

ADT = 12,804

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	81	1	81	1.4
1-2	0.5	45	1	45	0.8
2-3	0.4	36	1	36	0.6
3-4	0.4	36	1	36	0.6
4-5	0.6	54	1	54	0.9
5-6	1.8	161	1	161	2.7
6-7	4.4	394	0	0	0.0
7-8	6.2	556	0	0	0.0
8-9	5.7	511	0	0	0.0
9-10	5.1	457	0	0	0.0
10-11	5.2	466	0	0	0.0
11-12	5.6	502	0	0	0.0
12-13	6.0	538	0	0	0.0
13-14	5.9	529	0	0	0.0
14-15	6.4	574	0	0	0.0
15-16	7.4	663	0	0	0.0
16-17	7.8	699	0	0	0.0
17-18	7.5	672	0	0	0.0
18-19	5.9	529	2	1058	17.6
19-20	4.8	430	2	860	14.3
20-21	4.0	359	1	359	6.0
21-22	3.3	296	1	296	4.9
22-23	2.4	215	1	215	3.6
23-24	1.7	152	1	152	2.5
Totals		**8,954**		**3353**	**56**

Table C-53. Nightly delay time for ACP inlay on SR 2, Division Street and Francis Avenue – Division Street approaches.

SR 2 – Division Street and Francis Avenue

Division Street Approaches

ADT = 36,726

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	231	1	231	3.9
1-2	0.5	129	1	129	2.2
2-3	0.4	103	1	103	1.7
3-4	0.4	103	1	103	1.7
4-5	0.6	154	1	154	2.6
5-6	1.8	463	1	463	7.7
6-7	4.4	1,131	0	0	0.0
7-8	6.2	1,594	0	0	0.0
8-9	5.7	1,465	0	0	0.0
9-10	5.1	1,311	0	0	0.0
10-11	5.2	1,337	0	0	0.0
11-12	5.6	1,440	0	0	0.0
12-13	6.0	1,542	0	0	0.0
13-14	5.9	1,517	0	0	0.0
14-15	6.4	1,645	0	0	0.0
15-16	7.4	1,902	0	0	0.0
16-17	7.8	2,005	0	0	0.0
17-18	7.5	1,928	0	0	0.0
18-19	5.9	1,517	2	3,034	50.6
19-20	4.8	1,234	2	2,468	41.1
20-21	4.0	1,028	1	1,028	17.1
21-22	3.3	848	1	848	14.1
22-23	2.4	617	1	617	10.3
23-24	1.7	437	1	437	7.3
Totals		**25,682**		**9,615**	**160**

Table C-54. Nightly delay time for ACP inlay on SR 2, Division Street and Francis Avenue – Francis Avenue approaches.

SR 2 – Division Street and Francis Avenue

Francis Avenue Approaches

ADT = 31,768

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	200	1	200	3.3
1-2	0.5	111	1	111	1.9
2-3	0.4	89	1	89	1.5
3-4	0.4	89	1	89	1.5
4-5	0.6	133	1	133	2.2
5-6	1.8	400	1	400	6.7
6-7	4.4	978	0	0	0.0
7-8	6.2	1,379	0	0	0.0
8-9	5.7	1,268	0	0	0.0
9-10	5.1	1,134	0	0	0.0
10-11	5.2	1,156	0	0	0.0
11-12	5.6	1,245	0	0	0.0
12-13	6.0	1,334	0	0	0.0
13-14	5.9	1,312	0	0	0.0
14-15	6.4	1,423	0	0	0.0
15-16	7.4	1,646	0	0	0.0
16-17	7.8	1,735	0	0	0.0
17-18	7.5	1,668	0	0	0.0
18-19	5.9	1,312	2	2,624	43.7
19-20	4.8	1,067	2	2,134	35.6
20-21	4.0	890	1	890	14.8
21-22	3.3	734	1	734	12.2
22-23	2.4	534	1	534	8.9
23-24	1.7	378	1	378	6.3
Totals		**22,215**		**8,316**	**139**

Table C-55. Nightly delay time for ACP inlay on SR 291, Francis Avenue with Maple and Ash Streets – Francis Avenue approaches.

SR 291 – Francis Avenue with Maple and Ash Streets

Francis Avenue Approaches

ADT = 31,768

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	200	1	200	3.3
1-2	0.5	111	1	111	1.9
2-3	0.4	89	1	89	1.5
3-4	0.4	89	1	89	1.5
4-5	0.6	133	1	133	2.2
5-6	1.8	400	1	400	6.7
6-7	4.4	978	0	0	0.0
7-8	6.2	1,379	0	0	0.0
8-9	5.7	1,268	0	0	0.0
9-10	5.1	1,134	0	0	0.0
10-11	5.2	1,156	0	0	0.0
11-12	5.6	1,245	0	0	0.0
12-13	6.0	1,334	0	0	0.0
13-14	5.9	1,312	0	0	0.0
14-15	6.4	1,423	0	0	0.0
15-16	7.4	1,646	0	0	0.0
16-17	7.8	1,735	0	0	0.0
17-18	7.5	1,668	0	0	0.0
18-19	5.9	1,312	2	2,624	43.7
19-20	4.8	1,067	2	2,134	35.6
20-21	4.0	890	1	890	14.8
21-22	3.3	734	1	734	12.2
22-23	2.4	534	1	534	8.9
23-24	1.7	378	1	378	6.3
Totals		**22,215**		**8,316**	**139**

Table C-56. Nightly delay time for ACP inlay on SR 291, Francis Avenue with Maple and Ash Streets – city streets approaches.

SR 291 - Francis Avenue with Maple and Ash Streets

City Streets Approaches

ADT = 15,884

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	100	1	100	1.7
1-2	0.5	56	1	56	0.9
2-3	0.4	44	1	44	0.7
3-4	0.4	44	1	44	0.7
4-5	0.6	67	1	67	1.1
5-6	1.8	200	1	200	3.3
6-7	4.4	489	0	0	0.0
7-8	6.2	689	0	0	0.0
8-9	5.7	634	0	0	0.0
9-10	5.1	567	0	0	0.0
10-11	5.2	578	0	0	0.0
11-12	5.6	623	0	0	0.0
12-13	6.0	667	0	0	0.0
13-14	5.9	656	0	0	0.0
14-15	6.4	712	0	0	0.0
15-16	7.4	823	0	0	0.0
16-17	7.8	867	0	0	0.0
17-18	7.5	834	2	1,668	27.8
18-19	5.9	656	2	1,312	21.9
19-20	4.8	534	1	534	8.9
20-21	4.0	445	1	445	7.4
21-22	3.3	367	1	367	6.1
22-23	2.4	267	1	267	4.4
23-24	1.7	189	1	189	3.2
Totals		**11,108**		**5,293**	**88**

Table C-57. Nightly delay time for ACP inlay on SR 395, SR 395 with 19th Avenue – SR 395 approaches.

SR 395 - SR 395 and 19th Avenue

SR 395 Approach Legs

ADT = 13,370

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	84	1	84	1.4
1-2	0.5	47	1	47	0.8
2-3	0.4	37	1	37	0.6
3-4	0.4	37	1	37	0.6
4-5	0.6	56	1	56	0.9
5-6	1.8	168	1	168	2.8
6-7	4.4	412	0	0	0.0
7-8	6.2	580	0	0	0.0
8-9	5.7	533	0	0	0.0
9-10	5.1	477	0	0	0.0
10-11	5.2	487	0	0	0.0
11-12	5.6	524	0	0	0.0
12-13	6.0	562	0	0	0.0
13-14	5.9	552	0	0	0.0
14-15	6.4	599	0	0	0.0
15-16	7.4	693	0	0	0.0
16-17	7.8	730	0	0	0.0
17-18	7.5	702	0	0	0.0
18-19	5.9	552	2	1,104	18.4
19-20	4.8	449	2	898	15.0
20-21	4.0	374	1	374	6.2
21-22	3.3	309	1	309	5.2
22-23	2.4	225	1	225	3.8
23-24	1.7	159	1	159	2.7
Totals		**9,350**		**3,498**	**58**

Table C-58. Nightly delay time for ACP inlay on SR 395, SR 395 with 19th Avenue – 19th Avenue approaches.

SR 395 - SR 395 and 19th Avenue

19th Avenue Approach Legs

ADT = 10,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	63	1	63	1.1
1-2	0.5	35	1	35	0.6
2-3	0.4	28	1	28	0.5
3-4	0.4	28	1	28	0.5
4-5	0.6	42	1	42	0.7
5-6	1.8	126	1	126	2.1
6-7	4.4	308	0	0	0.0
7-8	6.2	434	0	0	0.0
8-9	5.7	399	0	0	0.0
9-10	5.1	357	0	0	0.0
10-11	5.2	364	0	0	0.0
11-12	5.6	392	0	0	0.0
12-13	6.0	420	0	0	0.0
13-14	5.9	413	0	0	0.0
14-15	6.4	448	0	0	0.0
15-16	7.4	518	0	0	0.0
16-17	7.8	546	0	0	0.0
17-18	7.5	525	0	0	0.0
18-19	5.9	413	2	826	13.8
19-20	4.8	336	2	672	11.2
20-21	4.0	280	1	280	4.7
21-22	3.3	231	1	231	3.9
22-23	2.4	168	1	168	2.8
23-24	1.7	119	1	119	2.0
Totals		**6,993**		**2,618**	**44**

Table C-59. Nightly delay time for ACP inlay on SR 90, Broadway Avenue and Thierman Roads – Broadway Avenue approaches.

SR 90 - Broadway Avenue and Thierman Road

Broadway Avenue Approaches

ADT = 17,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	107	1	107	1.8
1-2	0.5	60	1	60	1.0
2-3	0.4	48	1	48	0.8
3-4	0.4	48	1	48	0.8
4-5	0.6	71	1	71	1.2
5-6	1.8	214	1	214	3.6
6-7	4.4	524	0	0	0.0
7-8	6.2	738	0	0	0.0
8-9	5.7	678	0	0	0.0
9-10	5.1	607	0	0	0.0
10-11	5.2	619	0	0	0.0
11-12	5.6	666	0	0	0.0
12-13	6.0	714	0	0	0.0
13-14	5.9	702	0	0	0.0
14-15	6.4	762	0	0	0.0
15-16	7.4	881	0	0	0.0
16-17	7.8	928	0	0	0.0
17-18	7.5	893	0	0	0.0
18-19	5.9	702	2	1,402	23.4
19-20	4.8	571	2	1,142	19.0
20-21	4.0	476	1	476	7.9
21-22	3.3	393	1	393	6.6
22-23	2.4	286	1	286	4.8
23-24	1.7	202	1	202	3.4
Totals		**11,888**		**4,451**	**74**

Table C-60. Nightly delay time for ACP inlay on SR 90, Broadway Avenue and Thierman Roads – City Streets approaches.

SR 90 - Broadway Avenue and Thierman Road

City Street Approaches

ADT = 2,500

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	16	1	16	0.3
1-2	0.5	9	1	9	0.1
2-3	0.4	7	1	7	0.1
3-4	0.4	7	1	7	0.1
4-5	0.6	11	1	11	0.2
5-6	1.8	32	1	32	0.5
6-7	4.4	77	0	0	0.0
7-8	6.2	109	0	0	0.0
8-9	5.7	100	0	0	0.0
9-10	5.1	89	0	0	0.0
10-11	5.2	91	0	0	0.0
11-12	5.6	98	0	0	0.0
12-13	6.0	105	0	0	0.0
13-14	5.9	103	0	0	0.0
14-15	6.4	112	0	0	0.0
15-16	7.4	130	0	0	0.0
16-17	7.8	137	0	0	0.0
17-18	7.5	131	0	0	0.0
18-19	5.9	103	2	206	3.4
19-20	4.8	84	2	168	2.8
20-21	4.0	70	1	70	1.2
21-22	3.3	58	1	58	1.0
22-23	2.4	42	1	42	0.7
23-24	1.7	30	1	30	0.5
Totals		**1,748**		**656**	**11**

Table C-61. Nightly delay time for ACP inlay on SR 2, Division Street and Third Avenue – Division Street approaches.

SR 2 – Division Street and Third Avenue

Division Approach Legs

ADT = 12,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	76	1	76	1.3
1-2	0.5	42	1	42	0.7
2-3	0.4	34	1	34	0.6
3-4	0.4	34	1	34	0.6
4-5	0.6	50	1	50	0.8
5-6	1.8	151	1	151	2.5
6-7	4.4	370	0	0	0.0
7-8	6.2	521	0	0	0.0
8-9	5.7	479	0	0	0.0
9-10	5.1	428	0	0	0.0
10-11	5.2	437	0	0	0.0
11-12	5.6	470	0	0	0.0
12-13	6.0	504	0	0	0.0
13-14	5.9	496	0	0	0.0
14-15	6.4	538	0	0	0.0
15-16	7.4	622	0	0	0.0
16-17	7.8	655	0	0	0.0
17-18	7.5	630	0	0	0.0
18-19	5.9	496	2	992	16.5
19-20	4.8	403	2	806	13.4
20-21	4.0	336	1	336	5.6
21-22	3.3	277	1	277	4.6
22-23	2.4	202	1	202	3.4
23-24	1.7	143	1	143	2.4
Totals		**8,392**		**3,142**	**52**

Table C-62. Nightly delay time for ACP inlay on SR 2, Division Street and Third Avenue – Third Avenue approaches.

SR 2 – Division Street and Third Avenue

Third Avenue Approaches

ADT = 6,000

Hour	Hourly Distribution	Hourly ADT	Delay per Vehicle (minutes)	Total Delay (minutes)	Total Delay (hours)
12-1	0.9	38	1	38	0.6
1-2	0.5	21	1	21	0.4
2-3	0.4	17	1	17	0.3
3-4	0.4	17	1	17	0.3
4-5	0.6	25	1	25	0.4
5-6	1.8	76	1	76	1.3
6-7	4.4	185	0	0	0.0
7-8	6.2	260	0	0	0.0
8-9	5.7	239	0	0	0.0
9-10	5.1	214	0	0	0.0
10-11	5.2	218	0	0	0.0
11-12	5.6	235	0	0	0.0
12-13	6.0	252	0	0	0.0
13-14	5.9	248	0	0	0.0
14-15	6.4	269	0	0	0.0
15-16	7.4	311	0	0	0.0
16-17	7.8	328	0	0	0.0
17-18	7.5	315	0	0	0.0
18-19	5.9	248	2	496	8.3
19-20	4.8	202	2	404	6.7
20-21	4.0	168	1	168	2.8
21-22	3.3	139	1	139	2.3
22-23	2.4	101	1	101	1.7
23-24	1.7	71	1	71	1.2
Totals		**4,197**		**1,573**	**26**

APPENDIX D – USER DELAY COST CALCULATIONS

Tables D-1 to D-22 show the calculations used to compute total delay costs at each intersection for PCCP and ACP reconstruction or ACP inlay at four-, six-, or eight-year cycles.

Tables	**Calculation**
D-1	Delay costs for PCCP or ACP initial construction.
D-2 to D-8	Calculation of delay costs at each intersection for ACP inlays at four year cycles.
D-9 to D-15	Calculation of delay costs at each intersection for ACP inlays at six year cycles.
D-16 to D-22	Calculation of delay costs at each intersection for ACP inlays at eight year cycles.

Table D-1. Delay costs for initial PCCP or ACP construction.

SR 27 and Sprague Avenue

Delay Type	Hours	Delay Cost ($/hr)	Delay Cost ($)
Truck Delay	663	18.50	12,265.50
Auto Delay	9537	11.50	109,675.50
Total Delay Cost			**$121,941**

SR 27 and Broadway Avenue

Delay Type	Hours	Delay Cost ($/hr)	Delay Cost ($)
Truck Delay	1208	18.50	22,348.00
Auto Delay	17382	11.50	199,893.00
Total Delay Cost			**$222,241**

Division Street and Francis Avenue

Delay Type	Hours	Delay Cost ($/hr)	Delay Cost ($)
Truck Delay	1733	18.50	32,060.50
Auto Delay	62617	11.50	720,095.50
Total Delay Cost			**$752,156.00**

Francis Avenue with Maple and Ash Streets

Delay Type	Hours	Delay Cost ($/hr)	Delay Cost ($)
Truck Delay	402	18.50	7,437.00
Auto Delay	15471	11.50	177,916.50
Total Delay Cost			**$185,353.50**

Table D-1 (cont.). Delay costs for initial PCCP or ACP construction.

SR 395 and 19th Avenue

Delay Type	Hours	Delay Cost ($/hr)	Delay Cost ($)
Truck Delay	518	18.50	9,583.00
Auto Delay	3467	11.50	39,870.50
Total Delay Cost			**$49,454**

Broadway Avenue and Thierman Road

Delay Type	Hours	Delay Cost ($/hr)	Delay Cost ($)
Truck Delay	1397	18.50	25,844.50
Auto Delay	6088	11.50	70,012.00
Total Delay Cost			**$92,857**

Division Street and Third Avenue

Delay Type	Hours	Delay Cost ($/hr)	Delay Cost ($)
Truck Delay	296	18.50	5,476.00
Auto Delay	5084	11.50	58,466.00
Total Delay Cost			**$63,942**

Table D-2. Calculation of delay costs on SR 27, Pines Road and Sprague Avenue for ACP inlays with four-year cycles.

SR 27 - Pines Road and Sprague Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	42		18.50	$777	
Auto Delay		600	11.50	$6,900	
					$7,677
Year 4					
Truck Delay	45		18.50	$833	
Auto Delay		650	11.50	$7,475	
					$8,308
Year 8					
Truck Delay	49		18.50	$907	
Auto Delay		703	11.50	$8,085	
					$8,991
Year 12					
Truck Delay	53		18.50	$981	
Auto Delay		761	11.50	$8,752	
					$9,732
Year 16					
Truck Delay	57		18.50	$1,055	
Auto Delay		824	11.50	$9,476	
					$10,531

Table D-2 (cont.). Calculation of delay costs on SR 27, Pines Road and Sprague Avenue for ACP inlays with four-year cycles.

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 20					
Truck Delay	62		18.50	$1,147	
Auto Delay		892	11.50	$10,258	
					$11,405
Year 24					
Truck Delay	67		18.50	$1,240	
Auto Delay		965	11.50	$11,098	
					$12,337
Year 28					
Truck Delay	73		18.50	$1,351	
Auto Delay		1045	11.50	$12,018	
					$13,368
Year 32					
Truck Delay	79		18.50	$1,462	
Auto Delay		1131	11.50	$13,007	
					$14,468
Year 36					
Truck Delay	85		18.50	$1,573	
Auto Delay		1224	11.50	$14,076	
					$15,649

Table D-3. Calculation of delay costs on SR 27, Pines Road and Broadway Avenue for ACP inlays with four-year cycles.

SR 27 - Pines Road and Broadway Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	33		18.50	$611	
Auto Delay		471	11.50	$5,417	
					$6,027
Year 4					
Truck Delay	35		18.50	$648	
Auto Delay		510	11.50	$5,865	
					$6,513
Year 8					
Truck Delay	38		18.50	$703	
Auto Delay		552	11.50	$6,348	
					$7,051
Year 12					
Truck Delay	42		18.50	$777	
Auto Delay		598	11.50	$6,877	
					$7,654
Year 16					
Truck Delay	45		18.50	$833	
Auto Delay		647	11.50	$7,441	
					$8,273

Table D-3 (cont.). Calculation of delay costs on SR 27, Pines Road and Broadway Avenue for ACP inlays with four-year cycles.

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 20					
Truck Delay	49		18.50	$907	
Auto Delay		700	11.50	$8,050	
					$8,957
Year 24					
Truck Delay	53		18.50	$981	
Auto Delay		758	11.50	$8,717	
					$9,698
Year 28					
Truck Delay	57		18.50	$1,055	
Auto Delay		820	11.50	$9,430	
					$10,485
Year 32					
Truck Delay	62		18.50	$1,147	
Auto Delay		888	11.50	$10,212	
					$11,359
Year 36					
Truck Delay	67		18.50	$1,240	
Auto Delay		961	11.50	$11,052	
					$12,291

Table D-4. Calculation of delay costs on SR 2, Division Street and Francis Avenue for ACP inlays with four-year cycles.

SR 2 - Division Street and Francis Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	24		18.50	$444	
Auto Delay		873	11.50	$10,040	
					$10,484
Year 4					
Truck Delay	26		18.50	$481	
Auto Delay		945	11.50	$10,868	
					$11,349
Year 8					
Truck Delay	28		18.50	$518	
Auto Delay		1023	11.50	$11,765	
					$12,283
Year 12					
Truck Delay	31		18.50	$574	
Auto Delay		1107	11.50	$12,731	
					$13,304
Year 16					
Truck Delay	33		18.50	$611	
Auto Delay		1198	11.50	$13,777	
					$14,388

Table D-4. Calculation of delay costs on SR 2, Division Street and Francis Avenue for ACP inlays with four-year cycles.

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 20					
Truck Delay	36		18.50	$666	
Auto Delay		1297	11.50	$14,916	
					$15,582
Year 24					
Truck Delay	39		18.50	$722	
Auto Delay		1404	11.50	$16,146	
					$16,868
Year 28					
Truck Delay	42		18.50	$777	
Auto Delay		1520	11.50	$17,480	
					$18,257
Year 32					
Truck Delay	46		18.50	$851	
Auto Delay		1645	11.50	$18,918	
					$19,769
Year 36					
Truck Delay	49		18.50	$907	
Auto Delay		1781	11.50	$20,482	
					$21,388

Table D-5. Calculation of delay costs on SR 291, Francis Avenue with Maple and Ash Streets for ACP inlays with four-year cycles.

SR 2 – Francis Avenue with Maple and Ash Streets

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	17		18.50	$315	
Auto Delay		664	11.50	$7,636	
					$7,951
Year 4					
Truck Delay	18		18.50	$333	
Auto Delay		719	11.50	$8,269	
					$8,602
Year 8					
Truck Delay	20		18.50	$370	
Auto Delay		778	11.50	$8,947	
					$9,317
Year 12					
Truck Delay	22		18.50	$407	
Auto Delay		842	11.50	$9,683	
					$10,090
Year 16					
Truck Delay	23		18.50	$426	
Auto Delay		912	11.50	$10,488	
					$10,914

Table D-5 (cont.). Calculation of delay costs on SR 291, Francis Avenue with Maple and Ash Streets for ACP inlays with four-year cycles.

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 20					
Truck Delay	25		18.50	$463	
Auto Delay		987	11.50	$11,351	
					$11,813
Year 24					
Truck Delay	27		18.50	$500	
Auto Delay		1068	11.50	$12,282	
					$12,782
Year 28					
Truck Delay	30		18.50	$555	
Auto Delay		1156	11.50	$13,294	
					$13,849
Year 32					
Truck Delay	32		18.50	$592	
Auto Delay		1251	11.50	$14,387	
					$14,979
Year 36					
Truck Delay	35		18.50	$648	
Auto Delay		1355	11.50	$15,583	
					$16,230

Table D-6. Calculation of delay costs on SR 395, SR 395 and 19th Avenue for ACP inlays with four-year cycles.

SR 395 - SR 395 and 19th Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	40		18.50	$740	
Auto Delay		266	11.50	$3,059	
					$3,799
Year 4					
Truck Delay	43		18.50	$796	
Auto Delay		288	11.50	$3,312	
					$4,108
Year 8					
Truck Delay	46		18.50	$851	
Auto Delay		312	11.50	$3,588	
					$4,439
Year 12					
Truck Delay	50		18.50	$925	
Auto Delay		338	11.50	$3,887	
					$4,812
Year 16					
Truck Delay	54		18.50	$999	
Auto Delay		366	11.50	$4,209	
					$5,208

Table D-6 (cont.). Calculation of delay costs on SR 395, SR 395 and 19th Avenue for ACP inlays with four-year cycles.

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 20					
Truck Delay	59		18.50	$1,092	
Auto Delay		396	11.50	$4,554	
					$5,646
Year 24					
Truck Delay	64		18.50	$1,184	
Auto Delay		428	11.50	$4,922	
					$6,106
Year 28					
Truck Delay	69		18.50	$1,277	
Auto Delay		464	11.50	$5,336	
					$6,613
Year 32					
Truck Delay	75		18.50	$1,388	
Auto Delay		502	11.50	$5,773	
					$7,161
Year 36					
Truck Delay	81		18.50	$1,499	
Auto Delay		543	11.50	$6,245	
					$7,743

Table D-7. Calculation of delay costs on SR 90, Broadway Avenue and Thierman Road for ACP inlays with four-year cycles.

SR 90 - Broadway Avenue and Thierman Road

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	48		18.50	$888	
Auto Delay		207	11.50	$2,381	
					$3,269
Year 4					
Truck Delay	52		18.50	$962	
Auto Delay		224	11.50	$2,576	
					$3,538
Year 8					
Truck Delay	56		18.50	$1,036	
Auto Delay		243	11.50	$2,795	
					$3,831
Year 12					
Truck Delay	60		18.50	$1,110	
Auto Delay		263	11.50	$3,025	
					$4,135
Year 16					
Truck Delay	65		18.50	$1,203	
Auto Delay		285	11.50	$3,278	
					$4,480

Table D-7 (cont.). Calculation of delay costs on SR 90, Broadway Avenue and Thierman Road for ACP inlays with four-year cycles.

	Truck Delay (hours)	**Auto Delay (hours)**	**Delay Cost ($/hr)**	**Delay Cost ($)**	**Total Delay Cost ($)**
Year 20					
Truck Delay	71		18.50	$1,314	
Auto Delay		308	11.50	$3,542	
					$4,856
Year 24					
Truck Delay	77		18.50	$1,425	
Auto Delay		334	11.50	$3,841	
					$5,266
Year 28					
Truck Delay	83		18.50	$1,536	
Auto Delay		361	11.50	$4,152	
					$5,687
Year 32					
Truck Delay	90		18.50	$1,665	
Auto Delay		391	11.50	$4,497	
					$6,162
Year 36					
Truck Delay	97		18.50	$1,795	
Auto Delay		423	11.50	$4,865	
					$6,659

Table D-8. Calculation of delay costs on SR 2, Division Street and Third Avenue for ACP inlays with four-year cycles.

SR 2 - Division Street and Third Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	2		18.50	$37	
Auto Delay		76	11.50	$874	
					$911
Year 4					
Truck Delay	2		18.50	$37	
Auto Delay		82	11.50	$943	
					$980
Year 8					
Truck Delay	3		18.50	$56	
Auto Delay		89	11.50	$1,024	
					$1,079
Year 12					
Truck Delay	3		18.50	$56	
Auto Delay		96	11.50	$1,104	
					$1,160
Year 16					
Truck Delay	3		18.50	$56	
Auto Delay		104	11.50	$1,196	
					$1,252

Table D-8 (cont.). Calculation of delay costs on SR 2, Division Street and Third Avenue for ACP inlays with four-year cycles.

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 20					
Truck Delay	3		18.50	$56	
Auto Delay		113	11.50	$1,300	
					$1,355
Year 24					
Truck Delay	4		18.50	$74	
Auto Delay		122	11.50	$1,403	
					$1,477
Year 28					
Truck Delay	4		18.50	$74	
Auto Delay		132	11.50	$1,518	
					$1,592
Year 32					
Truck Delay	4		18.50	$74	
Auto Delay		143	11.50	$1,645	
					$1,719
Year 36					
Truck Delay	4		18.50	$74	
Auto Delay		155	11.50	$1,783	
					$1,857

Table D-9. Calculation of delay costs on SR 27, Pines Road and Sprague Avenue for ACP inlays with six-year cycles.

SR 27 - Pines Road and Sprague Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	42		18.50	$777	
Auto Delay		600	11.50	$6,900	
					$7,677
Year 6					
Truck Delay	47		18.50	$870	
Auto Delay		676	11.50	$7,774	
					$8,644
Year 12					
Truck Delay	53		18.50	$981	
Auto Delay		761	11.50	$8,752	
					$9,732
Year 18					
Truck Delay	60		18.50	$1,110	
Auto Delay		857	11.50	$9,856	
					$10,966
Year 24					
Truck Delay	67		18.50	$1,240	
Auto Delay		965	11.50	$11,098	
					$12,337
Year 30					
Truck Delay	76		18.50	$1,406	
Auto Delay		1087	11.50	$12,501	
					$13,907
Year 36					
Truck Delay	85		18.50	$1,573	
Auto Delay		1224	11.50	$14,076	
					$15,649

Table D-10. Calculation of delay costs on SR 27, Pines Road and Broadway Avenue for ACP inlays with six-year cycles.

SR 27 - Pines Road and Broadway Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	33		18.50	$611	
Auto Delay		471	11.50	$5,417	
					$6,027
Year 6					
Truck Delay	37		18.50	$685	
Auto Delay		531	11.50	$6,107	
					$6,791
Year 12					
Truck Delay	42		18.50	$777	
Auto Delay		598	11.50	$6,877	
					$7,654
Year 18					
Truck Delay	47		18.50	$870	
Auto Delay		673	11.50	$7,740	
					$8,609
Year 24					
Truck Delay	53		18.50	$981	
Auto Delay		758	11.50	$8,717	
					$9,698
Year 30					
Truck Delay	59		18.50	$1,092	
Auto Delay		854	11.50	$9,821	
					$10,913
Year 36					
Truck Delay	67		18.50	$1,240	
Auto Delay		961	11.50	$11,052	
					$12,291

Table D-11. Calculation of delay costs on SR 2, Division Street and Francis Avenue for ACP inlays with six-year cycles.

SR 2 - Division Street and Francis Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	24		18.50	$444	
Auto Delay		873	11.50	$10,040	
					$10,484
Year 6					
Truck Delay	27		18.50	$500	
Auto Delay		983	11.50	$11,305	
					$11,804
Year 12					
Truck Delay	31		18.50	$574	
Auto Delay		1107	11.50	$12,731	
					$13,304
Year 18					
Truck Delay	35		18.50	$648	
Auto Delay		1247	11.50	$14,341	
					$14,988
Year 24					
Truck Delay	39		18.50	$722	
Auto Delay		1404	11.50	$16,146	
					$16,868
Year 30					
Truck Delay	44		18.50	$814	
Auto Delay		1581	11.50	$18,182	
					$18,996
Year 36					
Truck Delay	49		18.50	$907	
Auto Delay		1781	11.50	$20,482	
					$21,388

Table D-12. Calculation of delay costs on SR 2, Francis Avenue with Maple and Ash Streets for ACP inlays with six-year cycles.

SR 291 - Francis Avenue with Maple and Ash Streets

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	17		18.50	$315	
Auto Delay		664	11.50	$7,636	
					$7,951
Year 6					
Truck Delay	19		18.50	$352	
Auto Delay		748	11.50	$8,602	
					$8,954
Year 12					
Truck Delay	22		18.50	$407	
Auto Delay		842	11.50	$9,683	
					$10,090
Year 18					
Truck Delay	24		18.50	$444	
Auto Delay		948	11.50	$10,902	
					$11,346
Year 24					
Truck Delay	27		18.50	$500	
Auto Delay		1068	11.50	$12,282	
					$12,782
Year 30					
Truck Delay	31		18.50	$574	
Auto Delay		1203	11.50	$13,835	
					$14,408
Year 36					
Truck Delay	35		18.50	$648	
Auto Delay		1355	11.50	$15,583	
					$16,230

Table D-13. Calculation of delay costs on SR 395, SR 395 and 19th Avenue for ACP inlays with six-year cycles.

SR 395 - SR 395 and 19th Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	40		18.50	$740	
Auto Delay		266	11.50	$3,059	
					$3,799
Year 6					
Truck Delay	45		18.50	$833	
Auto Delay		300	11.50	$3,450	
					$4,283
Year 12					
Truck Delay	50		18.50	$925	
Auto Delay		338	11.50	$3,887	
					$4,812
Year 18					
Truck Delay	57		18.50	$1,055	
Auto Delay		380	11.50	$4,370	
					$5,425
Year 24					
Truck Delay	64		18.50	$1,184	
Auto Delay		428	11.50	$4,922	
					$6,106
Year 30					
Truck Delay	72		18.50	$1,332	
Auto Delay		482	11.50	$5,543	
					$6,875
Year 36					
Truck Delay	81		18.50	$1,499	
Auto Delay		543	11.50	$6,245	
					$7,743

Table D-14. Calculation of delay costs on SR 90, Broadway Avenue and Thierman Street for ACP inlays with six-year cycles.

SR 90 - Broadway Avenue and Thierman Street

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	48		18.50	$888	
Auto Delay		207	11.50	$2,381	
					$3,269
Year 6					
Truck Delay	54		18.50	$999	
Auto Delay		234	11.50	$2,691	
					$3,690
Year 12					
Truck Delay	60		18.50	$1,110	
Auto Delay		263	11.50	$3,025	
					$4,135
Year 18					
Truck Delay	68		18.50	$1,258	
Auto Delay		296	11.50	$3,404	
					$4,662
Year 24					
Truck Delay	77		18.50	$1,425	
Auto Delay		334	11.50	$3,841	
					$5,266
Year 30					
Truck Delay	86		18.50	$1,591	
Auto Delay		376	11.50	$4,324	
					$5,915
Year 36					
Truck Delay	97		18.50	$1,795	
Auto Delay		423	11.50	$4,865	
					$6,659

Table D-15. Calculation of delay costs on SR 2, Division Street and Third Avenue for ACP inlays with six-year cycles.

SR 2 - Division Street and Third Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	2		18.50	$37	
Auto Delay		76	11.50	$874	
					$911
Year 6					
Truck Delay	2		18.50	$37	
Auto Delay		85	11.50	$978	
					$1,015
Year 12					
Truck Delay	3		18.50	$56	
Auto Delay		96	11.50	$1,104	
					$1,160
Year 18					
Truck Delay	3		18.50	$56	
Auto Delay		108	11.50	$1,242	
					$1,298
Year 24					
Truck Delay	4		18.50	$74	
Auto Delay		122	11.50	$1,403	
					$1,477
Year 30					
Truck Delay	4		18.50	$74	
Auto Delay		137	11.50	$1,576	
					$1,650
Year 36					
Truck Delay	4		18.50	$74	
Auto Delay		155	11.50	$1,783	
					$1,857

Table D-16. Calculation of delay costs on SR 27, Pines Road and Sprague Avenue for ACP inlays with eight-year cycles.

SR 27 - Pines Road and Sprague Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	42.0		18.50	777	
Auto Delay		600.0	11.50	6900	
					$7,677
Year 8					
Truck Delay	49.0		18.50	906.5	
Auto Delay		703.0	11.50	8084.5	
					$8,991
Year 16					
Truck Delay	57.0		18.50	1054.5	
Auto Delay		824.0	11.50	9476	
					$10,531
Year 24					
Truck Delay	67.0		18.50	1239.5	
Auto Delay		965.0	11.50	11097.5	
					$12,337
Year 32					
Truck Delay	79.0		18.50	1461.5	
Auto Delay		1131.0	11.50	13006.5	
					$14,468

Table D-17. Calculation of delay costs on SR 27, Pines Road and Broadway Avenue for ACP inlays with eight-year cycles.

SR 27 - Pines Road and Broadway Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	33.0		18.50	610.5	
Auto Delay		471.0	11.50	5416.5	
					$6,027
Year 8					
Truck Delay	38.0		18.50	703	
Auto Delay		552.0	11.50	6348	
					$7,051
Year 16					
Truck Delay	45.0		18.50	832.5	
Auto Delay		647.0	11.50	7440.5	
					$8,273
Year 24					
Truck Delay	53.0		18.50	980.5	
Auto Delay		758.0	11.50	8717	
					$9,698
Year 32					
Truck Delay	62.0		18.50	1147	
Auto Delay		888.0	11.50	10212	
					$11,359

Table D-18. Calculation of delay costs on SR 2, Division Street and Francis Avenue for ACP inlays with eight-year cycles.

SR 2 - Division Street and Francis Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	24.0		18.50	444	
Auto Delay		873.0	11.50	10039.5	
					$10,484
Year 8					
Truck Delay	28.0		18.50	518	
Auto Delay		1023.0	11.50	11764.5	
					$12,283
Year 16					
Truck Delay	33.0		18.50	610.5	
Auto Delay		1198.0	11.50	13777	
					$14,388
Year 24					
Truck Delay	39.0		18.50	721.5	
Auto Delay		1404.0	11.50	16146	
					$16,868
Year 32					
Truck Delay	46.0		18.50	851	
Auto Delay		1645.0	11.50	18917.5	
					$19,769

Table D-19. Calculation of delay costs on SR 2, Francis Avenue with Maple and Ash Streets for ACP inlays with eight-year cycles.

SR 2 - Francis Avenue with Maple and Ash Streets

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	17.0		18.50	314.5	
Auto Delay		664.0	11.50	7636	
					$7,951
Year 8					
Truck Delay	20.0		18.50	370	
Auto Delay		778.0	11.50	8947	
					$9,317
Year 16					
Truck Delay	23.0		18.50	425.5	
Auto Delay		912.0	11.50	10488	
					$10,914
Year 24					
Truck Delay	27.0		18.50	499.5	
Auto Delay		1068.0	11.50	12282	
					$12,782
Year 32					
Truck Delay	32.0		18.50	592	
Auto Delay		1251.0	11.50	14386.5	
					$14,979

Table D-20. Calculation of delay costs on SR 395, SR 395 and 19th Avenue for ACP inlays with eight-year cycles.

SR 395 - SR 395 and 19th Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	40.0		18.50	740	
Auto Delay		266.0	11.50	3059	
					$3,799
Year 8					
Truck Delay	46.0		18.50	851	
Auto Delay		312.0	11.50	3588	
					$4,439
Year 16					
Truck Delay	54.0		18.50	999	
Auto Delay		366.0	11.50	4209	
					$5,208
Year 24					
Truck Delay	64.0		18.50	1184	
Auto Delay		428.0	11.50	4922	
					$6,106
Year 32					
Truck Delay	75.0		18.50	1387.5	
Auto Delay		502.0	11.50	5773	
					$7,161

Table D-21. Calculation of delay costs on SR 90, Broadway Avenue and Thierman Road for ACP inlays with eight-year cycles.

SR 90 - Broadway Avenue and Thierman Road

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	48.0		18.50	888	
Auto Delay		207.0	11.50	2380.5	
					$3,269
Year 8					
Truck Delay	56.0		18.50	1036	
Auto Delay		243.0	11.50	2794.5	
					$3,831
Year 16					
Truck Delay	65.0		18.50	1202.5	
Auto Delay		285.0	11.50	3277.5	
					$4,480
Year 24					
Truck Delay	77.0		18.50	1424.5	
Auto Delay		334.0	11.50	3841	
					$5,266
Year 32					
Truck Delay	90.0		18.50	1665	
Auto Delay		391.0	11.50	4496.5	
					$6,162

Table D-22. Calculation of delay costs on SR 2, Division Street and Third Avenue for ACP inlays with eight-year cycles.

SR 2 - Division Street and Third Avenue

	Truck Delay (hours)	Auto Delay (hours)	Delay Cost ($/hr)	Delay Cost ($)	Total Delay Cost ($)
Year 0					
Truck Delay	2.0		18.50	37	
Auto Delay		76.0	11.50	874	
					$911
Year 8					
Truck Delay	2.0		18.50	37	
Auto Delay		89.0	11.50	1023.5	
					$1,061
Year 16					
Truck Delay	3.0		18.50	55.5	
Auto Delay		104.0	11.50	1196	
					$1,252
Year 24					
Truck Delay	3.0		18.50	55.5	
Auto Delay		122.0	11.50	1403	
					$1,459
Year 32					
Truck Delay	4.0		18.50	74	
Auto Delay		143.0	11.50	1644.5	
					$1,719

APPENDIX E – SAMPLE CONSTRUCTION STAGING

The following plans show the staging sequence used by ACME Materials and Construction from Spokane, Washington to construct concrete intersections. Three examples include:

Figure	**Staging Type**
E-1 to E-6.	**Construction under traffic** - SR 2, Division Street and Francis Avenue, Stages 1 through 6.
E-7 to E-9.	**Partial closure with detours** - SR 27, Pines Road and Broadway Avenue, Stages 1 through 3.
E-10 to E-15.	**Combination closure with construction under traffic and a full intersection closure** - SR 395, SR 395 and West Kennewick Avenue, Stages 1 through 4.

Figure E–1. Construction staging for construction under traffic - SR 2, Division Street and Francis Avenue, Stage 1.

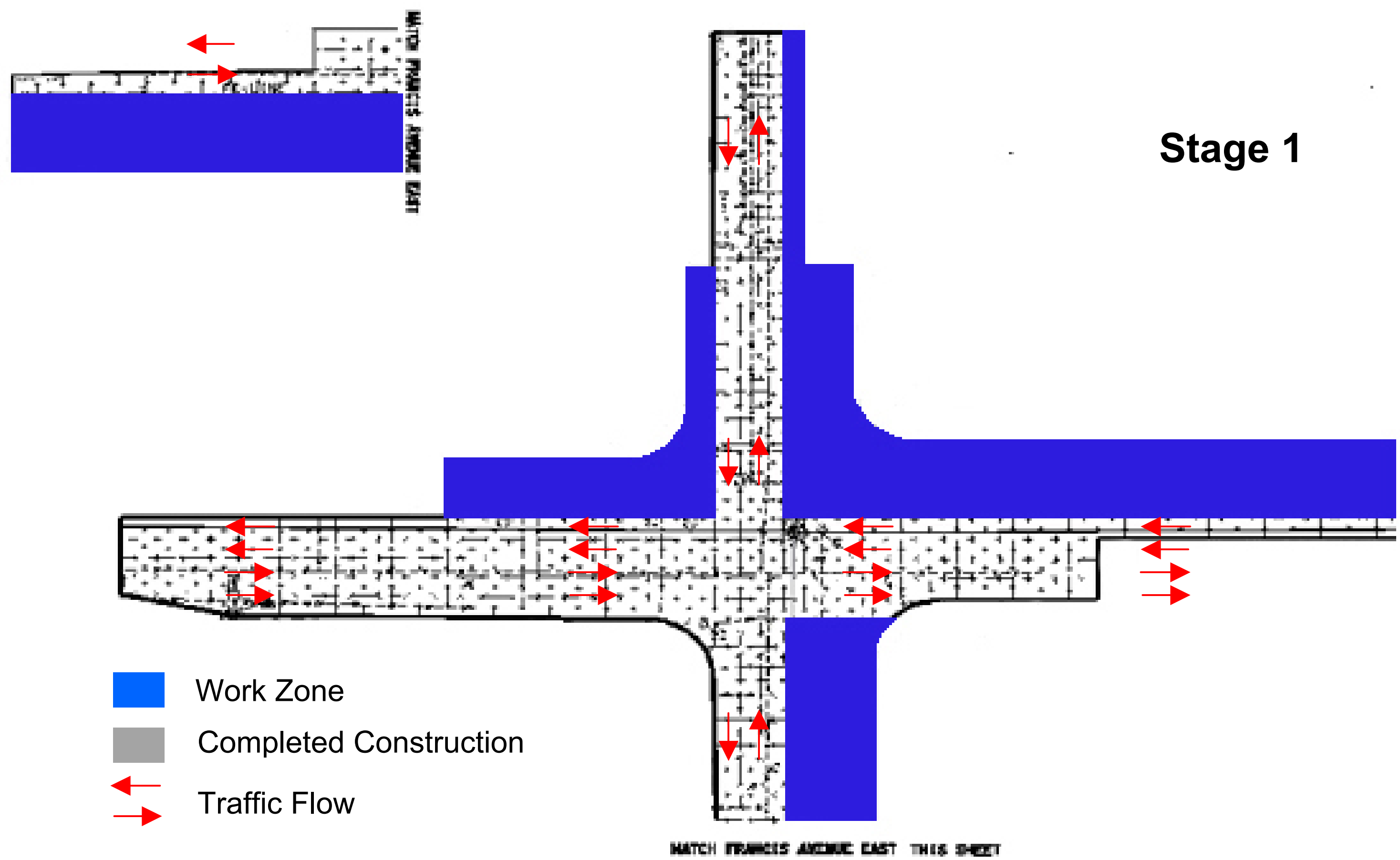


Figure E–2. Construction staging for construction under traffic - SR 2, Division Street and Francis Avenue, Stage 2.

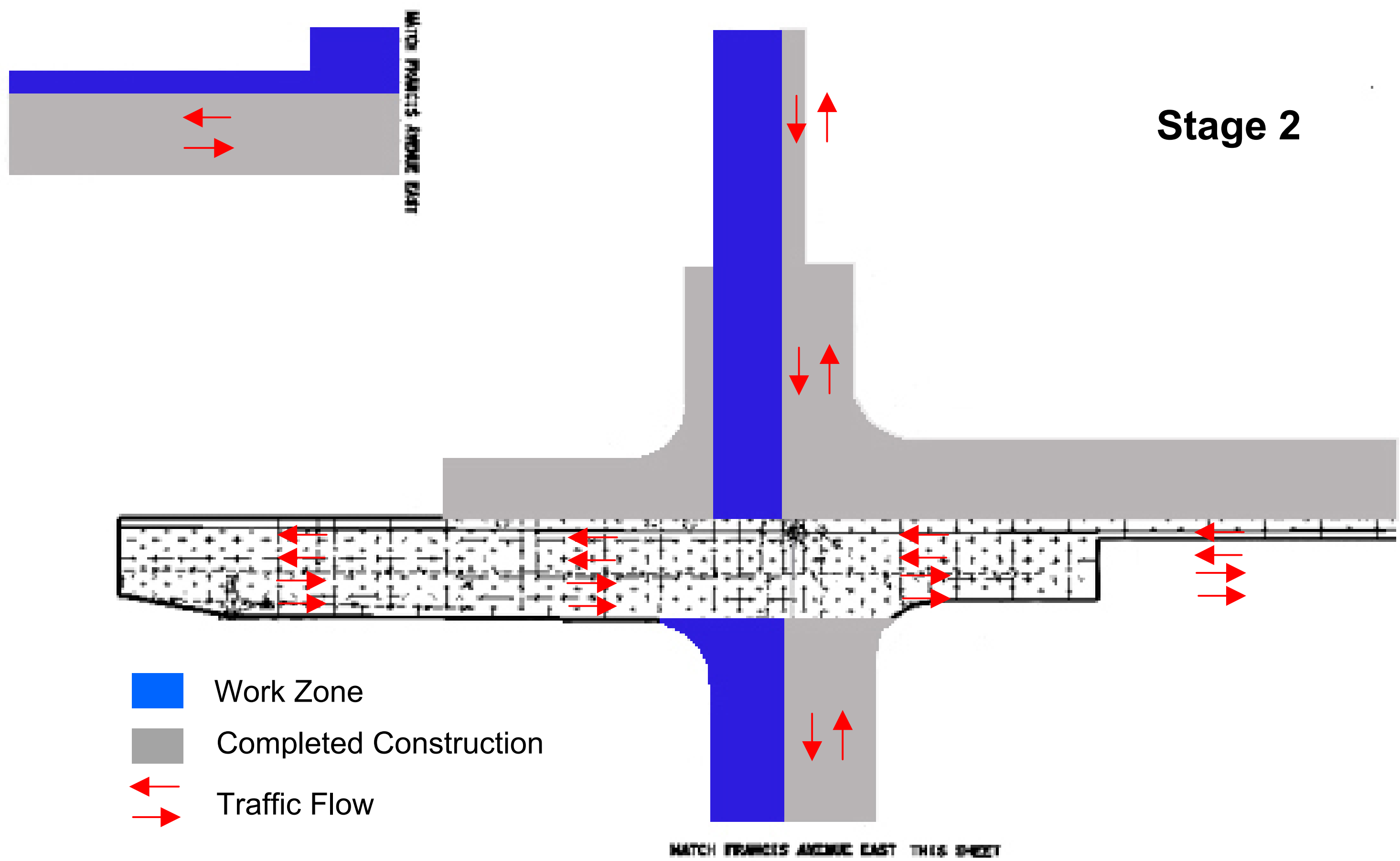


Figure E–3. Construction staging for construction under traffic - SR 2, Division Street and Francis Avenue, Stage 3.

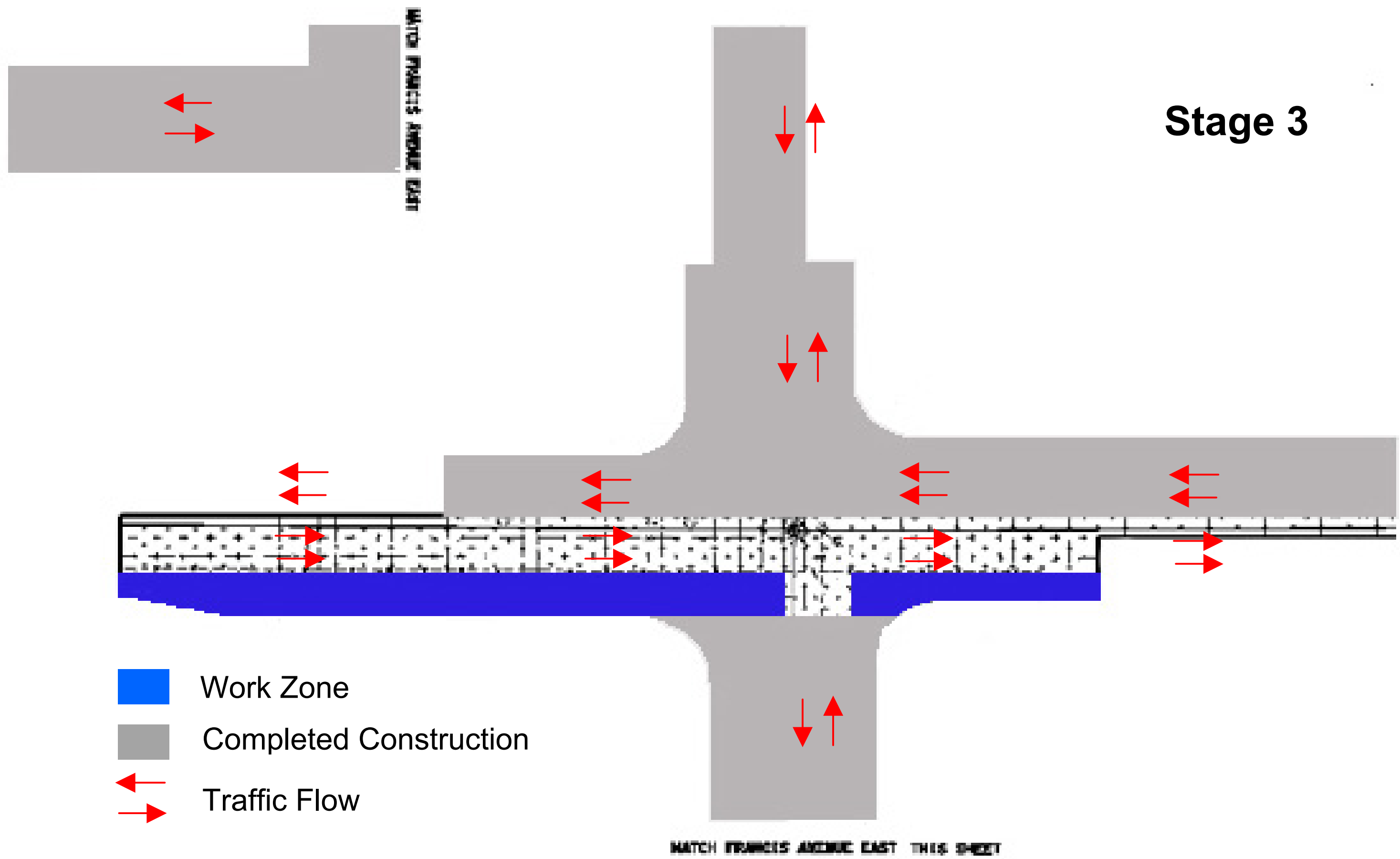


Figure E–4. Construction staging for construction under traffic - SR 2, Division Street and Francis Avenue, Stage 4.

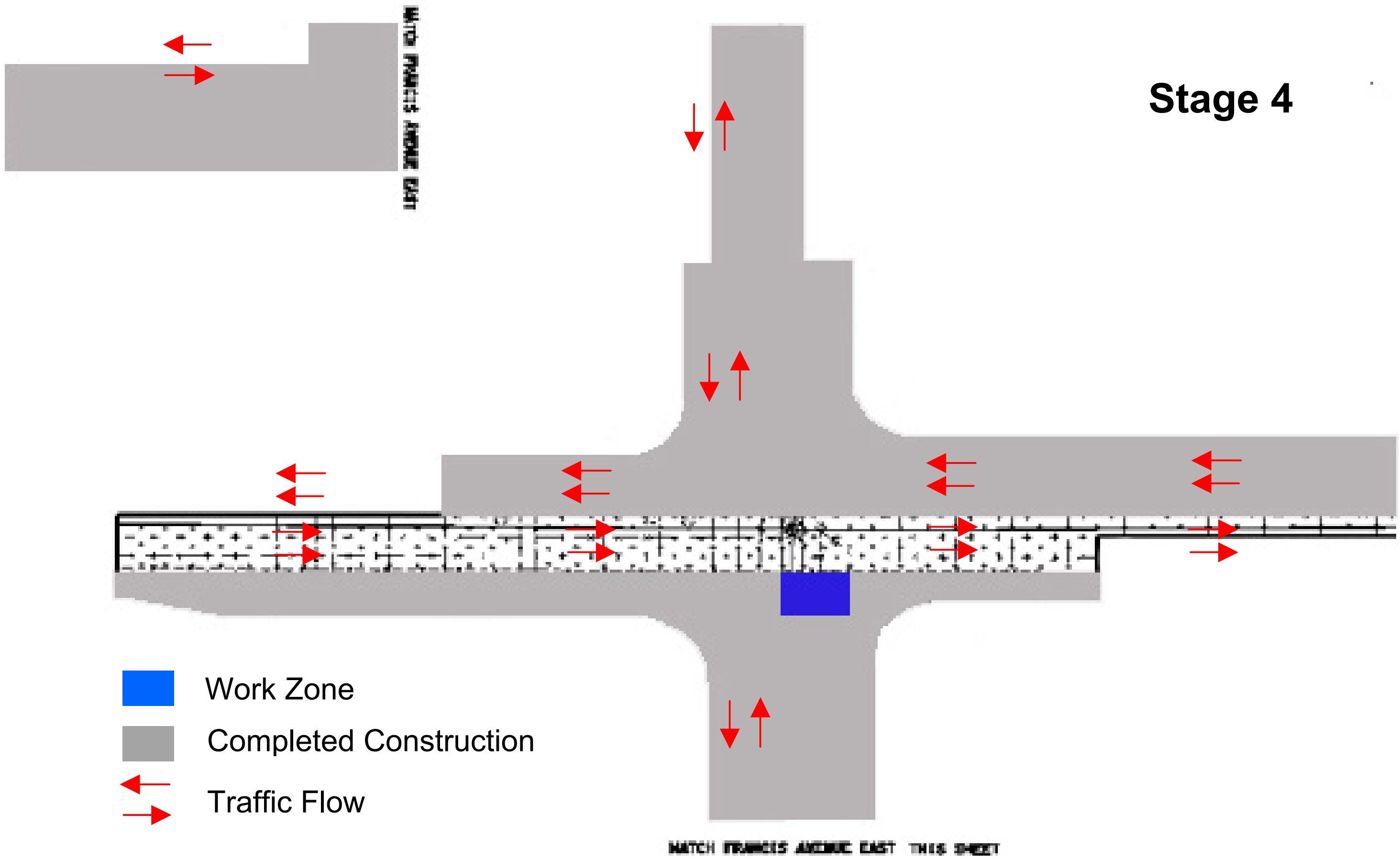


Figure E–5. Construction staging for construction under traffic - SR 2, Division Street and Francis Avenue, Stage 5.

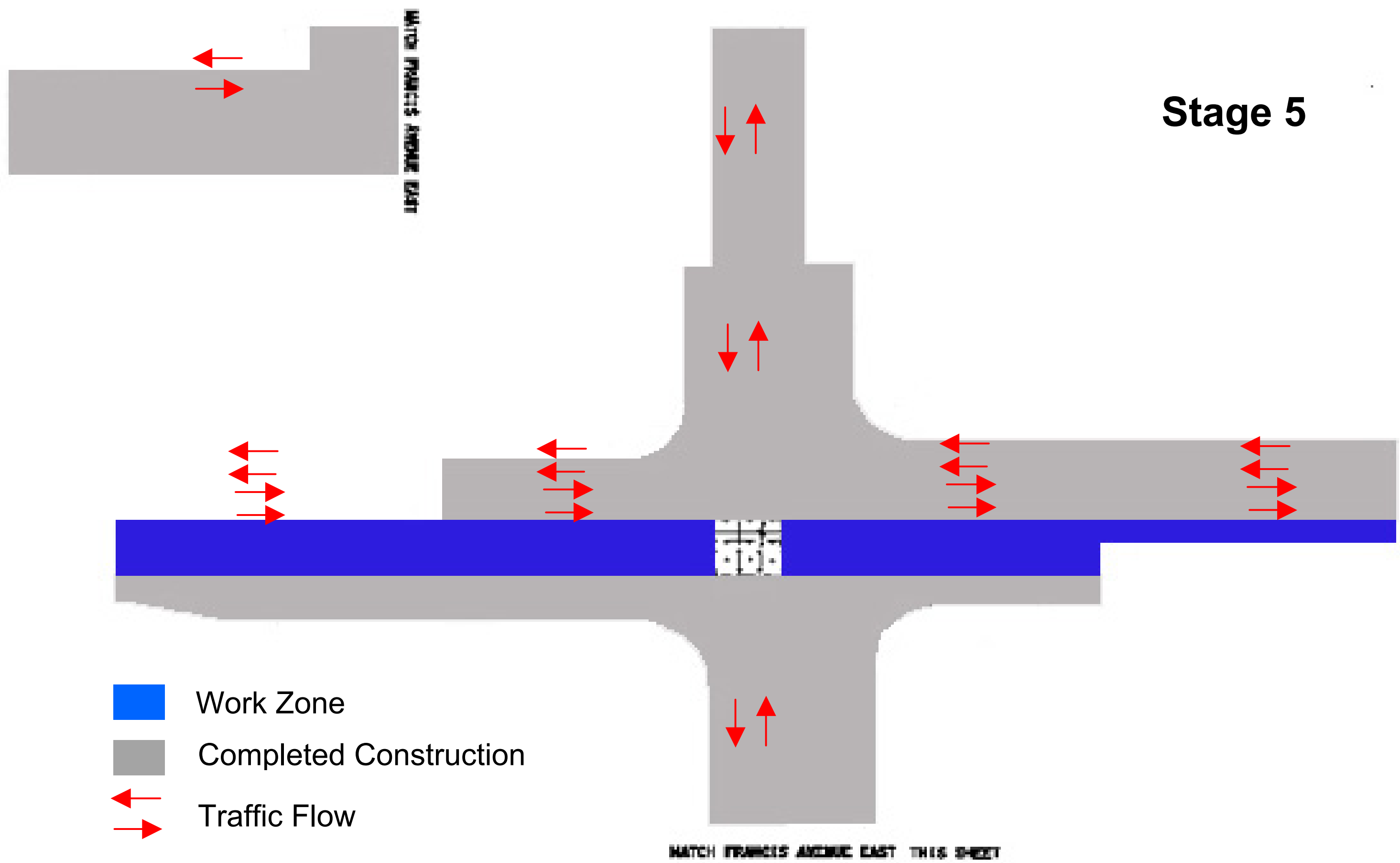


Figure E–6. Construction staging for construction under traffic - SR 2, Division Street and Francis Avenue, Stage 6.

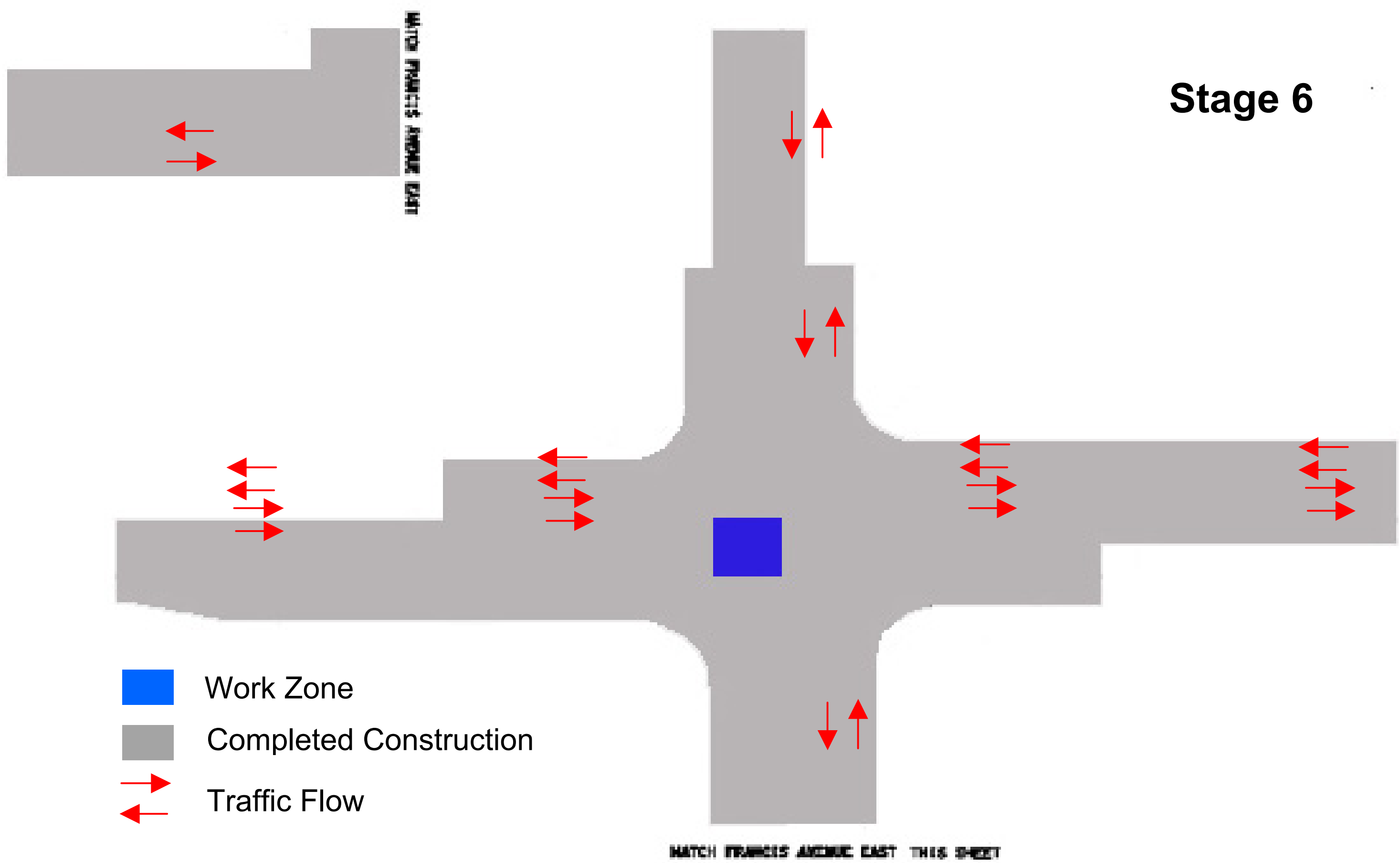


Figure E-7. Construction staging for a partial closure with detours - SR 27, Pines Road and Broadway Avenue, Stage 1.

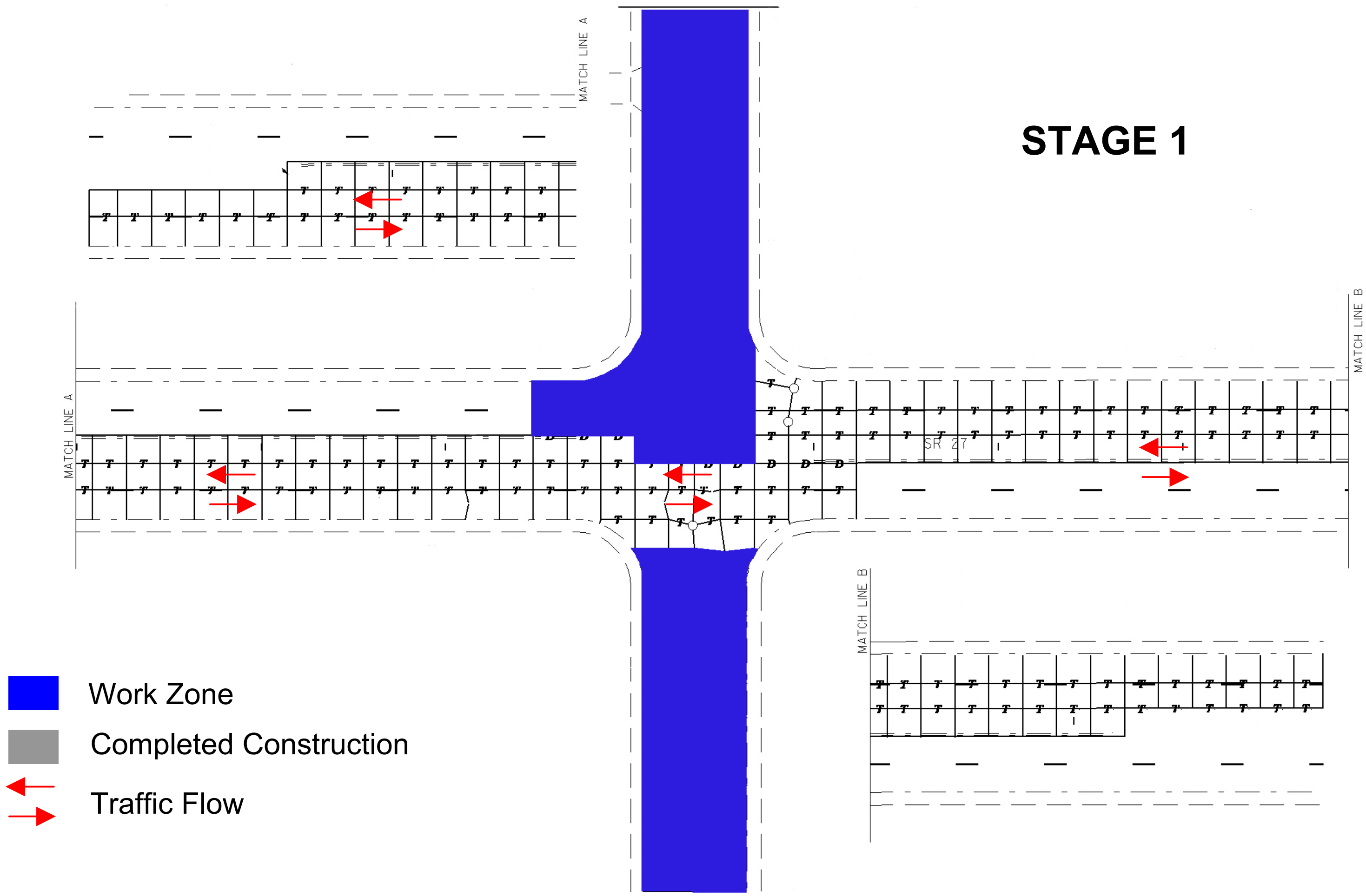


Figure E-8. Construction staging for a partial closure with detours - SR 27, Pines Road and Broadway Avenue, Stage 2.

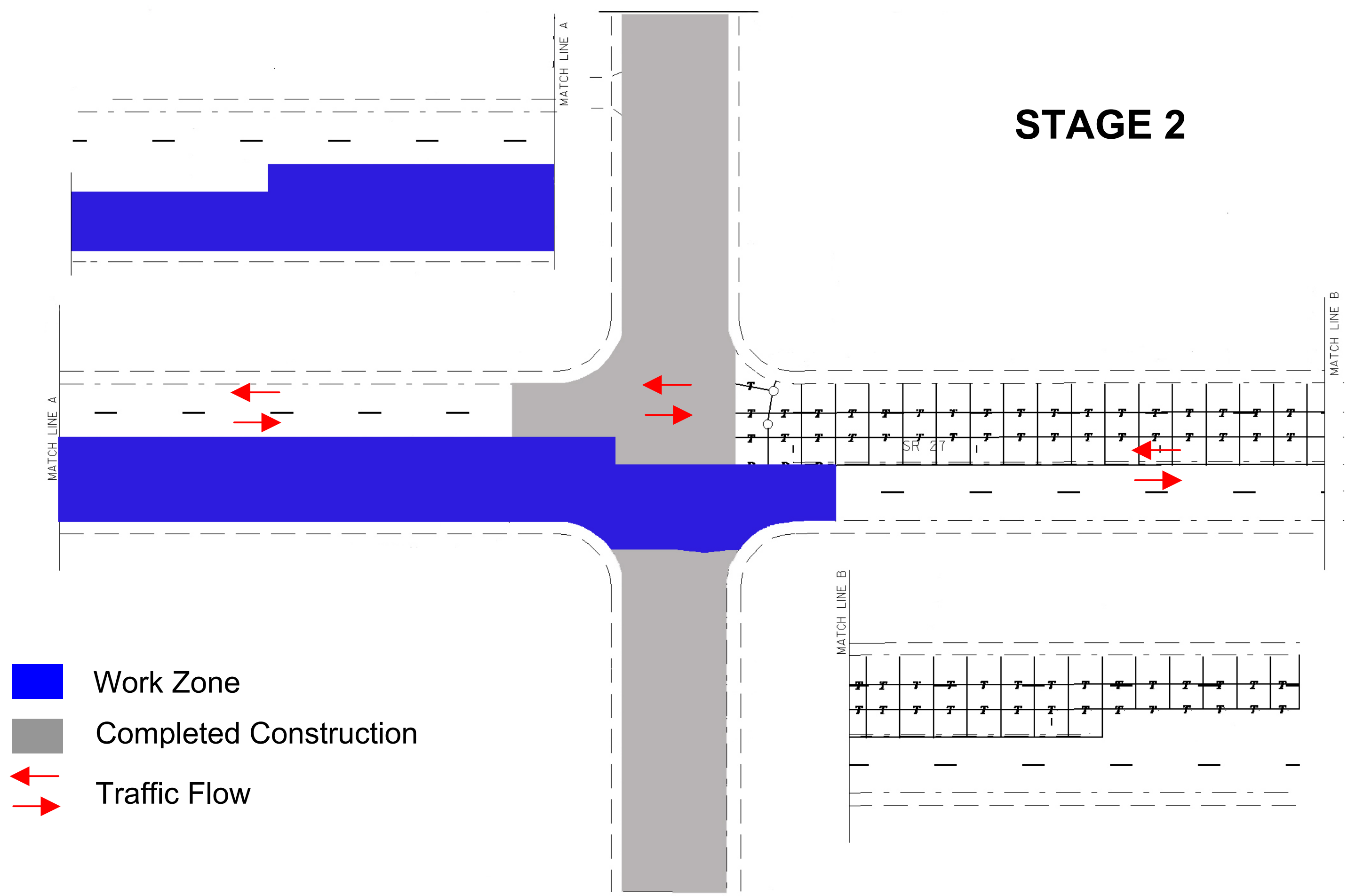


Figure E-9. Construction staging for a partial closure with detours - SR 27, Pines Road and Broadway Avenue, Stage 3.

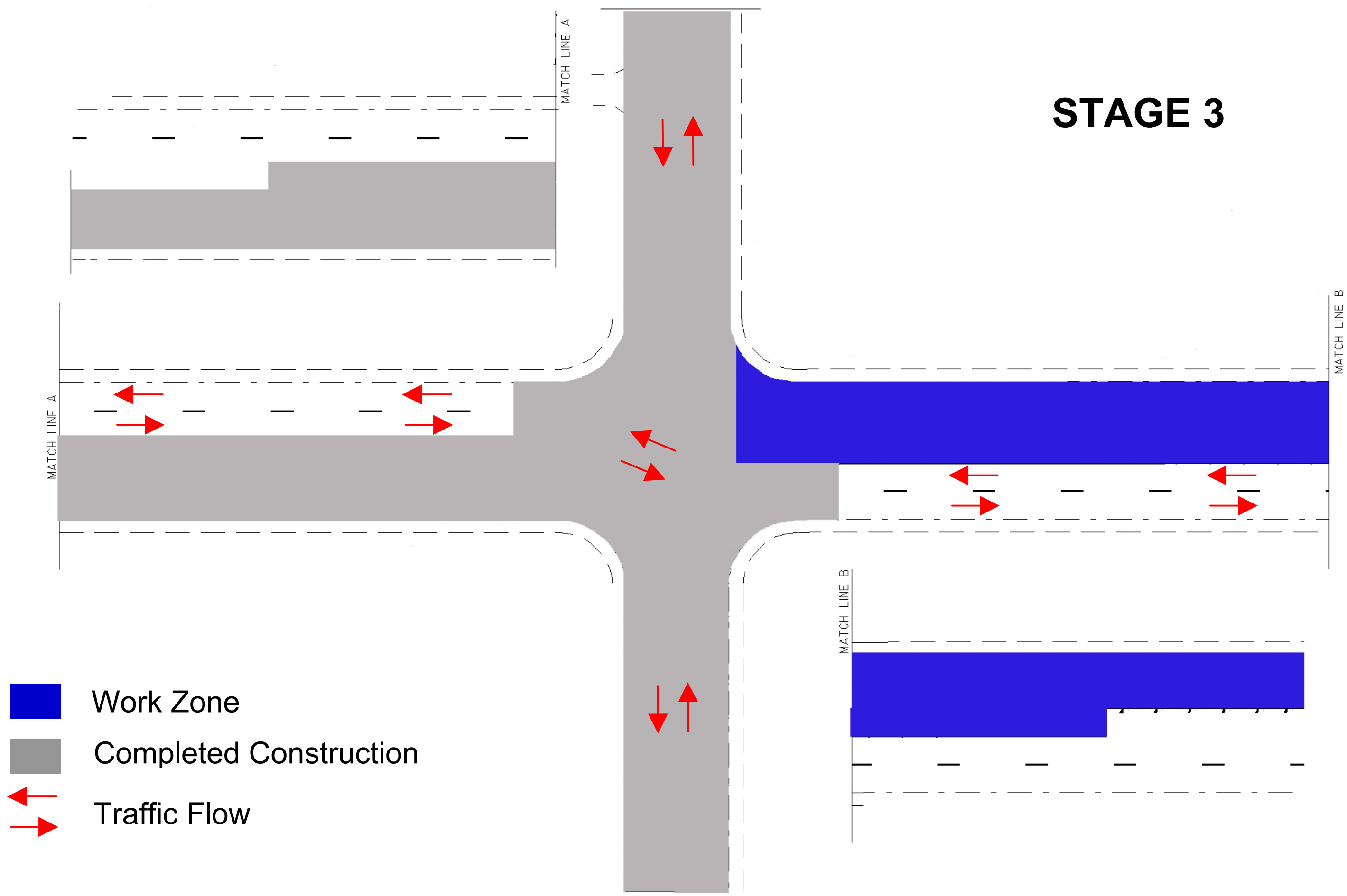


Figure E-10. Construction staging for a combination closure with construction under traffic and a full intersection closure - SR 395, SR 395 and West Kennewick Avenue, Stage 1.

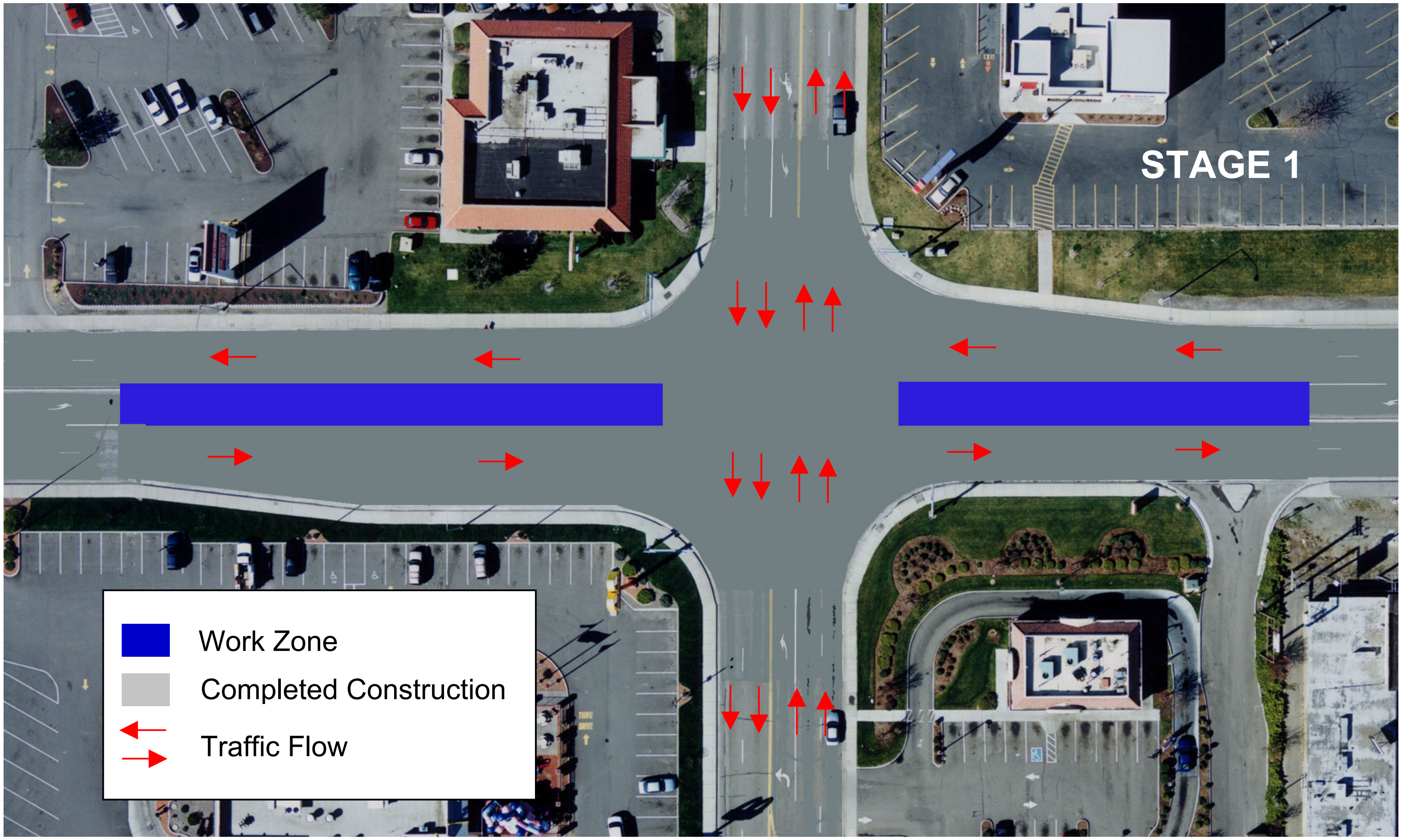


Figure E-11. Construction staging for a combination closure with construction under traffic and a full intersection closure - SR 395, SR 395 and West Kennewick Avenue, Stage 2.

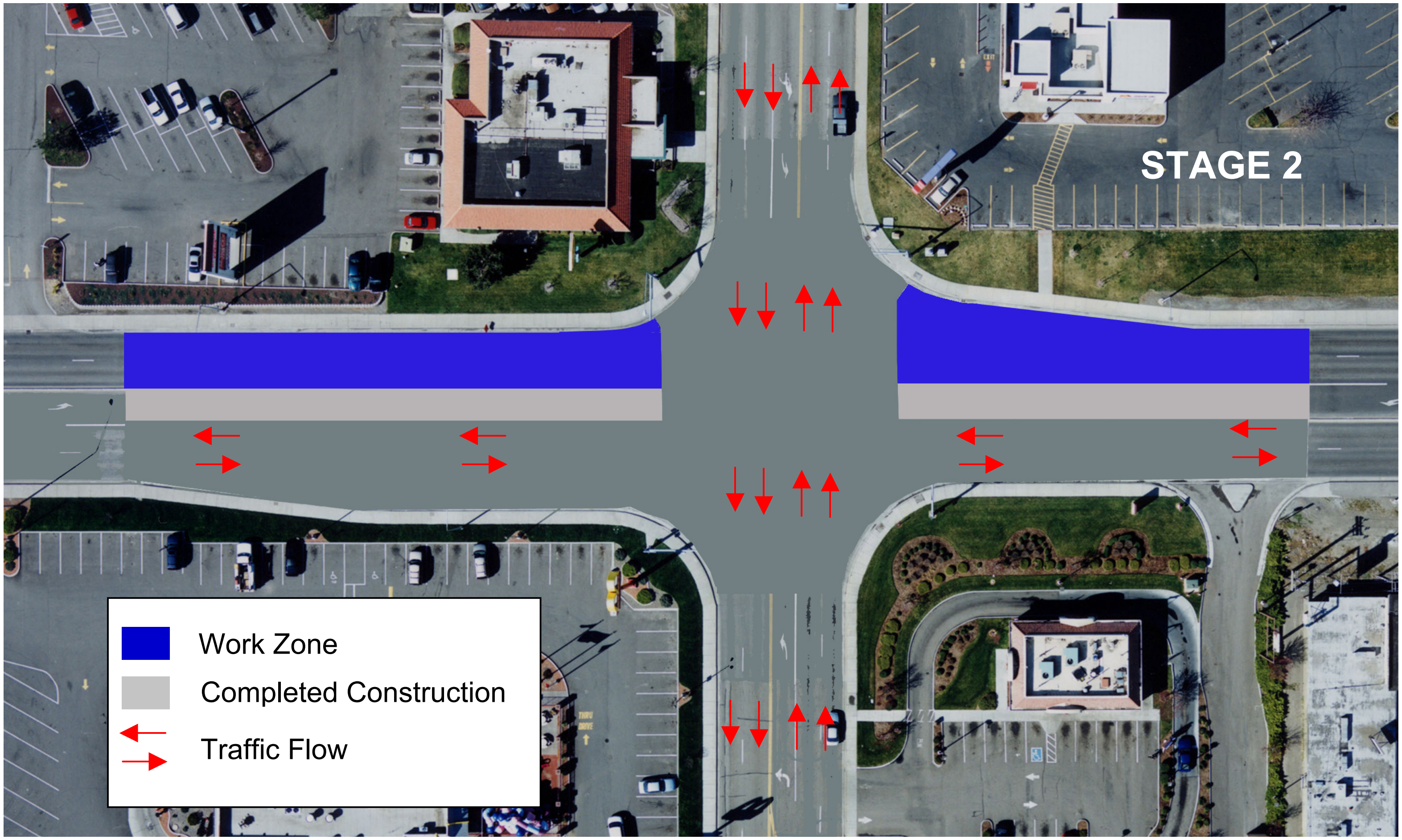


Figure E-12. Construction staging for a combination with construction under traffic and a full intersection closure - SR 395, SR 395 and West Kennewick Avenue, Stage 3.

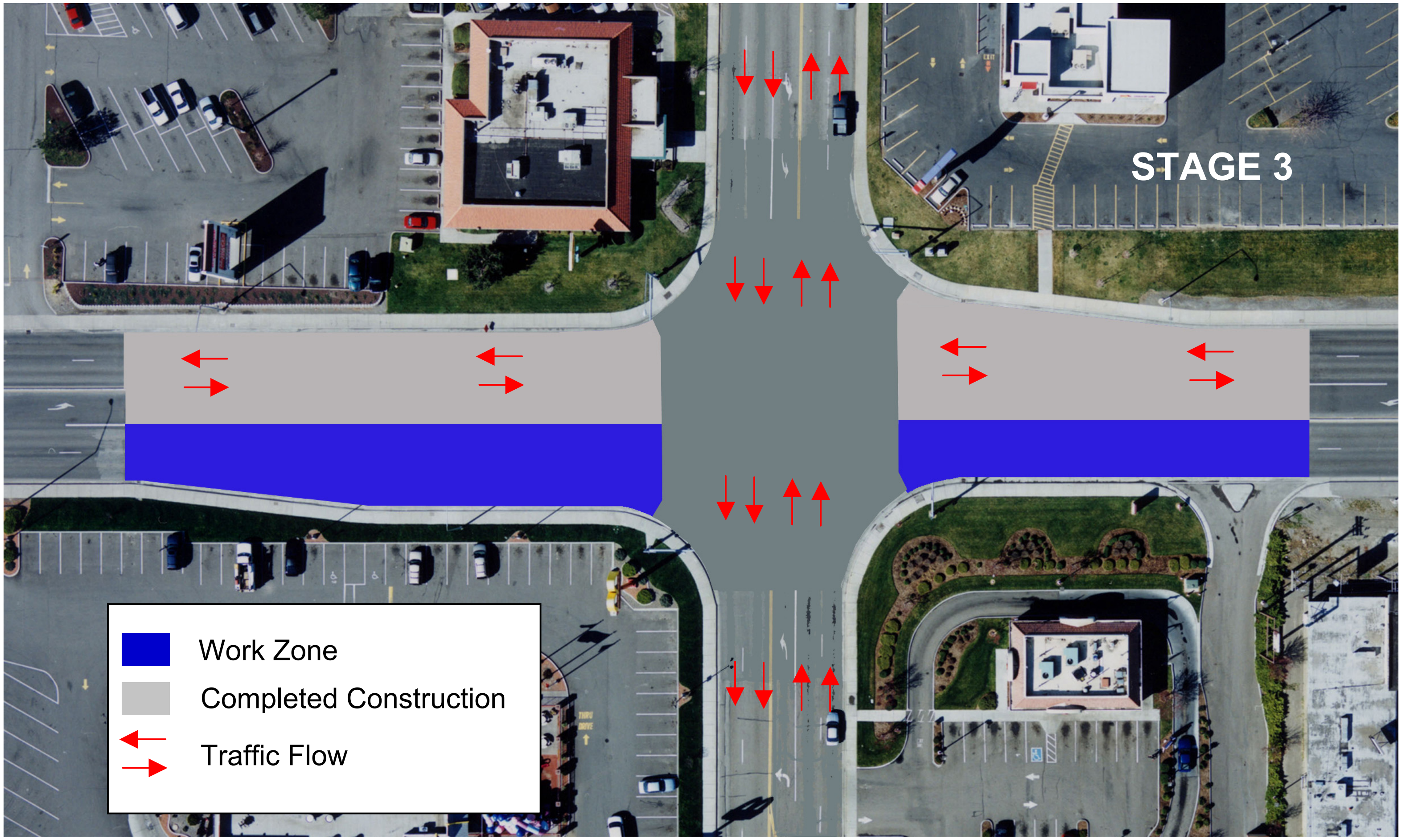


Figure E-13. Construction staging for a combination closure with construction under traffic and a full intersection closure - SR 395, SR 395 and West Kennewick Avenue, Stage 4.

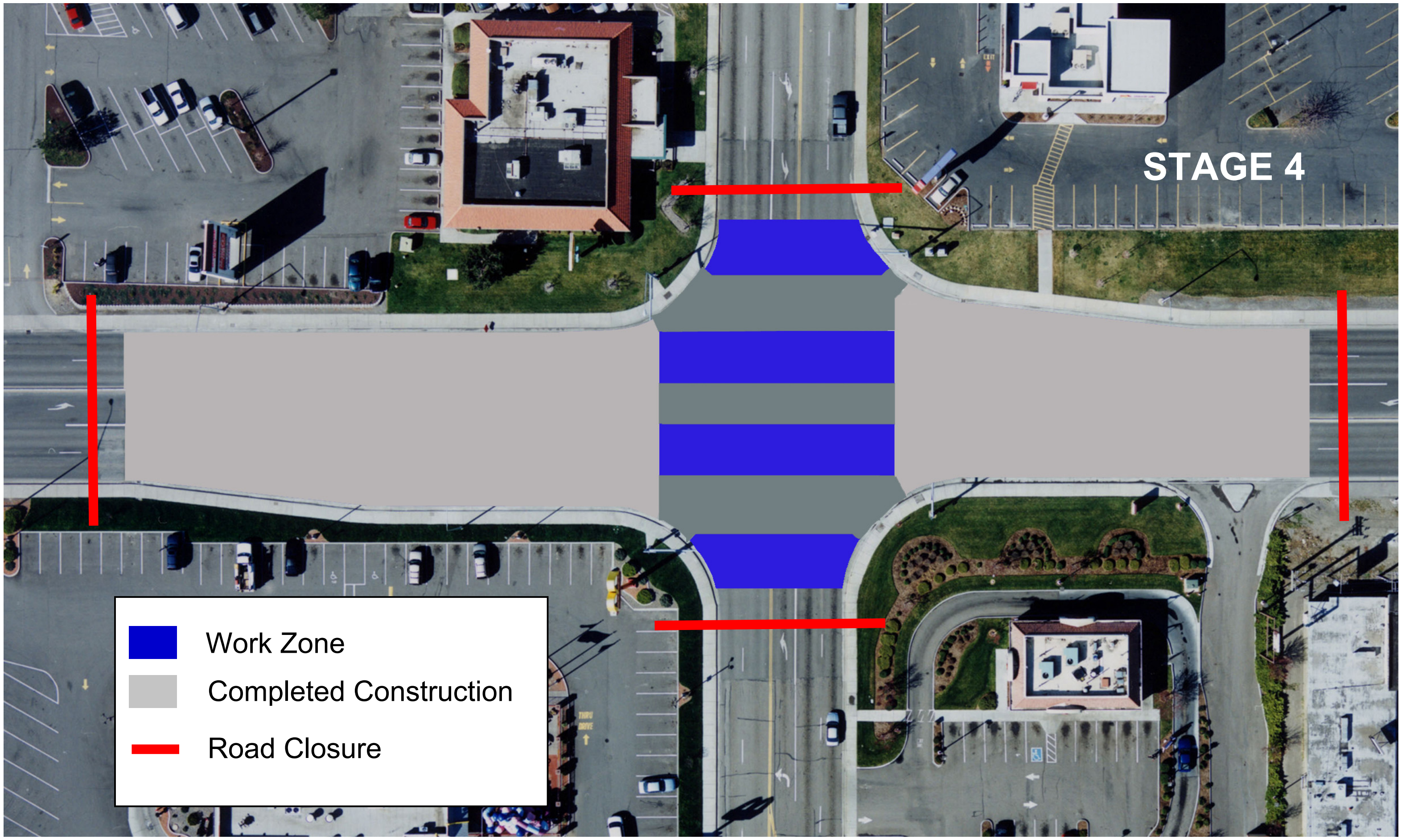


Figure E-14. Construction staging for a combination closure with construction under traffic and a full intersection closure - SR 395, SR 395 and West Kennewick Avenue, Stage 4A.

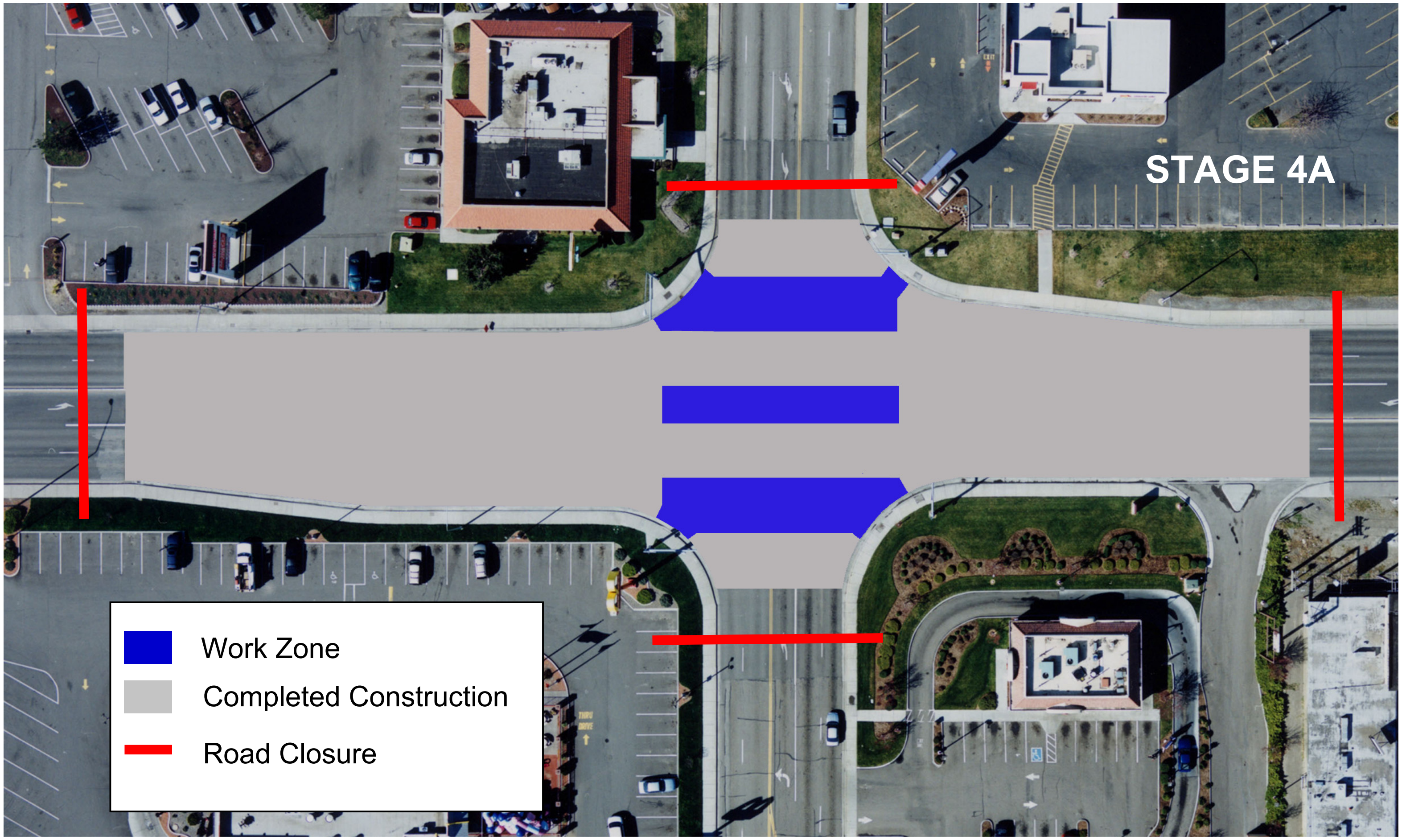


Figure E-15. Completed construction - SR 395, SR 395 and West Kennewick Avenue.

APPENDIX F – TRAFFIC CONTROL RESTRICTIONS AND STAGING REQUIREMENTS

The following special provision for traffic control restrictions and staging requirements is from the SR 2, Division Street and Francis Avenue contract.

Public Convenience and Safety

Construction Under Traffic

Section 1-07.23(1) is supplemented with the following:

The construction safety zone for this project measured from the outside edge of the traveled way is:

0.5 meters from SR 291 Sta. 0+000.000 to Sta. 5+854.000
8.7 meters from SR 291 Sta. 5+854.000 to Sta. 8+429.017

During nonworking hours equipment or materials shall not be within the safety zone unless it is protected by permanent guard rail or temporary concrete barrier. The use of temporary concrete barrier shall be permitted only if the Engineer approves the installation and location.

During the actual hours of work, unless protected as described above, only materials absolutely necessary to construction shall be within the safety zone and only construction vehicles absolutely necessary to construction shall be allowed within the safety zone or allowed to stop or park on the shoulder of the roadway.

The Contractor's nonessential vehicles and employees private vehicles shall not be permitted to park within the safety zone at any time unless protected as described above.

The third paragraph of Section 1-07.23(1) is supplemented with the following:

The Contractor shall notify in writing the affected business or residence and the Engineer 24 to 72 hours prior to beginning work. The notification shall include when the work will begin, the order in which driveways will be constructed, and the length of time the work will require. This shall be in effect for each business or residence.

Access to at least one driveway shall be provided at all times during business working hours.

Where the Contractor's operation requires the temporary closure of a driveway, the following shall apply:

At properties with alternate access, driveway closures shall be maintained for the minimum time required to perform work. If the closure is expected to exceed two hours, the work shall be performed during non-working hours of the affected business.

At properties without alternate access, the Contractor shall meet with the property owner(s) to find a mutually agreeable time to perform the work.

No vertical edges greater than 75 millimeters will be allowed in front or in back of the approach. Temporary crushed surfacing or asphalt pavement shims shall be used where required to provide adequate vehicle clearance.

During any suspension of work, asphalt pavement shims shall be used where drop-offs exceed 38 millimeters to provide adequate vehicle clearance. Shim placement may need to be re-evaluated in the event ponding occurs as a result of the shim.

Deviation from the above requirements shall not occur unless the Contractor has requested the deviation in writing and the Engineer has provided written approval.

Traffic Control Restrictions

There will be no interruptions to traffic except while performing work. The contractor shall maintain the following traffic control while performing actual work within the roadway:

Southbound Division Street

There shall be a minimum of two southbound lanes of traffic maintained on Division Street between the hours of 7:00 a.m. to 8:00 a.m. and 3:00 p.m. to 7:00 p.m. and during the Contractors non-working hours.

Northbound Division Street

There shall be a minimum of two northbound lanes of traffic maintained on Division Street between the hours of 7:00 a.m. to 8:00 a.m. and 3:00 p.m. to 7:00 p.m. and during the Contractors non-working hours.

Francis Avenue

With the exception of the PCCP construction at the intersections of Division St., Maple St., and Ash St., there shall be no disruptions to traffic on Francis Avenue between the hours of 7:00 a.m. to 8:00 a.m. and 3:30 p.m. to 5:00 p.m. a minimum of one through lane and the left turn lane of traffic in each direction shall be maintained at all other times. During all other work hours, additional lanes may be closed with prior approval from the Engineer.

The Contractor shall submit a traffic control plan to be approved by the Engineer prior to implementation.

Within the special provision for the Cement Concrete Pavement the following was included (see Appendix I):

Staging Plan

The Contractor shall submit a staging plan to the Engineer for approval for the construction of the Cement Concrete pavement at SR 2, Division Street, and SR 291, Maple Street and Ash Street intersections as shown in the plans at the preconstruction meeting.

The staging plans shall comply with the requirements of the Manual on Uniform Traffic Control Devices (M.U.T.C.D.) and as outlined in Section 1-07.23.

The 7th, 10th, 19th, and 27th Avenue Intersection contract in Kennewick included the following traffic control provisions:

Public Convenience and Safety

Construction Under Traffic

Section 1-07.23(1) is supplemented with the following:

The construction safety zone for this project is 9.4 meters from the outside edge of the traveled way.

During nonworking hours equipment or materials shall not be within the safety zone unless it is protected by permanent guard rail or temporary concrete barrier. The use of temporary concrete barrier shall be permitted only if the Engineer approves the installation and location.

During the actual hours of work, unless protected as described above, only materials absolutely necessary to construction shall be within the safety zone and only construction vehicles absolutely necessary to construction shall be allowed within the safety zone or allowed to stop or park on the shoulder of the roadway.

The Contractor’s nonessential vehicles and employees private vehicles shall not be permitted to park within the safety zone at any time unless protected as described above.

Deviation from the above requirements shall not occur unless the Contractor has requested the deviation in writing and the Engineer has provided written approval.

All lanes and shoulder areas on this project shall be clear and open to traffic on holidays and holiday weekends beginning at noon of the day preceding a holiday or holiday weekend and shall remain clear until 11:00 p.m. of the holiday of last day of the holiday weekend. Holidays shall be those as outlined in Section 1-08.5, and in addition, during the week of July 19-26, 1998, Tri Cities Columbia Cup (hydroplane races) all accesses shall be opened to their normal configurations. During this period the Contractor shall not be permitted to have lane closures.

The Contractor shall not close any two adjacent intersections to traffic at the same time. The maximum closure time at each intersection shall be 4 calendar days.

During work hours, the Contractor may restrict traffic through the construction areas; however, at least one lane in each direction on SR 395 or equivalent must remain open to traffic at all times.

Traffic shall not be delayed more than 15 minutes at any time. All traffic congestion shall be allowed to clear before traffic is delayed again. There shall be no delay to medical, fire, or any other emergency vehicles.

The Contractor shall provide access to the local businesses at all time during the construction.

When unforeseen conditions occur which require traffic control measures, the Contractor shall cooperate with the Engineer in providing proper control to ensure safety to the traveling public, and to the personnel and equipment working on this project.

The Contractor shall notify the Engineer, in writing, five working days in advance of implementing any wide load detours.

Grooved pavement signs shall be placed 200 meters in advance of any areas that are planed.

Bump signs shall be placed 100 meters prior to any bump area.

Abrupt lane edge signs shall be placed prior to any abrupt lane edges and every 760 meters staggered along each side of the abrupt lane edges.

Within the special provision for the Cement Concrete Pavement the following was included (see Appendix I):

Staging Plan

The Contractor shall submit a staging plan to the Engineer for approval for the construction of the Cement Concrete pavement at SR 395, 7th, 10th, 19th,and 27th Avenue.

The staging plans shall comply with the requirements of the Manual on Uniform Traffic Control Devices (M.U.T.C.D.) and as outlined in Section 1-07.23.

APPENDIX G – JOINTING DETAILS

The following instructions for intersection joint layout are taken from the ACPA's Concrete Information Pamphlet – Intersection Joint Layout [6]. These guidelines are by no means comprehensive for all intersections. The details show basic jointing for a right angle and skewed T-intersection. Other intersections may require individual attention for unique geometry that these examples do not address.

The primary goal of this method, as summarized by the ACPA, is to minimize or eliminate joints that intersect another joint or the pavement edge at an acute angle. Concrete panels with joints intersecting other joints or edges at angles of less than 60 degrees tend to crack. Right-angle intersections can be designed to eliminate all angles of less than 90 degrees for roadway slabs. There may be some acute angles at the curb line. Skewed intersections will likely require joints with angles of less than 90 degrees. In most cases angles of less than 60 degrees can be avoided.

The following definitions are provided for a better understanding of concrete intersection jointing terminology:

Doglegs: Construction block-outs at points where the pavement changes width.

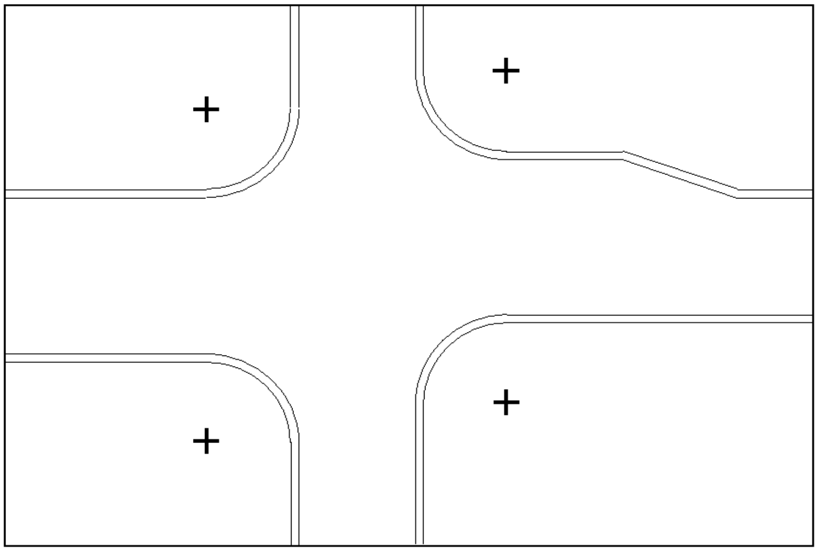
Circumference-Return Line: A lightly drawn line 0.5-1.0 m (1.5-3.0 ft.) from the face of the gutter along the curve between the edges of the intersecting roads. For obtuse angles the line is ½ the nominal lane width from the gutter. Any joint that meets the circumference-return line is brought along the curve's radius to the back of the curb and gutter.

Taper-Return Line: A lightly drawn line 0.5 m (1.5 ft.) from the face of the gutter at the start of a turn lane taper. Any longitudinal joint that meets a taper-return line defines a location for a dogleg in the gutter.

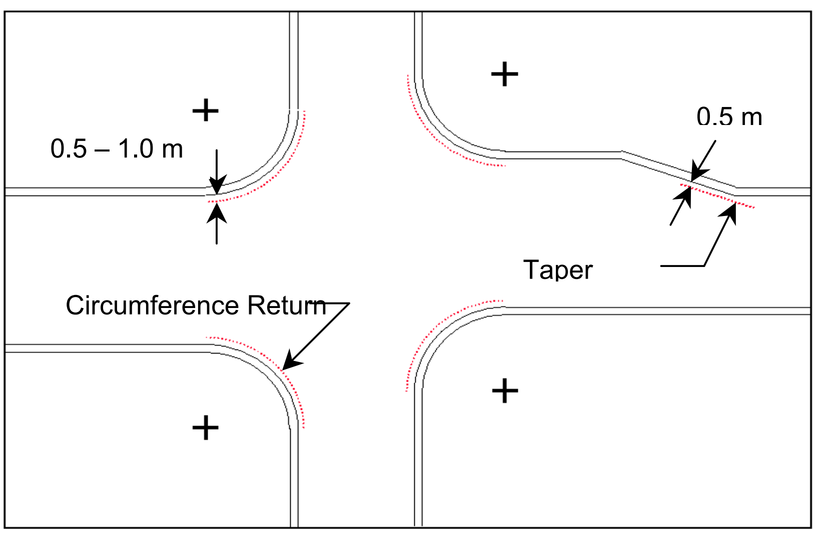
Cross-road Return Line: A lightly drawn line 0.5 m (1.5 ft) from the edge of the mainline roadway at a skewed intersection. Any cross-road longitudinal joint will meet a transverse joint for the mainline roadway at the cross-road return line.

Intersection Box: The box formed by the edge of the mainline and intersecting paving lanes (including turning lanes).

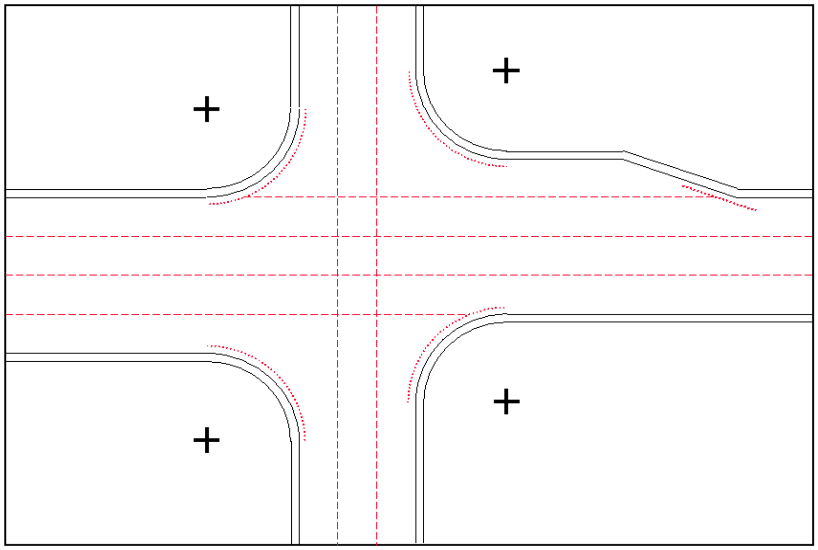
Jointing Guidelines for Right-Angle Intersections



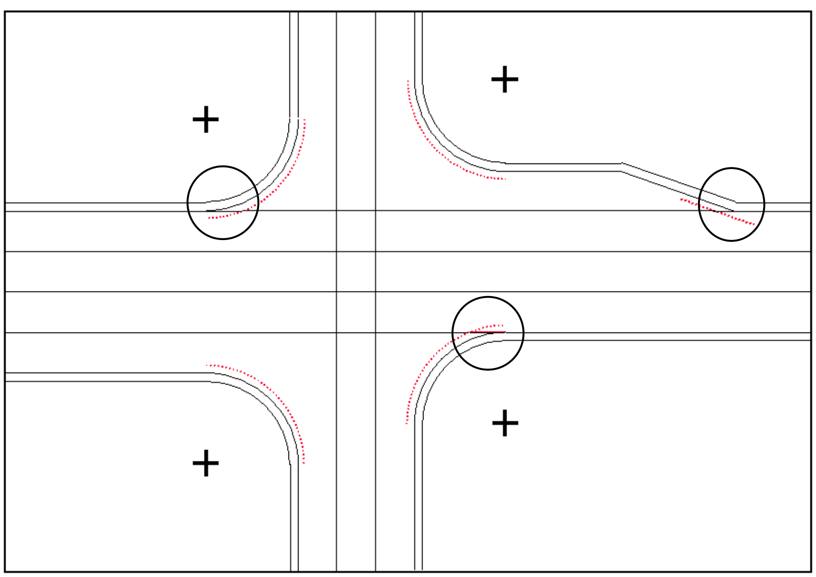
Step 1: Draw all pavement edges and back of curb lines on the plan view.



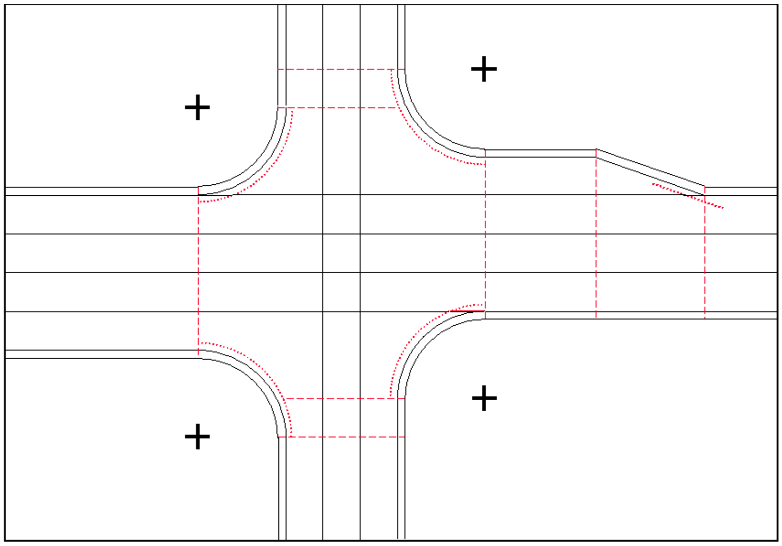
Step 2: Lightly draw the circumference-return, taper-return, and the cross-road-return line(s).



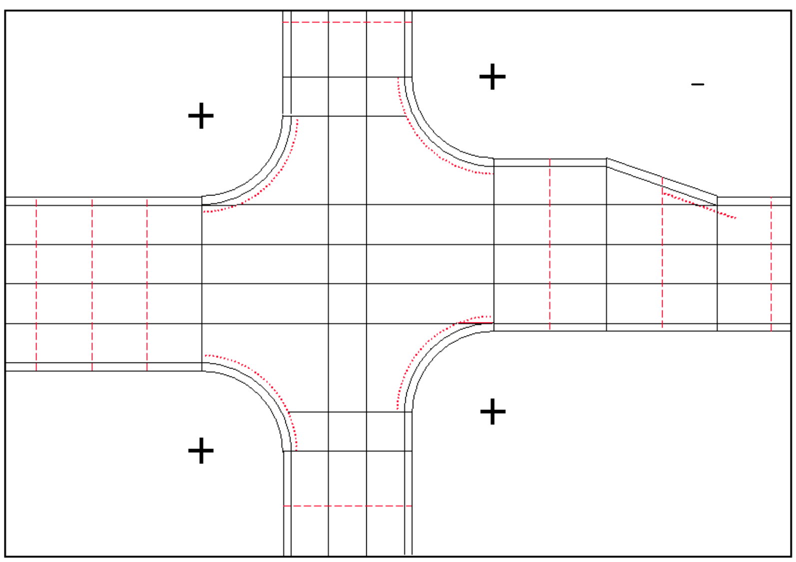
Step 3: Draw all lines that define lanes on the mainline and cross road. (Do not extend these lines past the circumference-return, taper-return, or cross-road-return lines.)



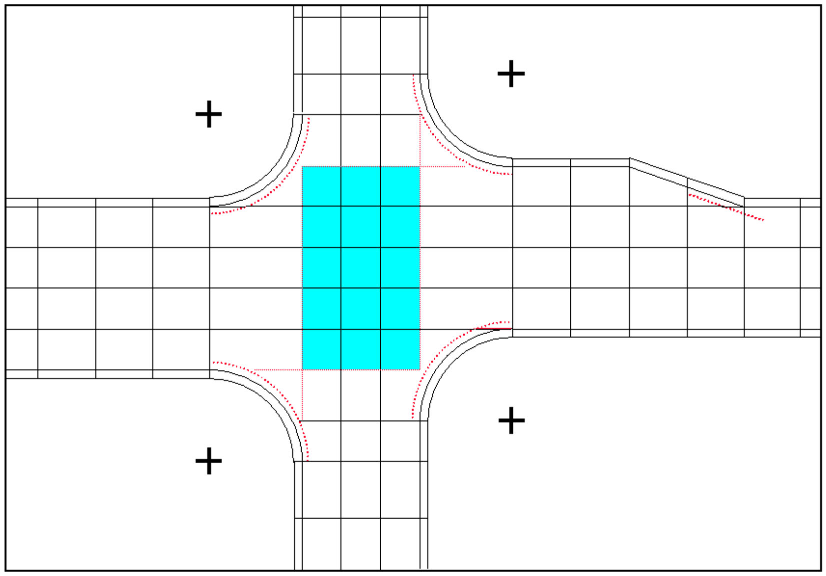
Step 4: Define the mainline lanes for paving. Find all locations where the mainline lanes intersect circumference-return or taper-return lines. At these locations only, extend the mainline paving edge lines past the circumference-return or taper return line(s).



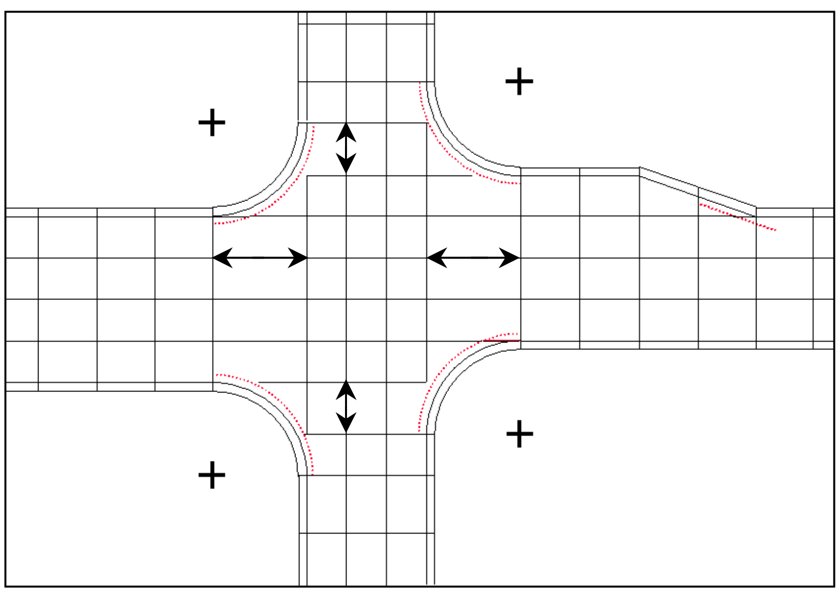
Step 5: Add transverse joints at all locations where the pavement changes width, extending the joints through the curb and gutter. Do not extend joints that intercept a circumference-return or cross-road-return line, except at the tangent points.



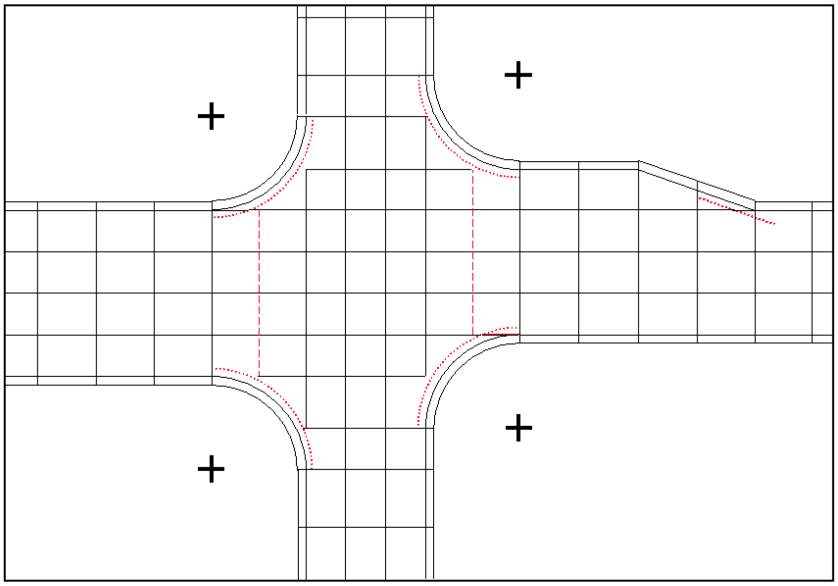
Step 6: Add transverse joint(s) between and beyond the joints you defined in Step 5, but do not add joints to the center of the intersection yet. Attempt to keep the distance between joints less than the maximum desirable length. Usually, the maximum length is about 3.6 to 4.5m (12 to15 ft.).



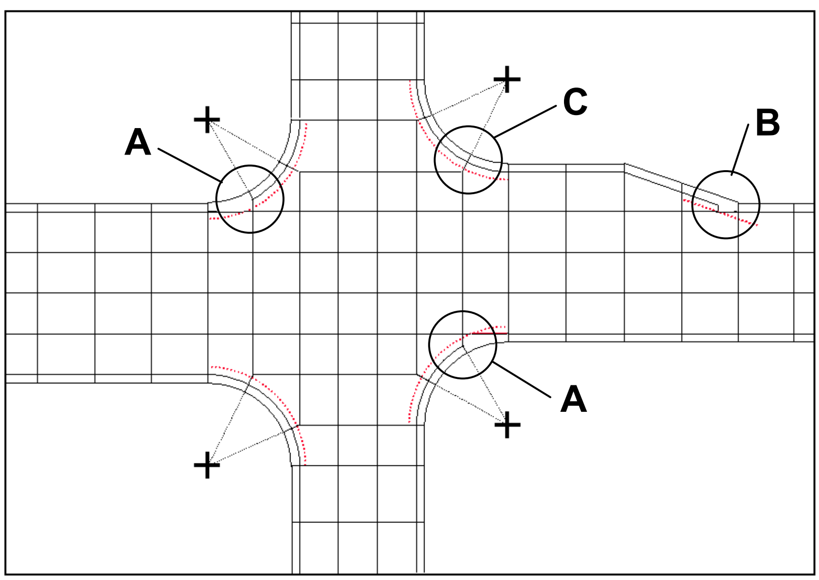
Step 7: By extending the edge of pavement lines for the cross road and any turning lanes, define the intersection box.



Step 8: Check the distances between the "intersection box" and the surrounding joints.



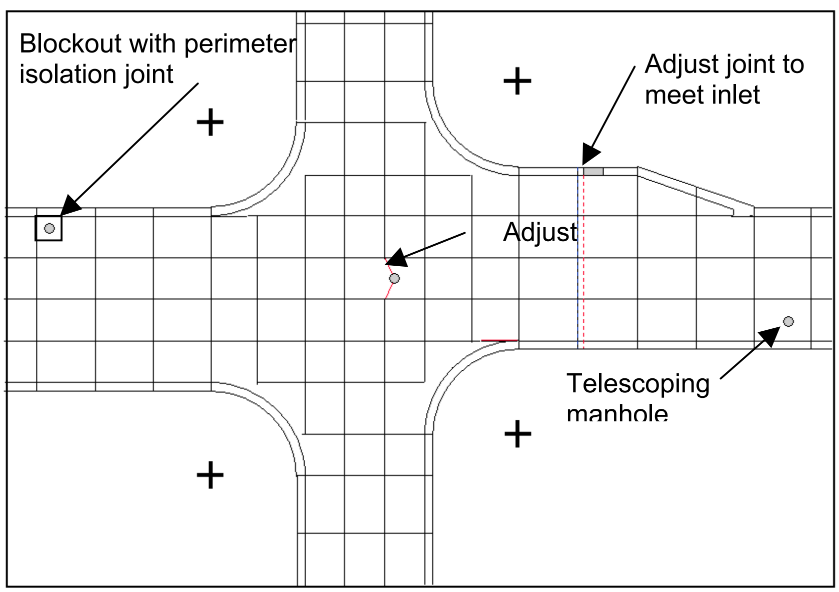
Step 9: If the distance is more than the maximum desirable joint spacing, then add transverse joint(s) at an equal spacing (panel lengths of 12 to 15 feet are desirable). Do not extend these joints past the circumference-return or cross-road-return lines.



Step 10: Lightly extend lines from the center of the curve(s) to the points defined by the "intersection box." Add joints along these radius lines. Finally, make slight adjustments to eliminate doglegs in the mainline edges (See figures G-1 to G-3).

After developing the jointing plan, plot any catch basins, manholes or other fixtures that are within the intersection. Non-telescoping manholes will require a boxout or isolation to allow for vertical and horizontal slab movement. Consider using rounded boxouts or placing fillets on the corners of square boxouts to avoid crack-inducing corners. Also, for square boxouts, wire-mesh or small diameter reinforcing bars in the concrete around any interior corners will hold cracks tight should they develop. Telescoping manholes can be cast integrally within the concrete and do not necessarily require a boxout. The two-piece casting does not inhibit vertical movement and is less likely to create cracks within the pavement.

Finally, when a joint is within 1.2 meters of a fixture, it is desirable to adjust the joint so that it will pass through the fixture or the boxout surrounding the fixture. These steps are shown in Step 11.



Step 11: Adjust joints for utility fixtures.

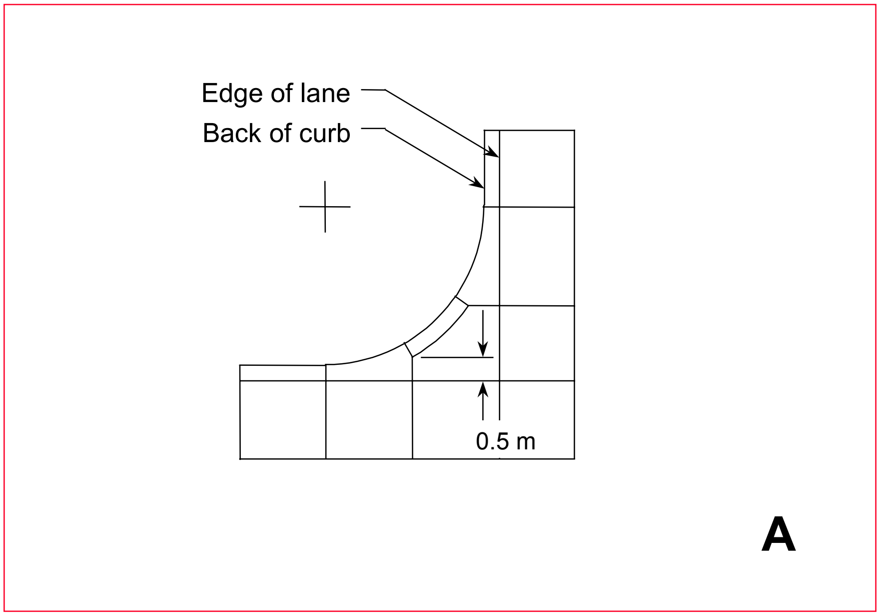


Figure G-1. Width change and dogleg in gutter near point of curvature.

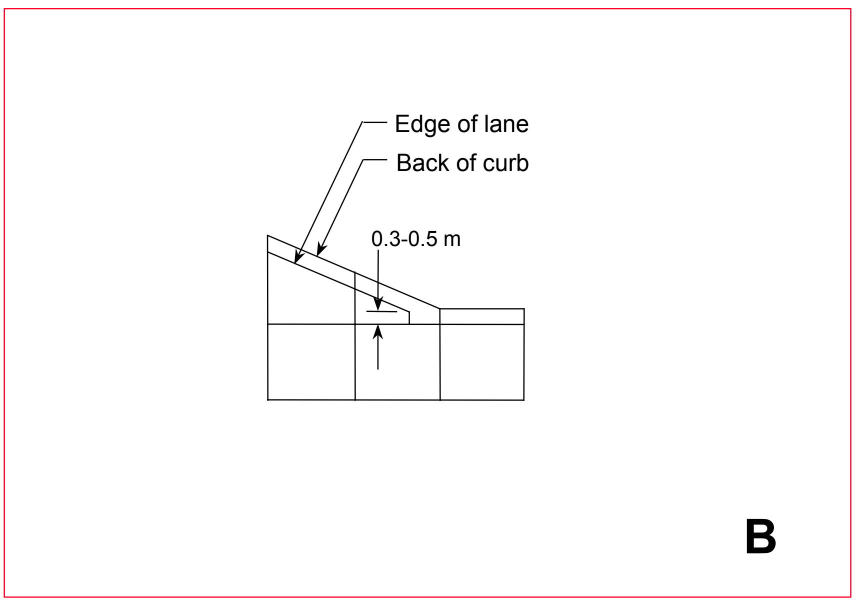


Figure G-2. Width change and dogleg in gutter near start of a taper.

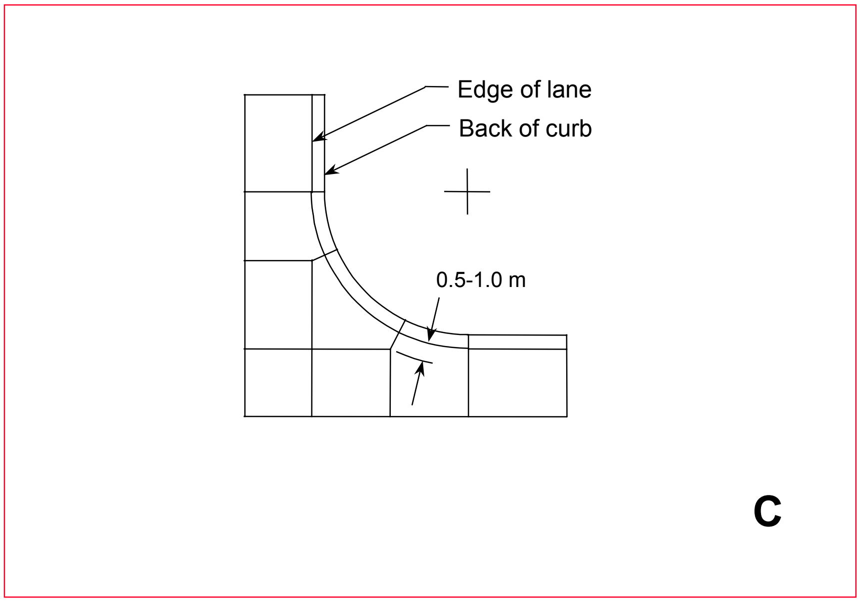
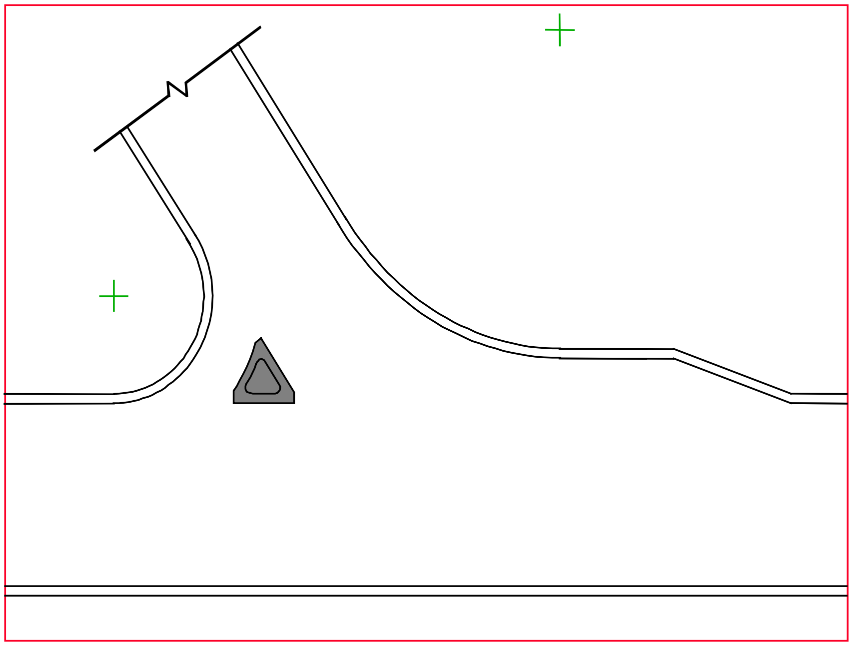
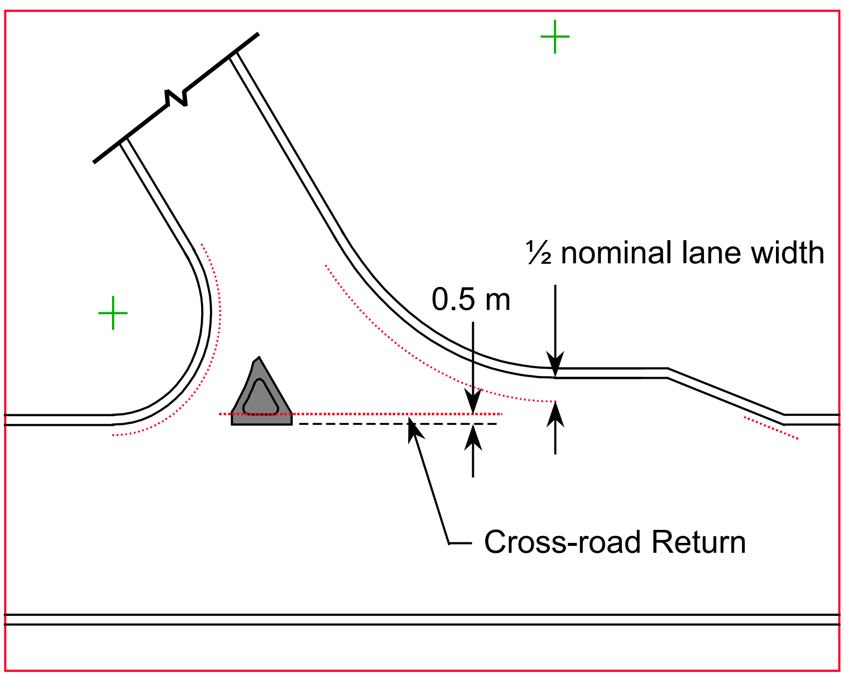


Figure G-3. Width change and dogleg in paving slab for hand-pour areas.

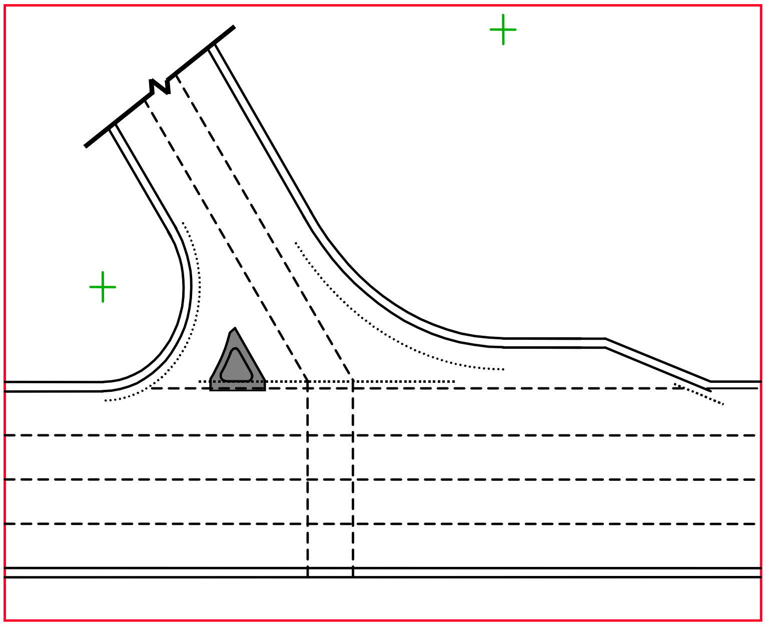
Jointing Guidelines for Skewed Intersection



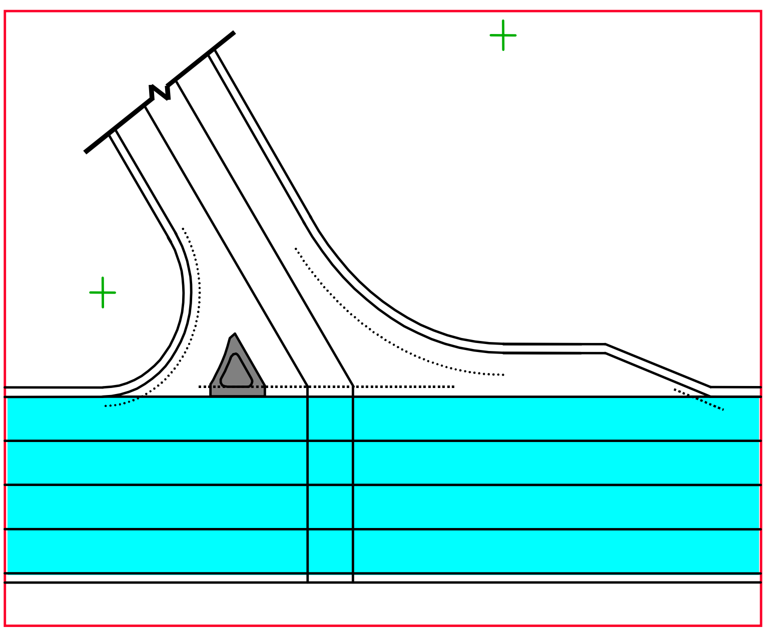
Step 1: Draw all pavement edges and back of curb lines on the plan view.



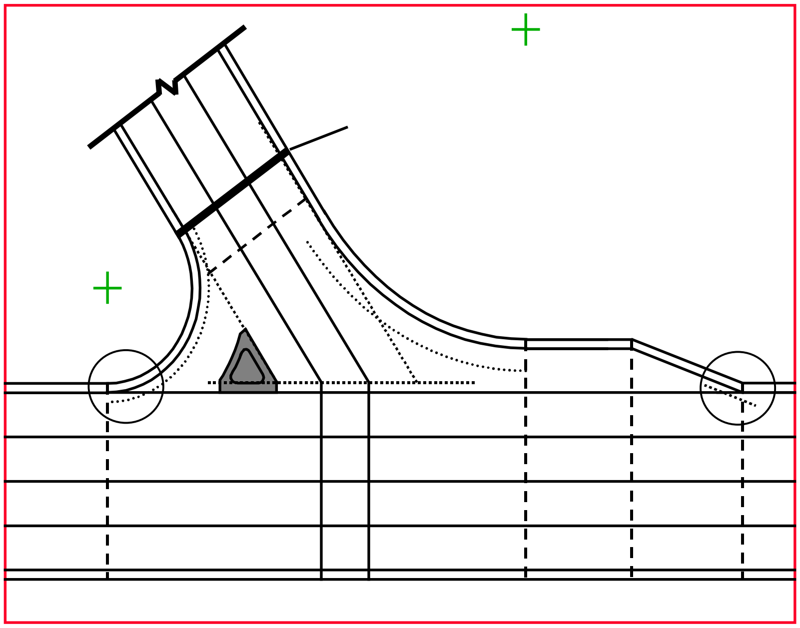
Step 2: Lightly draw the circumference-return, taper-return, and the cross-road-return line(s).



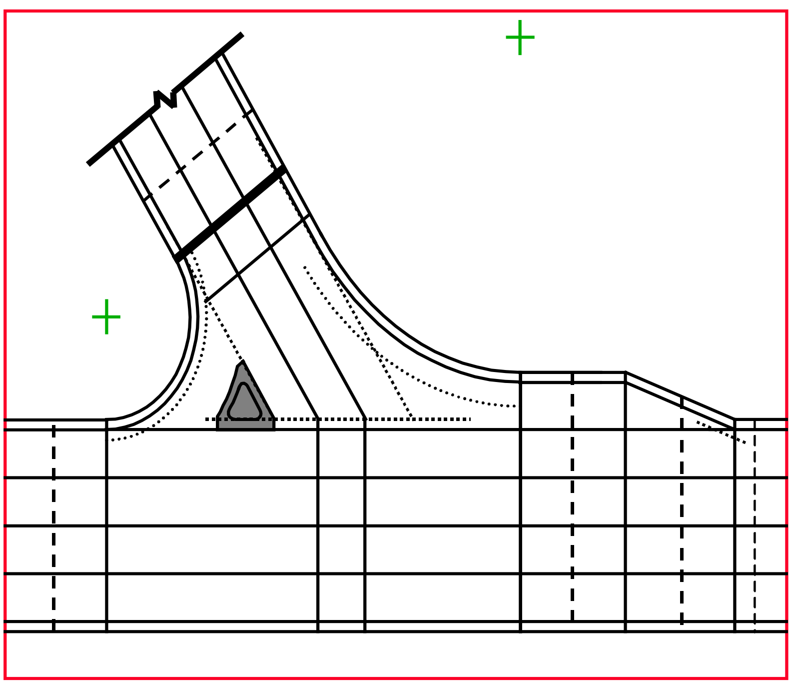
Step 3: Draw all lines that define lanes on the mainline and cross road. (Do not extend these lines past the circumference-return, taper-return, or cross-road-return lines.)



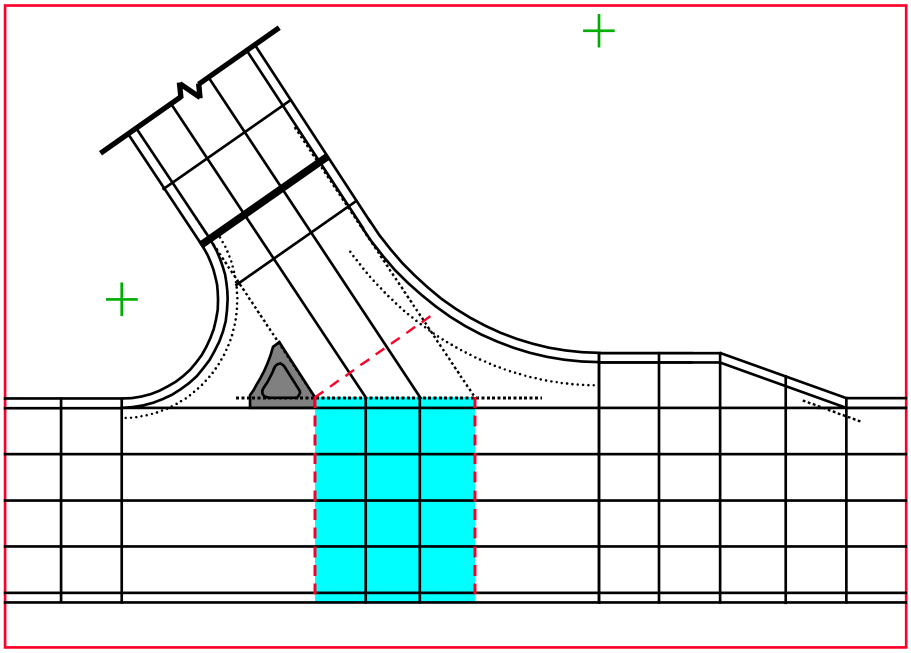
Step 4: Define the mainline lanes for paving. Find all locations where the mainline lanes intersect circumference-return or taper-return lines. At these locations only, extend the mainline paving edge lines past the circumference-return or taper return line(s).



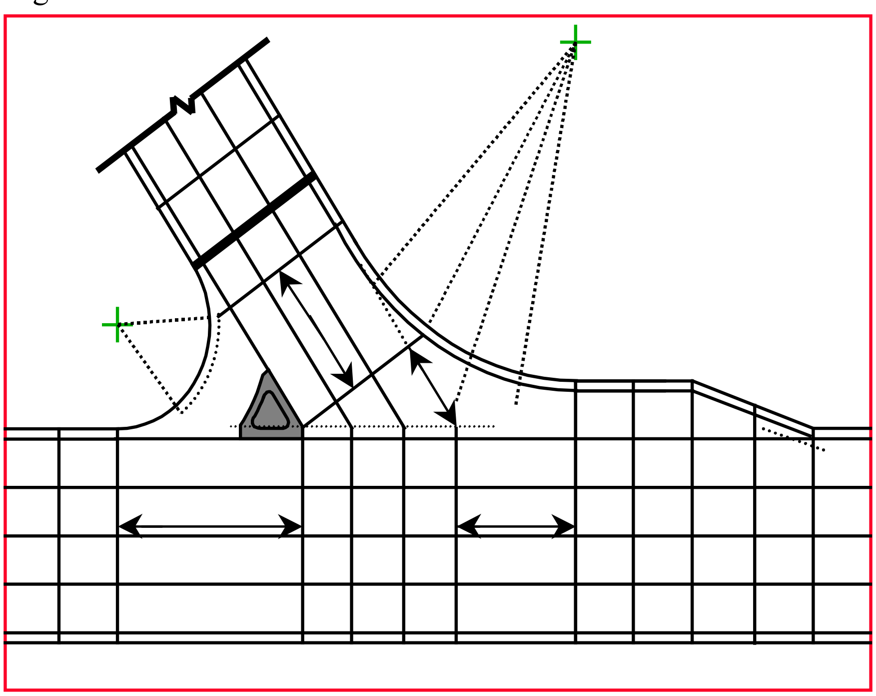
Step 5: Add transverse joints at all locations where the pavement changes width, extending the joints through the curb and gutter. Do not extend joints that intercept a circumference-return or cross-road-return line, except at the tangent points. The joint at the tangent point farthest from the mainline becomes an isolation joint in the cross road for T- and unsymmetrical intersections.



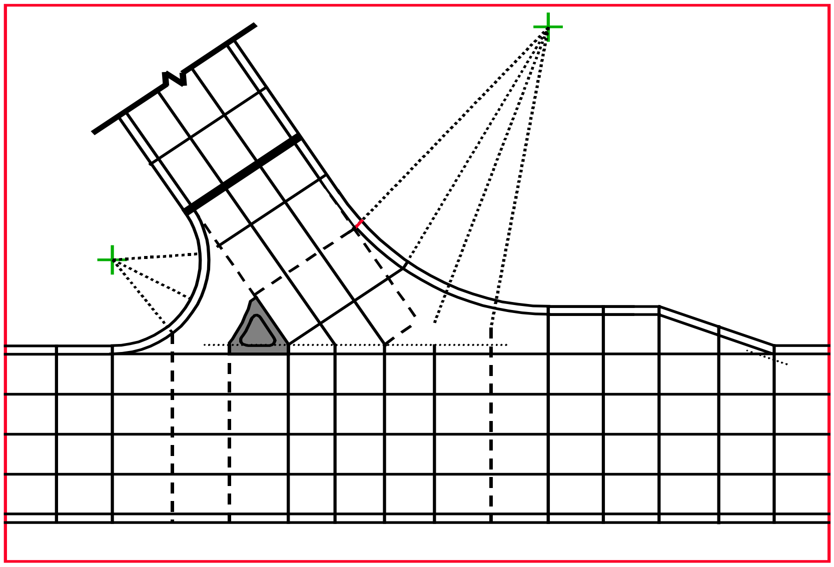
Step 6: Add transverse joint(s) between and beyond the joints you defined in Step 5, but do not add joints to the center of the intersection yet. Attempt to keep the distance between joints less than the maximum desirable length. Usually the maximum length is about 3.6 to 4.5m (12 to 15 ft.).



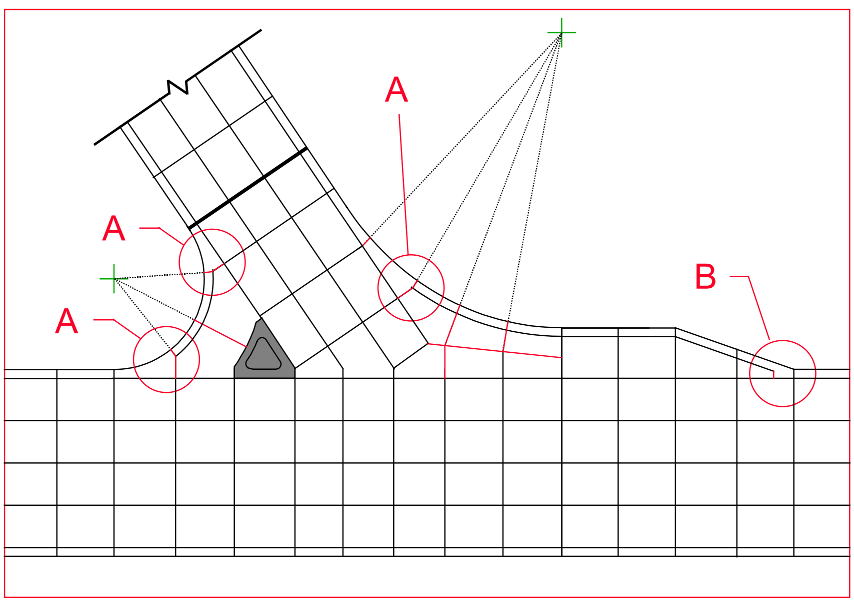
Step 7: By extending the edge of pavement lines for the cross road and any turning lanes, define the intersection box. For Skewed intersections do not extend the lines for the turning lanes. Instead, place a transverse joint normal to the cross road centerline starting from the corner of the intersection box that is nearest to the acute angle of the intersection.



Step 8: Check the distances between the "intersection box" and the surrounding joints.



Step 9: If the distance is more than the maximum desirable joint spacing, then add transverse joint(s) at an equal spacing (panel lengths of 12 to 15 feet are desirable). Do not extend these joints past the circumference-return or cross-road-return lines.



Step 10: Lightly extend lines from the center of the curve(s) to the points defined by the "intersection box". Add joints along these radius lines. Finally, make slight adjustments to eliminate doglegs in the mainline edges (See figures G-1 to G-3).

Skewed Intersection Layout Alternative

The alternative for a skewed intersection, shown in Figure G-4, is useful for simple curve radii greater than 11 m and offset or compound radius curves. It can simplify field construction when the contractor builds the curve area in a single hand pour (indicated by the shaded area).

It is necessary to add an additional longitudinal joint near the center of the slabs that exceed 5 meters wide. The additional joint should prevent the occurrence of a longitudinal crack. It is desirable to begin and end the additional longitudinal joint at a transverse joint, as shown in the diagram. Some agencies core a small 50-millimeter hole through the slab at the ends of this longitudinal joint to prevent sympathy cracking (see Photo G-1).

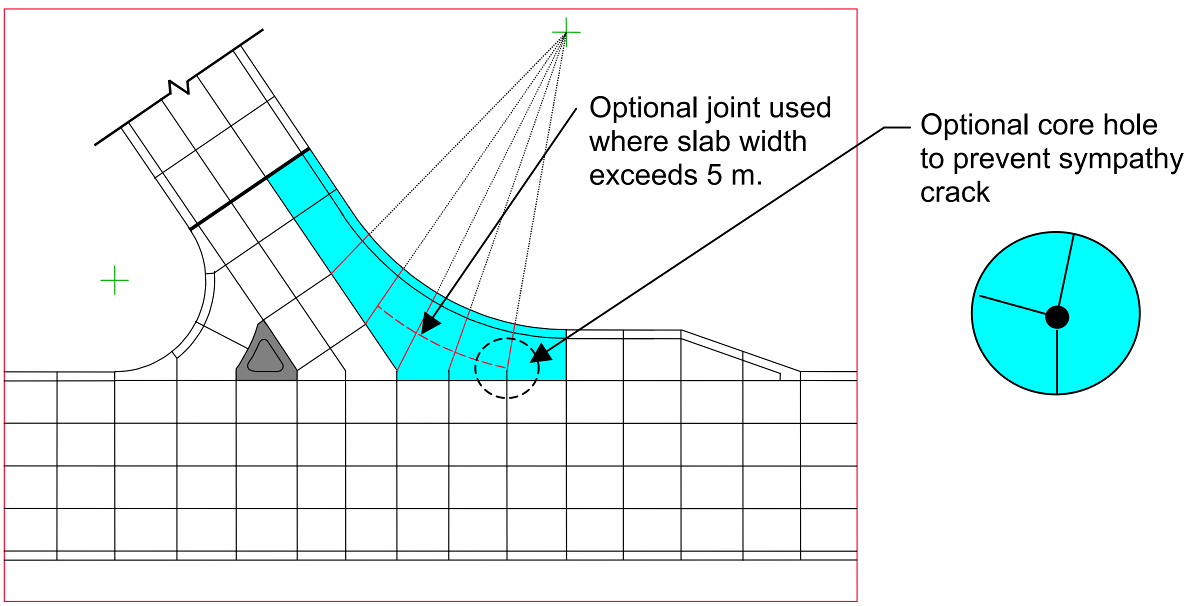


Figure G-4. Skewed intersection Layout Alternative.

Photo G-1. Drilled hole that can be used to prevent a sympathy crack where joints tee (See Photo 45).

Wide Medians and Dual Left-Turn Lanes Options

Large urban and suburban intersections that contain dual left turn lanes create joint alignment challenges. The medians in these large intersections are often up to 9.2 meters wide. The diagram in Figure G-5 shows how to skew joints through the intersection box in order to maintain the joints along the lane lines for dual left-turn lanes. The ability to use this method will depend on construction staging; it is just one option to apply for complex intersections.

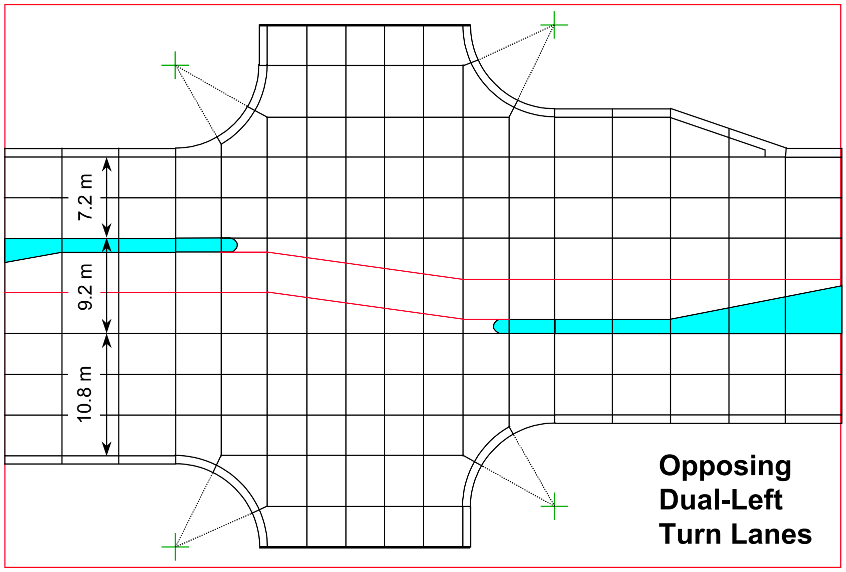


Figure G-5. Wide median and dual left-turn lane jointing.

APPENDIX H – SAMPLE JOINTING PLANS

Figures H-1 to H-13 show sample jointing plans that have been used on WSDOT contracts. A revised jointing plan follows each contract plan to illustrate revisions that should be made on future intersections.

Figure	**Intersection**
H-1	SR 2, Division Street and Francis Avenue - contract jointing plan
H-2	SR 2, Division Street and Francis Avenue - revised jointing plan
H-3	SR 27, Pines Road and Broadway Avenue - contract jointing plan
H-4	SR 27, Pines Road and Broadway Avenue - revised jointing plan
H-5	SR 27, Pines Road and Broadway Avenue - boxout details
H-6	SR 2, Division Street to Third Avenue - contract jointing plan
H-7	SR 2, Division Street to Third Avenue - revised jointing plan
H-8	SR 291, Francis Avenue with Maple Street - contract jointing plan
H-9	SR 291, Francis Avenue with Maple Street - revised jointing plan
H-10	SR 291, Francis Avenue with Ash Street - contract jointing plan
H-11	SR 291, Francis Avenue with Ash Street - revised jointing plan
H-12	SR 291, Division to Lowell Avenue - joint details
H-13	SR 90, Evergreen Interchange - PCCP interface at a skewed bridge approach slab
H-14	Spokane County jointing plan – Sullivan Road and 32nd Avenue intersection.

Figure H-1. SR 2, Division Street and Francis Avenue – contract jointing plan.

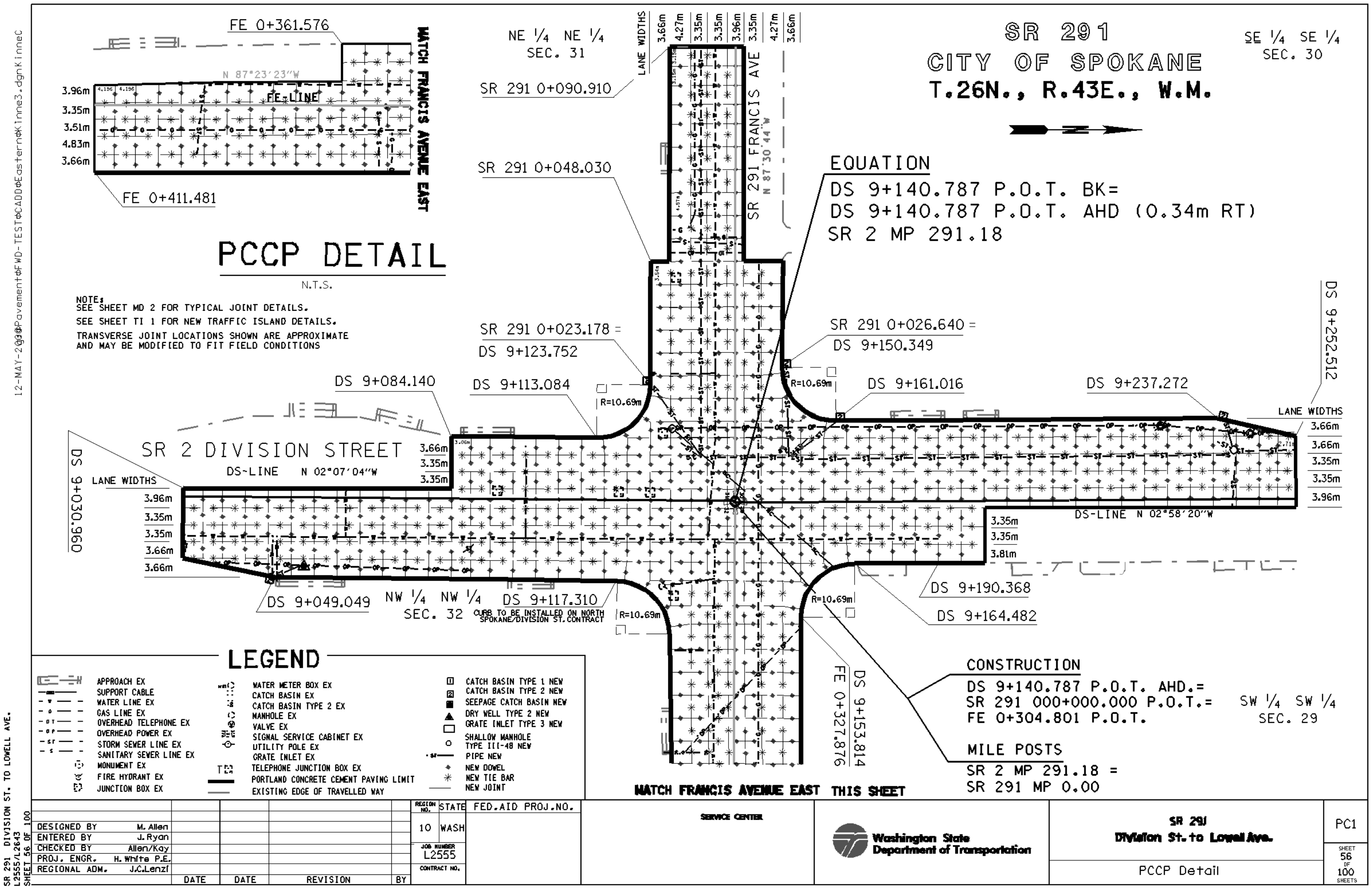


Figure H-2. SR 2, Division Street and Francis Avenue - revised jointing plan.

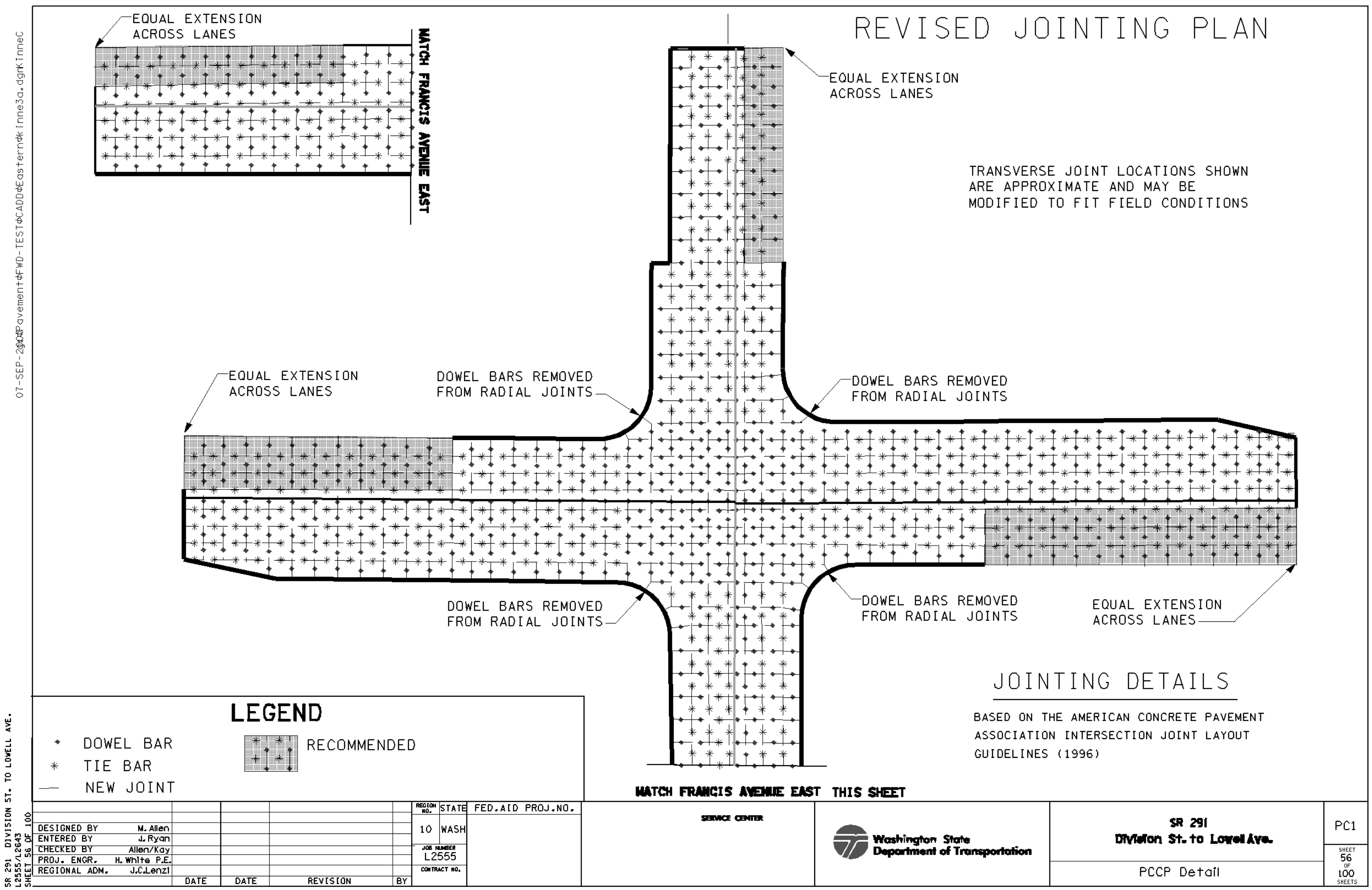


Figure H-3. SR 27, Pines Road and Broadway Avenue – contract jointing plan.

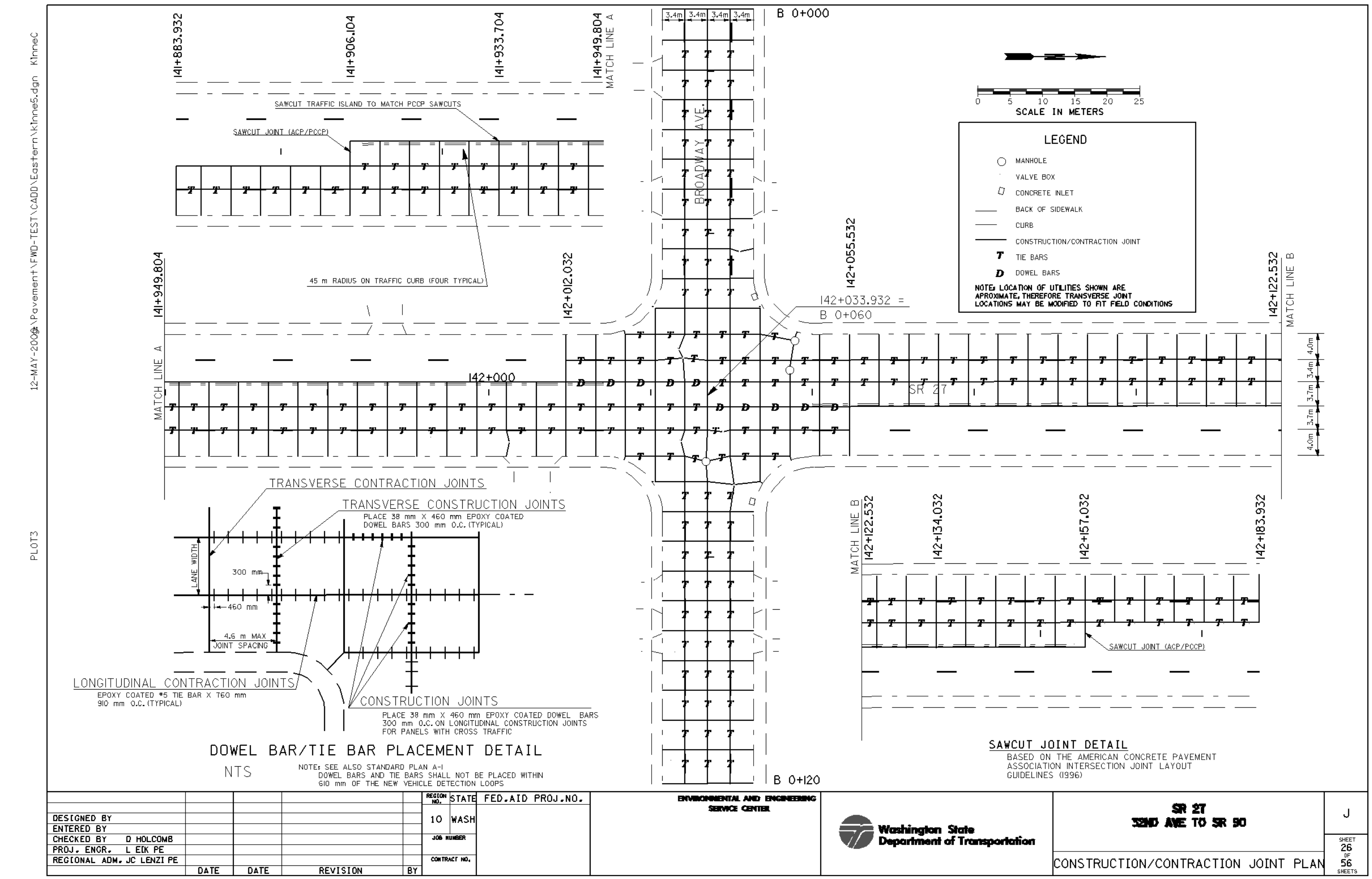


Figure H-4. SR 27, Pines Road and Broadway Avenue – revised jointing plan.

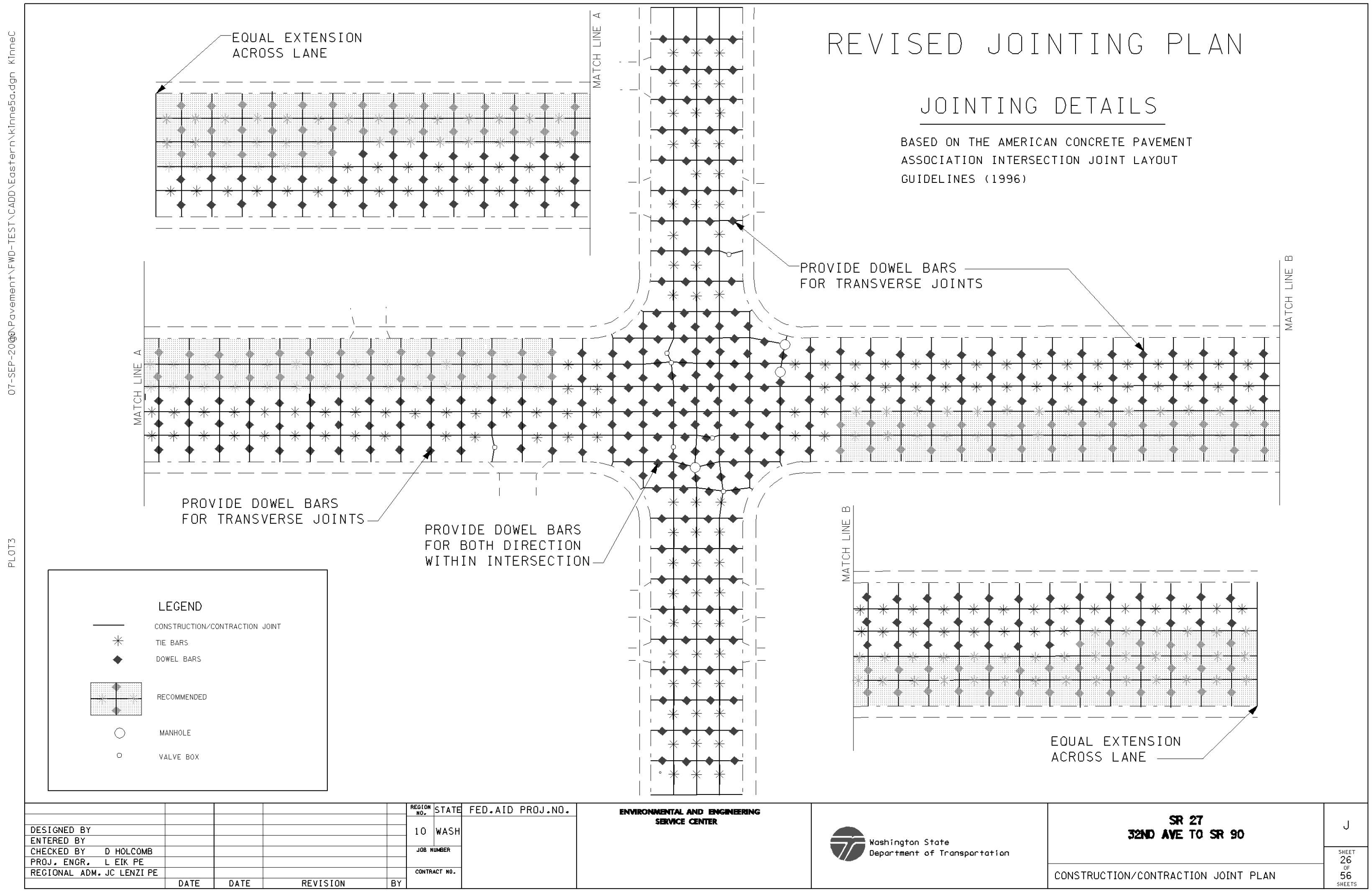
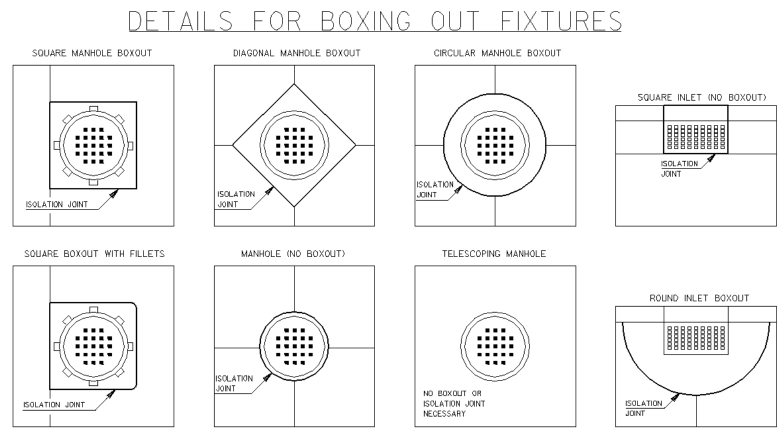


Figure H-5. SR 27, Pines Road and Broadway Avenue – boxout details.



NOTES: 1. ISOLATION JOINTS SHOULD BE AT LEAST 12 mm WIDE AND FILLED WITH A COMPRESSIBLE MATERIAL.
2. BOXOUTS SHOULD BE LARGE ENOUGH TO PROVIDE AT LEAST 0.3 m CLEARANCE BETWEEN THE FIXTURE AND THE SURROUNDING ISOLATION JOINT.

DESIGNED BY
ENTERED BY
CHECKED BY D HOLCOMB
PROJ. ENGR. L EIK PE
REGIONAL ADM. JC LENZI PE

DATE	DATE	REVISION	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER
CONTRACT NO.

ENVIRONMENTAL AND ENGINEERING SERVICE CENTER

Washington State Department of Transportation

SR 27
32ND AVE TO SR 90
MISC DETAILS

M1
SHEET 27 OF 56 SHEETS

07-SEP-2000\Pavement\FWD-TEST\CADD\Eastern\kinne5a.dgn KinneC
PLOT24

Figure H-6. SR 2, Division Street to Third Avenue – contract jointing plan.

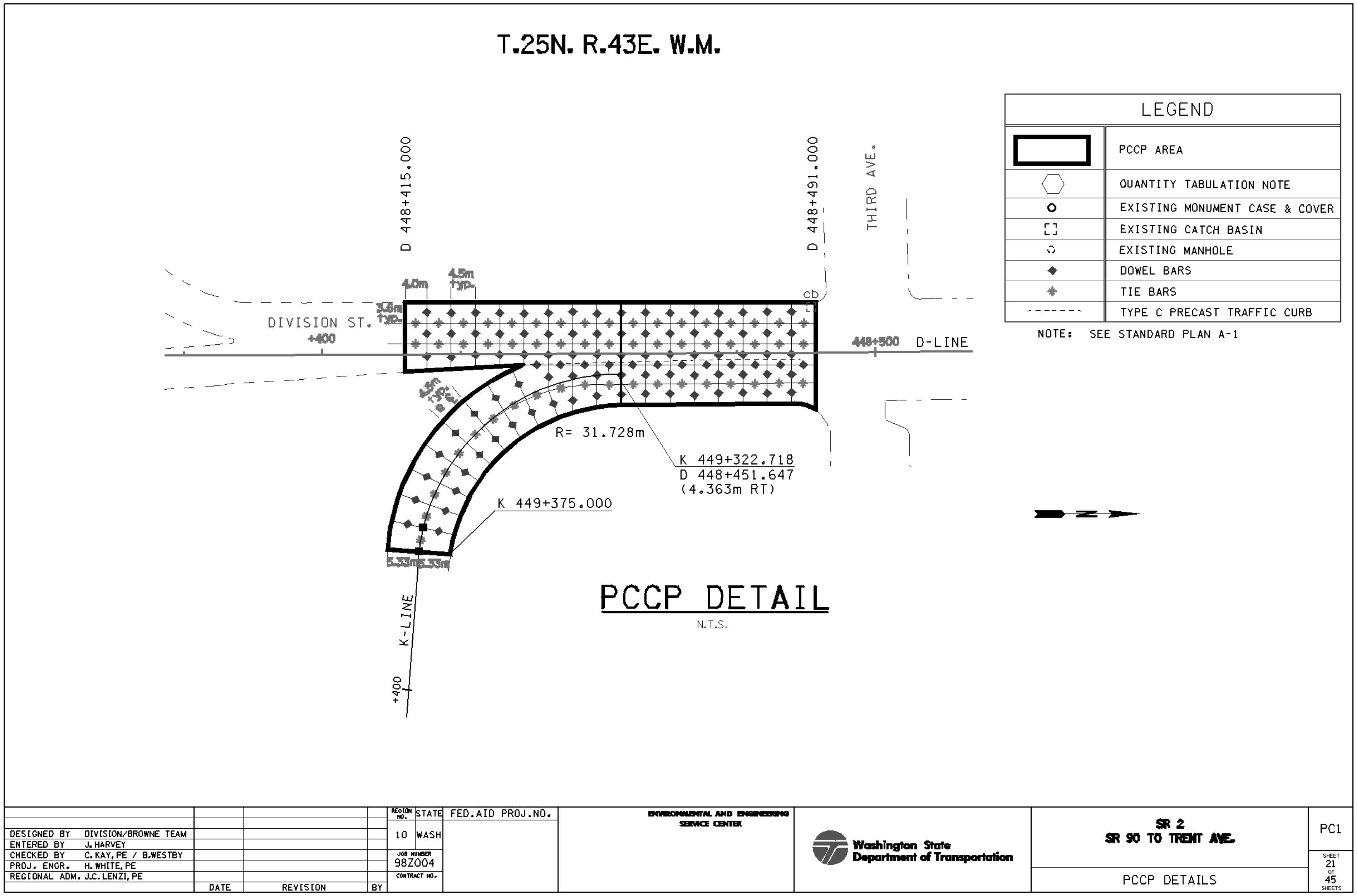


Figure H-7. SR 2, Division Street to Third Avenue – revised jointing plan.

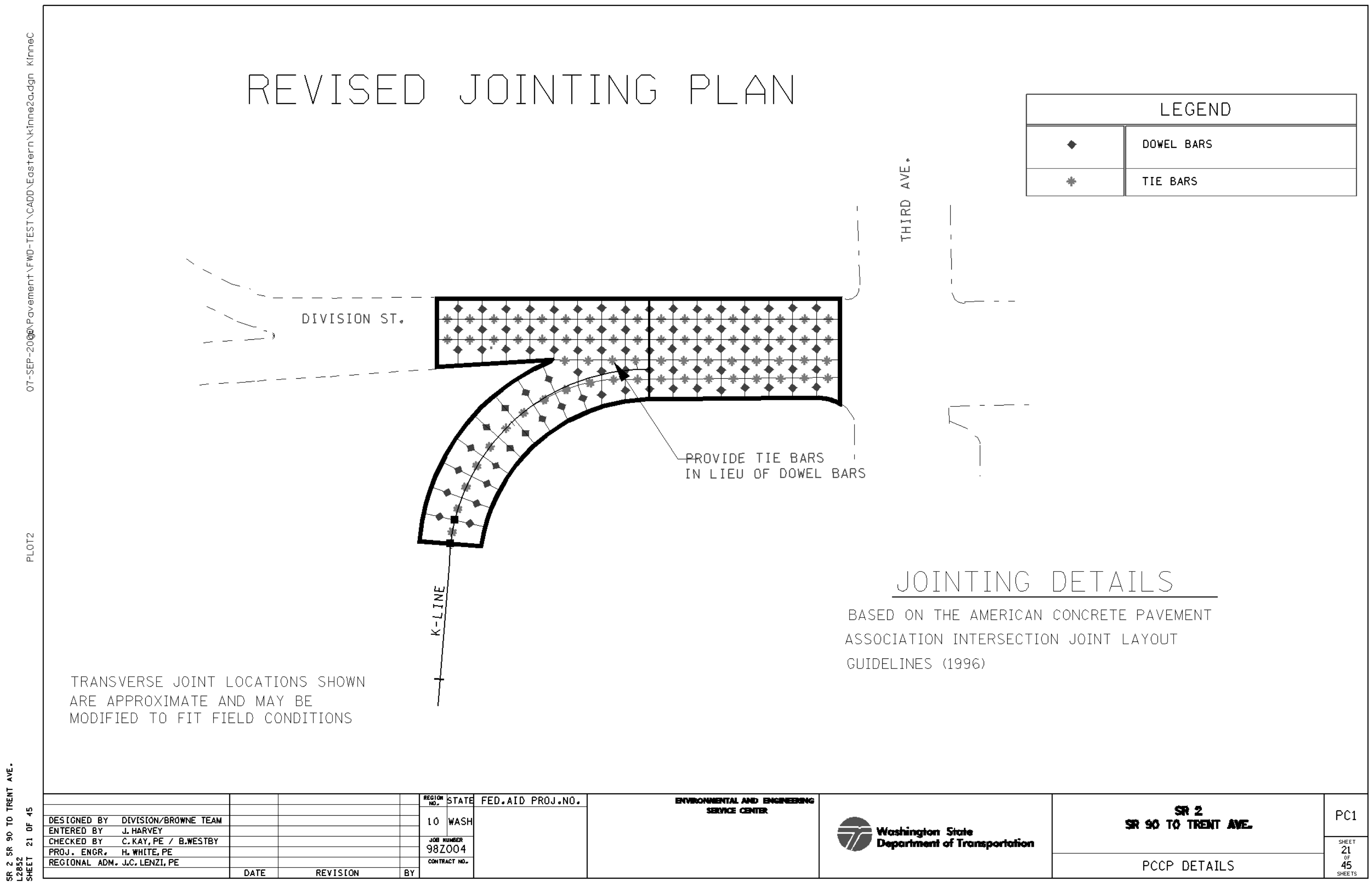


Figure H-8. SR 291, Francis Avenue with Maple Street – contract jointing plan.

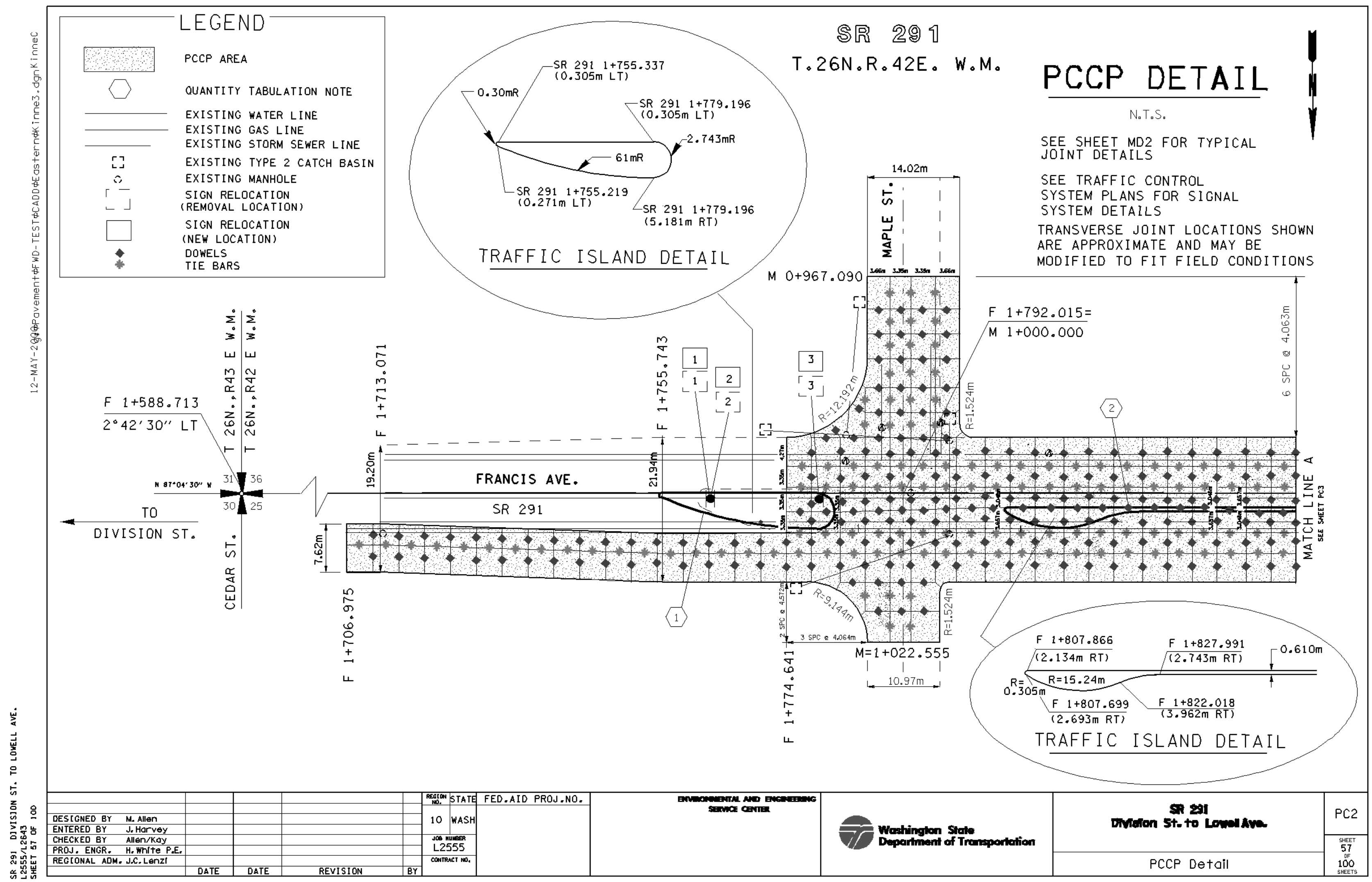


Figure H-9. SR 291, Francis Avenue with Maple Street – revised jointing plan.

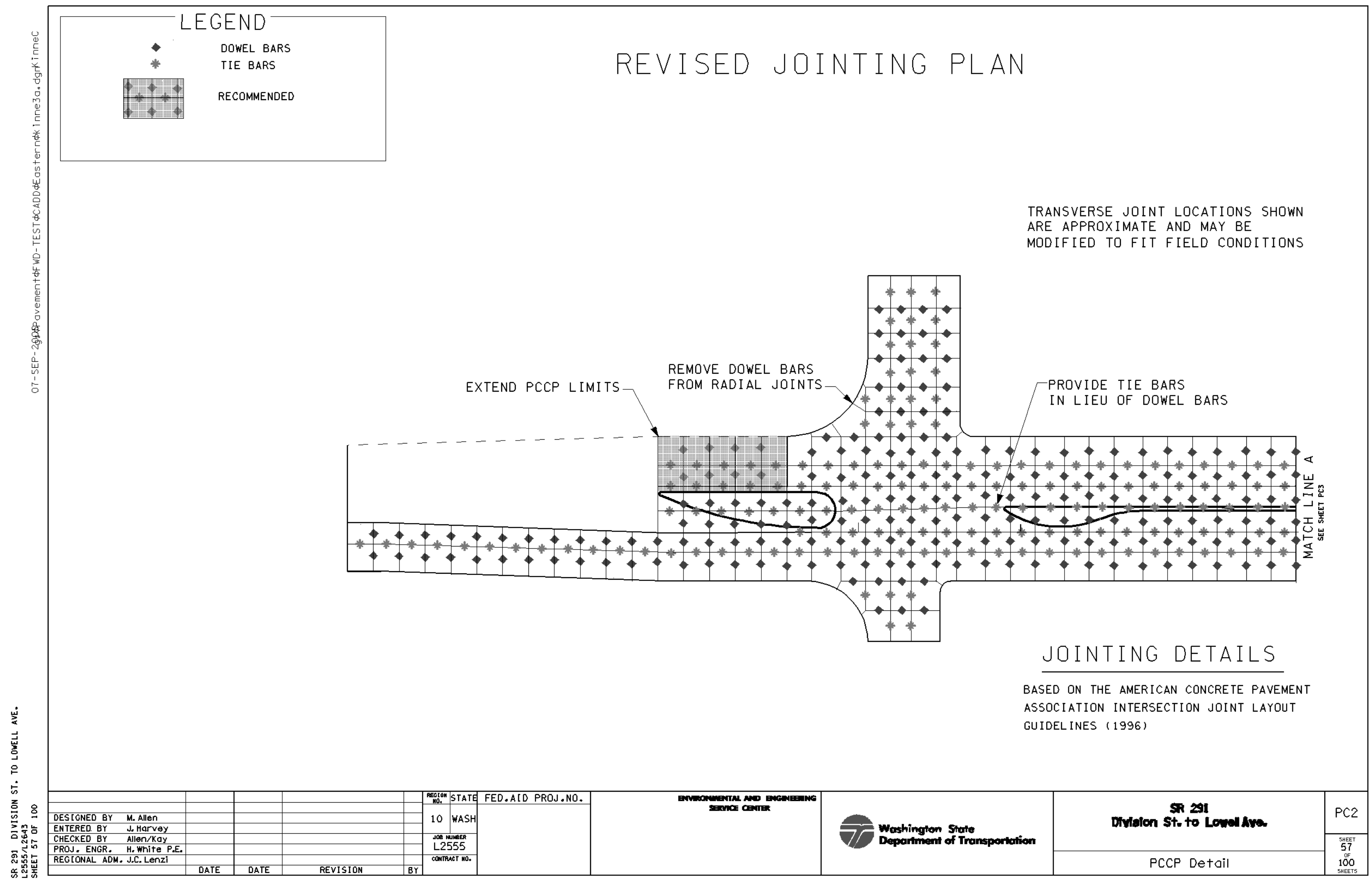


Figure H-10. SR 291, Francis Avenue with Ash Street – contract jointing plan.

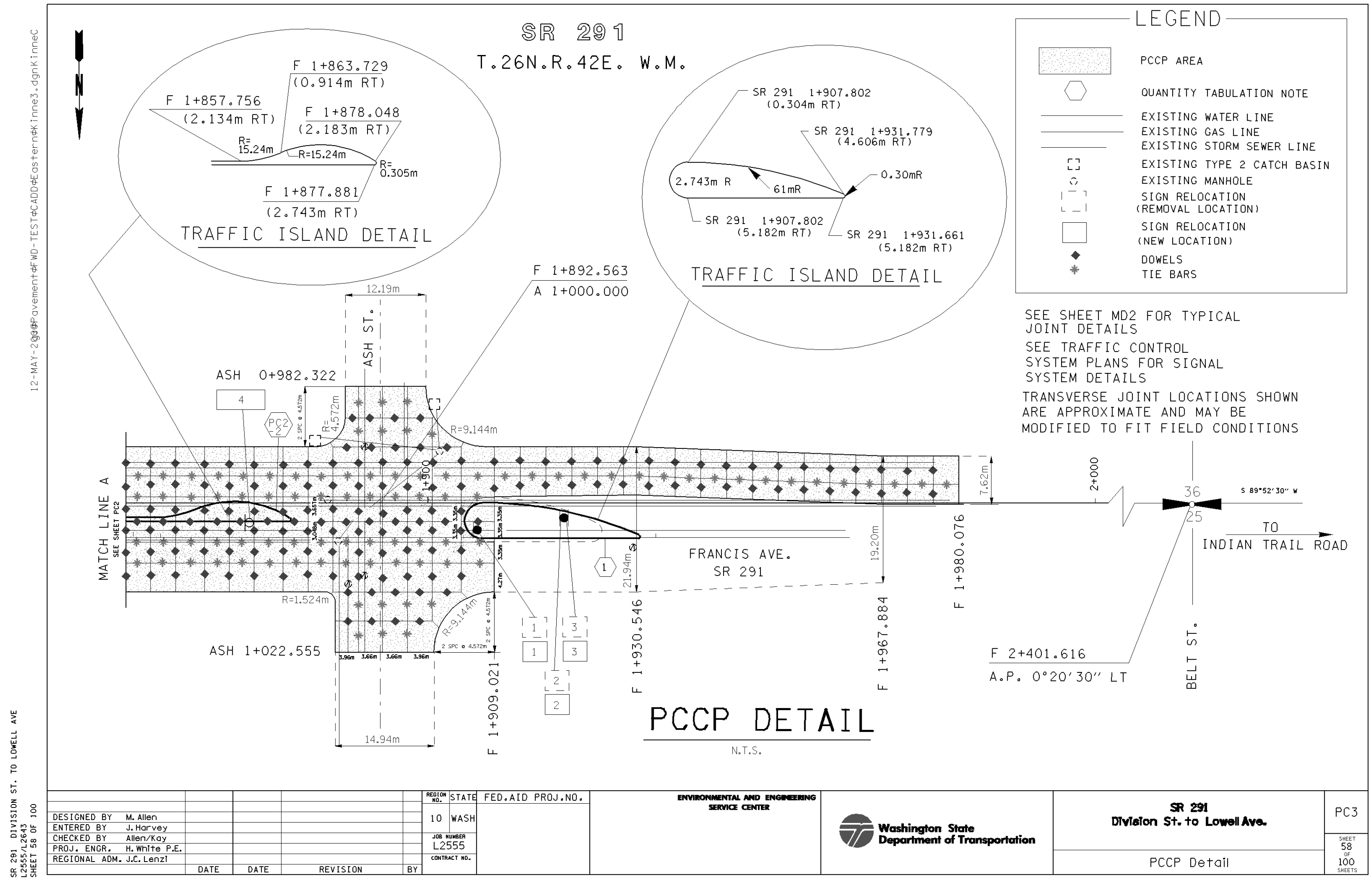


Figure H-11. SR 291, Francis Avenue with Ash Street – revised jointing plan.

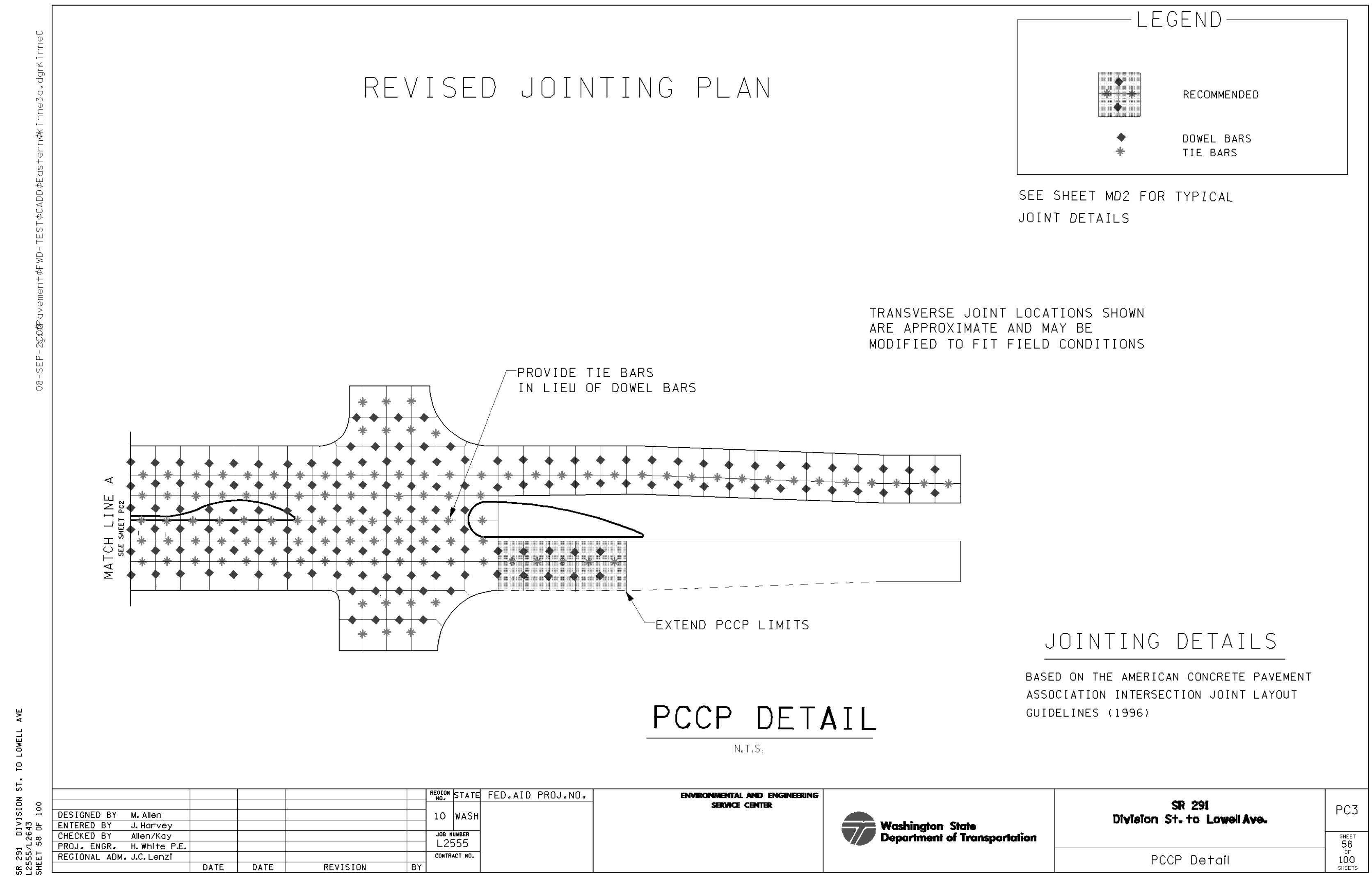


Figure H-12. SR 291, Division to Lowell Avenue – joint details.

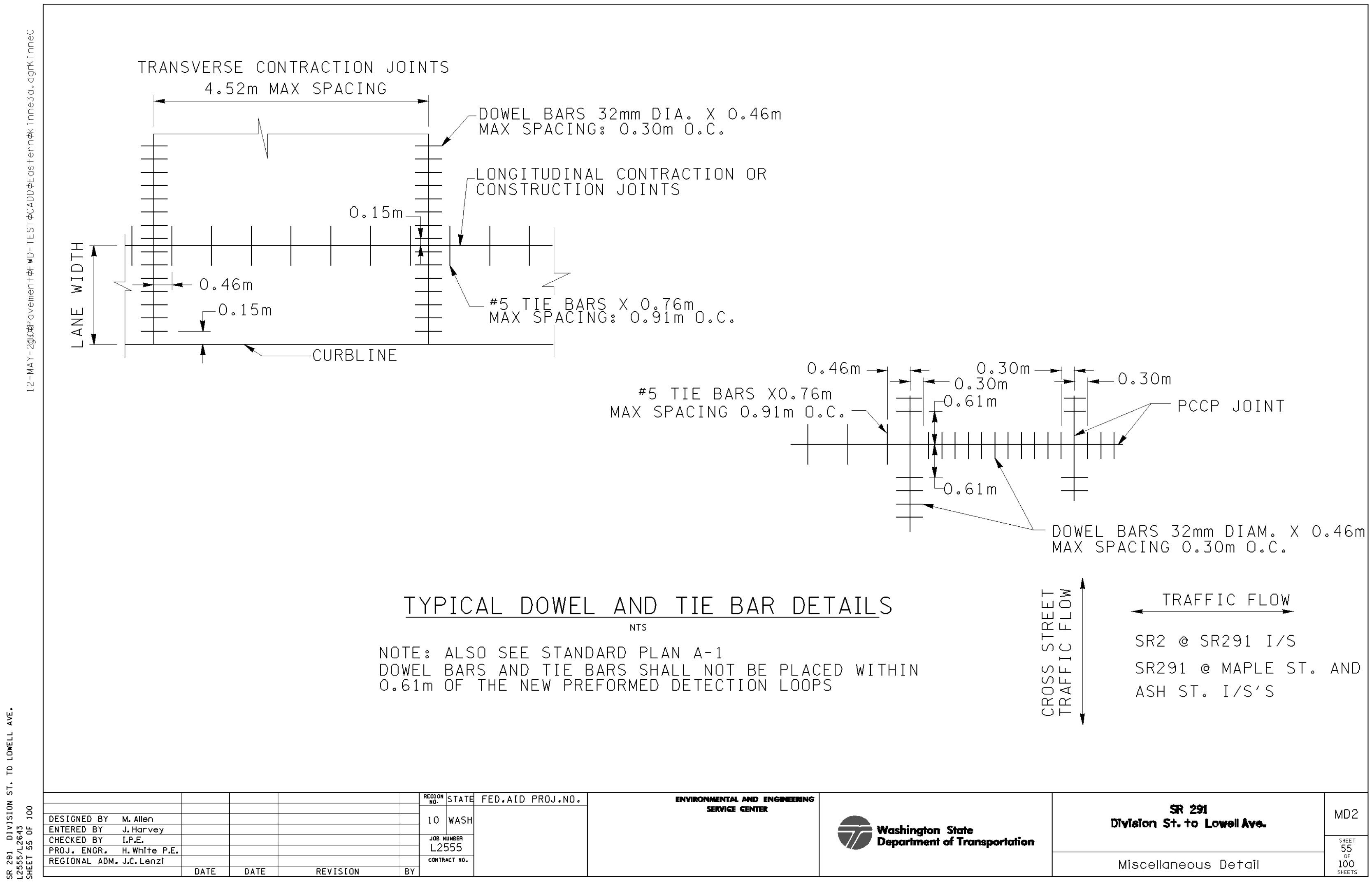


Figure H-13. SR 90, Evergreen Interchange – PCCP interface at a skewed bridge approach slab. Dowel bars should be aligned parallel with the roadway centerline.

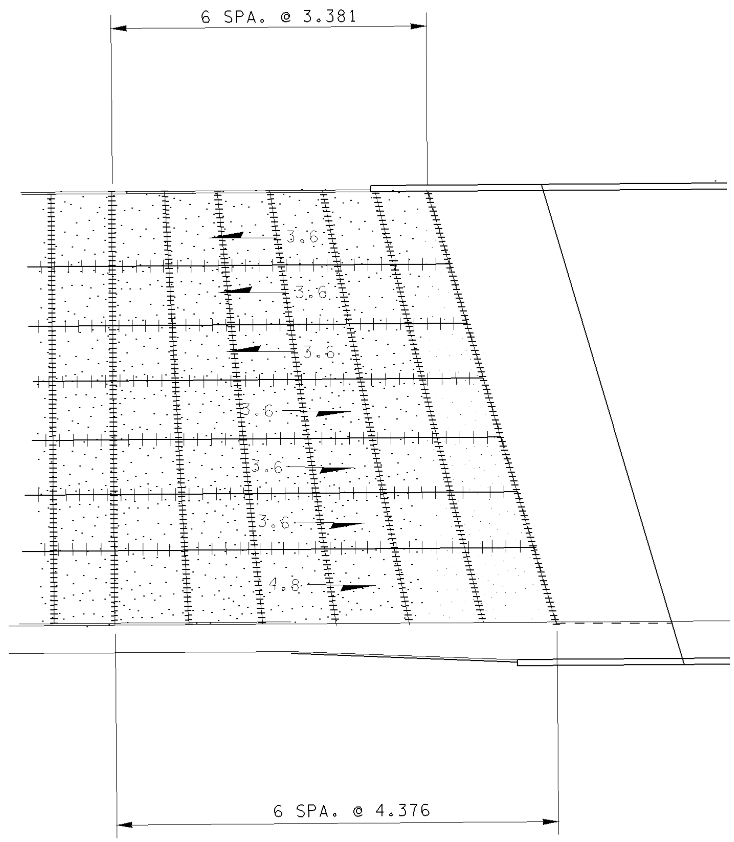
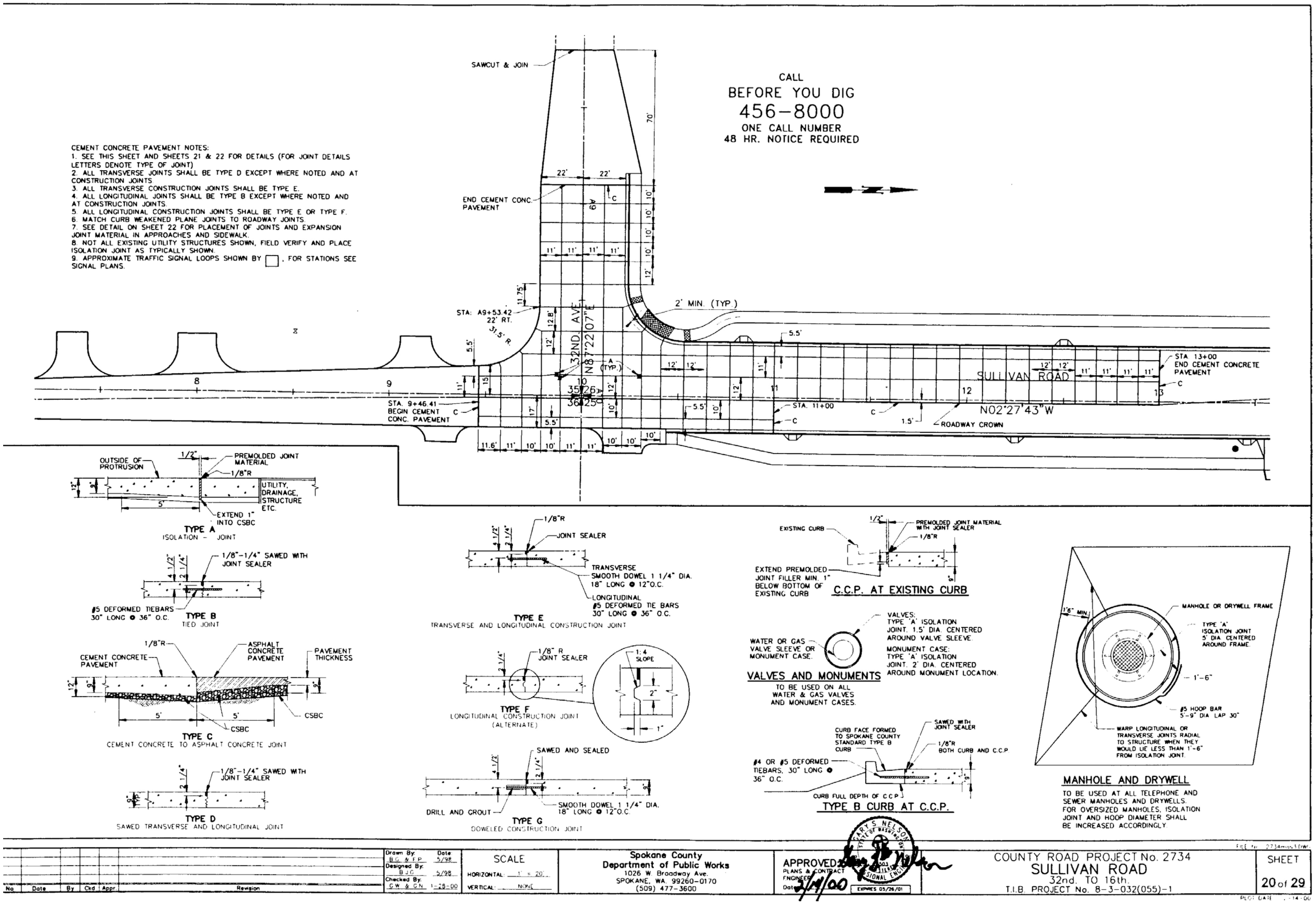


Figure H-14. Spokane County jointing plan – Sullivan Road and 32nd Avenue intersection.



APPENDIX I – SPECIAL PROVISON FOR INTERSECTION CONSTRUCTION

The following is sample special provision for traffic detection.

ILLUMINATION, TRAFFIC SIGNAL SYSTEMS AND ELECTRICAL

Construction Requirements

Inductive Loop Vehicle Detectors

Section 8-20.3(14)C is supplemented with the following:

Pre-Formed, round, induction loops shall be installed as follows:

1. All loops shall be installed as follows:
   A. In the crushed surfacing a maximum of 75 mm below the surface and a maximum of 48 hours prior to being overlaid with ACP or PCCP.
   B. Installed in the existing pavement (after any grinding and prior to final overlay as applicable). The loop and lead-in slot shall be a minimum of 20 mm wide and a maximum of 40 mm wide. (If a NFLS model F38 is used, the slot shall be 10 mm wide to 20 mm wide). The slots shall provide a minimum of 75 mm cover from loop to final pavement surface. The slots shall be sealed with high polymer rubber-asphalt sealant.
   C. The loops shall be tested in accordance with section 8-20.3(14)D tests A & D prior to overlay at the splice location.
   D. The loops shall be tested in accordance with section 8-20.3(14)D after the overlay and prior to signal turn on at the cabinet.

2. The lead-in conduit or hose shall be installed in unpaved areas between the pavement and the junction box by trenching to a depth of 0.5 m.

3. The lead-in shall be spliced to the two conductor shielded cable in accordance with the requirements of Standard Plan J-8a.

4. The loops for installation in sawcuts shall use 3/8” diameter hose or conduit. The loops for installation in the crushed surfacing shall use ½” or 5/8” hose or conduit.

5. The loops shall be from one of the vendors listed and constructed as detailed below:

   Never-Fail Loop Systems (NFLS)
   Model F or F38
   Model C

De-Tech MFG
c/o Capital Enterprises
Pre-formed loop assembly
Salem, OR

IDC Detector Systems
Model 1700 Series
Fullerton, CA

A. The loops shall have a minimum of 4 turns for installation in existing pavement. The loops shall have a minimum of 5 turns for installation in crushed surfacing below the PCCP overlay. The loop and loop lead-in shall be continuous (unspliced).

B. The loop and the loop lead-in shall be pre-formed and shall be encased in polyproplene conduit and/or 1700 kPa. hydraulic hose and/or 15500 kPa. flex hose. The loop and loop lead-in hose and/or conduit shall be 100% injected with a hot rubber-asphalt sealant.

C. The loop lead-in shall be twisted a minimum of two turns per 0.3 M.

Payment

Section 8-20.5 is supplemented with the following

"Pre-formed Induction Loop ", per each

The unit contract prices for "pre-formed Induction Loop" shall be full pay for all costs involved in furnishing all labor, materials, tools, and equipment necessary or incidental to the construction and installation of the complete and operable induction loop system.

Conduction Cable

Section 9-29.3, item 8 is deleted and replaced with the following:

Preformed Induction Loops

The detector loop wire shall be No. 16 AWG stranded copper wire, Class B, with chemically cross-linked polyethylene type THWN insulation of code thickness.

Surveying

The Contractor shall be responsible for setting and maintaining all alignment stakes and grades necessary for the construction of the grade by reshaping existing surfacing materials. Except for the survey control data to be furnished by the Contracting Agency, calculations, surveying, and measuring required for setting and maintaining the necessary lines and grades shall be the Contractor's responsibility. The Contractor shall provide the Contracting Agency copies of such calculations and staking data when requested by the Engineer. Copies of the Contracting Agency provided survey data are available for the bidder's inspection at the office of the Engineer.

To facilitate the establishment of these lines and elevations, the Contracting Agency will provide the Contractor with the following survey control:

1. An elevation bench mark and two points on roadway center line in the SR ***$$$*** intersection vicinity of ***$$$***.

2. Technical advice if requested.

3. One copy of transit notes showing references to control points in the vicinity of the intersection listed above.

The Contractor shall give the Contracting Agency one-week notification to allow adequate time to provide the data.

The Contractor shall ensure a surveying accuracy within the following tolerances:

Stationing	¼ inch
Alignment	¼ inch
Grade	+0/-1/4 inch

At the Contracting Agency's discretion, it may spot-check the Contractor's surveying. These spot-checks will not change the requirements for normal checking and testing as described elsewhere, and do not relieve the Contractor of the responsibility of producing a finished product that is in accordance with the contract.

In all disputes concerning accuracy of lines and elevation, the Contracting Agency shall be assumed correct and the Contractor shall correct the discrepancies before construction work may proceed. No additional compensations will be paid for the corrective work.

Placing, Spreading, and Compacting Concrete
Section 5-05.3(7) is revised to read as follows:

All of the requirements for concrete mix, finish, and surface smoothness apply, regardless of the methods used to place the pavement.

Joints
Section 5-05.3(8) is supplemented with the following:

The Contractor shall provide an isolation joint (see Details for Boxing Out Fixtures, Contract Plans sheet ***$$$***) around all valves, and manholes, located within the cement concrete pavement limits shown in the plans unless the valve or manhole flange Is located below the bottom of the cement concrete. If a transverse or longitudinal joint is within 4 feet of a manhole, or catch basin, the joint shall be skewed to pass through the center of the valve, manhole, or catch basin. If a transverse or longitudinal joint is within 1 foot of a valve the joint shall be skewed to pass through the center of the valve.

When cement concrete pavement is placed adjacent to existing cement concrete (i.e. existing curb), lightweight roofing paper shall be placed between the existing and new concrete to provide a bond breaker. In addition the joint next to the existing curbing shall be finished with a ½ inch radius edger.

Tie Bars and Dowel Bars
Section 5-05.3(10) is supplemented with the following:

Dowel and tie bars shall not be placed within 2 feet of the new detection loops.

The dowel bars to be placed at new transverse contraction joints shall be coated with parting compound on all sides before the bar is placed in a chair or approved device.

Tie bars shall not be placed within 18 inches of a transverse joint.

Dowel baskets shall be secured to the base material with steel stakes having a minimum diameter of ¼ inches. These stakes should be embedded into the vase a minimum depth of 10 inches for untreated aggregate base or natural subgrade. A minimum of 8 stakes per basket is recommended. The Contracting Agency will not require the Contractor to secure dowel baskets provided the Contractor demonstrates movement will not occur during concrete pour and vibration.

Surface Smoothness
Section 5-05.3(12) is revised to read:

The pavement smoothness will be checked under the supervision of the Engineer no later than 5:00 p.m. of the day following placement of concrete, with equipment furnished by the Contractor.

Surface smoothness will be measured with a 10-foot straightedge. A 10-foot straightedge will be placed parallel to the centerline so as to bridge any depression and touch all high spots. Should the surface vary more than 1/8-inch from the lower edge of the straightedge, the Contractor shall reduce the high portion to the 1/8-inch tolerance by abrasive means at no expense to the Contracting Agency. It is further provided that if reduction of high portions of the surface involves breaking, dislodging, or other disturbance of the aggregates, such cutting will not be permitted until the pavement has achieved its desired age. If in the opinion of the Engineer irregularities cannot be satisfactorily removed by such methods, the Contractor shall remove and replace the pavement at no expense to the Contraction Agency.

Smoothness perpendicular to the centerline will be measured with a 10-foot straightedge. The transverse slope of the finished pavement shall be uniform to a degree such that no variations greater than ¼-inch are present when tested with a 10-foot long straightedge laid in a direction perpendicular to the centerline. Any areas that are in excess of the specified tolerance shall be corrected by abrasive means.

Curing
Section 5-05.3(13) is supplemented with the following:

After the concrete surface has been finished as specified, A State specified white pigment curing compound shall be applied at 1.5 the normal rate specified.

Opening to Traffic
Section 5-05.3(17) is supplemented with the following:

Prior to opening to traffic, the cement concrete pavement shall have a minimum compressive strength of 2,500 psi as determined from cylinders made at the time of placement, cured under comparable conditions, and tested in accordance with AASHTO T22-92.

Fabrication, curing, and testing of cylinders to measure early strength shall be the responsibility of the Contractor. The Contractor shall obtain the services of an independent laboratory to perform these activities and these laboratories shall be approved by the Engineer. At the Contractor's option, the time for opening pavement may be determined through the use of the maturity in accordance with ASTM C 1074. The Contractor shall develop the maturity-strength relationship and provide maturity curves along with supporting data for approval by the Engineer. The Contractor shall furnish all equipment, including thermal or maturity meter, thermocouples, wire and qualified personnel to monitor maturity and provide information to the Engineer. Field procedures to monitor maturity shall be submitted to the Engineer for approval prior to use. The pavement shall not be opened to traffic until the maturity-strength relationship shows the pavement has a compressive strength of 2,500 psi and approved by the Engineer.

The use of the maturity meter for concrete acceptance will not be permitted.

The pavement shall be cleaned prior to opening to traffic.

All costs associated with furnishing molds, fabrication, curing, and testing of early strength cylinders shall be at the Contractor's expense.

Payment
Item 1 of Section 5-05.5 is revised to read:

"Cement Conc. Pavement", per cubic yard.

The unit contract price per cubic yard for "Cement Conc. Pavement" shall include all labor and costs associated with furnishing and installing epoxy coated dowel bars and tie bars, constructing isolation joints for valves, manholes, and catch basins, and setting and maintaining alignment stakes and grades necessary for the placement of "Cement Conc. Pavement".

APPENDIX J – SPECIAL PROVISION FOR TRAFFIC DETECTION

The following is a sample of a special provision for traffic detection:

ILLUMINATION, TRAFFIC SIGNAL SYSTEMS AND ELECTRICAL

Construction Requirements

Inductive Loop Vehicle Detectors
Section 8-20.3(14)C is supplemented with the following:

Pre-Formed, round, induction loops shall be installed as follows:

1. All loops shall be installed as follows:
   A. In the crushed surfacing a maximum of 75 mm below the surface and a maximum of 48 hours prior to being overlaid with ACP or PCCP.
   B. Installed in the existing pavement (after any grinding and prior to final overlay as applicable). The loop and lead-in slot shall be a minimum of 20 mm wide and a maximum of 40 mm wide. (If a NFLS model F38 is used, the slot shall be 10 mm wide to 20 mm wide). The slots shall provide a minimum of 75 mm cover from loop to final pavement surface. The slots shall be sealed with high polymer rubber-asphalt sealant.
   C. The loops shall be tested in accordance with section 8-20.3(14)D tests A & D prior to overlay at the splice location.
   D. The loops shall be tested in accordance with section 8-20.3(14)D after the overlay and prior to signal turn on at the cabinet.

2. The lead-in conduit or hose shall be installed in unpaved areas between the pavement and the junction box by trenching to a depth of 0.5 m.

3. The lead-in shall be spliced to the two conductor shielded cable in accordance with the requirements of Standard Plan J-8a.

4. The loops for installation in sawcuts shall use 3/8” diameter hose or conduit. The loops for installation in the crushed surfacing shall use ½” or 5/8” hose or conduit.

5. The loops shall be from one of the vendors listed and constructed as detailed below:

   Never-Fail Loop Systems (NFLS)
   Model F or F38
   Model C

De-Tech MFG
c/o Capital Enterprises
Pre-formed loop assembly
Salem, OR

IDC Detector Systems
Model 1700 Series
Fullerton, CA

A. The loops shall have a minimum of 4 turns for installation in existing pavement. The loops shall have a minimum of 5 turns for installation in crushed surfacing below the PCCP overlay. The loop and loop lead-in shall be continuous (unspliced).

B. The loop and the loop lead-in shall be pre-formed and shall be encased in polyproplene conduit and/or 1700 kPa. hydraulic hose and/or 15500 kPa. flex hose. The loop and loop lead-in hose and/or conduit shall be 100% injected with a hot rubber-asphalt sealant.

C. The loop lead-in shall be twisted a minimum of two turns per 0.3 M.

Payment

Section 8-20.5 is supplemented with the following

"Pre-formed Induction Loop ", per each

The unit contract prices for "pre-formed Induction Loop" shall be full pay for all costs involved in furnishing all labor, materials, tools, and equipment necessary or incidental to the construction and installation of the complete and operable induction loop system.

Conduction Cable

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The detector loop wire shall be No. 16 AWG stranded copper wire, Class B, with chemically cross-linked polyethylene type THWN insulation of code thickness.