CITY OF KYLE

Notice of Regular City Council Meeting

KYLE CITY HALL
100 W. Center Street

Notice is hereby given that the governing body of the City of Kyle, Texas will meet at 7:00 PM on 8/4/2015, at Kyle City Hall, 100 West Center Street, Kyle, Texas for the purpose of discussing the following agenda.

Posted this 31st day of July, 2015 prior to 7:00 p.m.

I. Call Meeting To Order

II. Approval of Minutes

1. City Council Regular Meeting - July 21, 2015. ~ *Amelia Sanchez, City Secretary*

   Attachments

2. City Council Workshop Meeting - July 21, 2015 ~ *Amelia Sanchez, City Secretary*

   Attachments

III. Citizen Comment Period With City Council

The City Council welcomes comments from Citizens early in the agenda of regular meetings. Those wishing to speak are encouraged to sign in before the meeting begins. Speakers may be provided with an opportunity to speak during this time period on any agenda item or any other matter concerning city business, and they must observe the three-minute time limit.

IV. Presentation

3. KAYAC "Year in Review" presentation. ~ *Terrah Friesenhahn (Chair) and James Collins (Vice Chair)*

   Attachments

4. Presentation on summarized findings from existing studies on electronic billboards related to driver distraction and review of methods used for the study of distraction due to electronic billboard presence. ~ *Mario Perez, Building Official*

   Attachments

5. Presentation regarding the newly proposed U.S. EPA regulations for ozone. ~ *Fred Blood, Air Quality Program Specialist, Central Texas Clean Air Coalition*

   Attachments

6. Discussion of land use, policies and effective strategies for attracting quality development on the I-35 Corridor and quarterly report. ~ *Jason Claunch, President*

   Attachments

V. Consent Agenda

7. (*Second Reading*) An ordinance amending Chapter 53 (Zoning) of the City of Kyle, Texas, for the purpose of assigning original zoning to approximately 5.125 acres of land from Agriculture "AG" to Retail Service District "RS", on property located at 400 E. RR 150, in Hays County, Texas. (MNT & S Development, LTD, Z-15-006). ~ *Howard J. Koontz, AICP, Director of Planning and Community Development*

   Planning and Zoning Commission voted 6-0 to recommend approval of the request.

   Attachments

8. Authorize execution of an interlocal agreement between the City of Kyle, and the City of San Marcos to establish the terms in the installation of gateway monument signs in each city's jurisdiction. ~ *J. Scott Sellers, City Manager*

   Attachments

9. Approve Supplement No. 1 to engineering services agreement with K FRIESE & ASSOCIATES, INC., Austin, Texas, in order to reduce the contract amount by $44,840.00 and related scope of work for engineering and environmental services associated with the Marketplace Avenue improvement project. ~ *Leon Barba, P.E., City Engineer*

   Attachments

10. Approve Supplement No. 2 to engineering services agreement with HDR ENGINEERING, INC., Austin, Texas, in an amount not to exceed $72,596.00 for additional engineering and design services for a drainage detention pond, a bridge structure at Plum Creek, and for water line relocation associated with the Lehman Road improvement project. ~ *Leon Barba, P.E., City Engineer*

    Attachments

11. Approve Supplement No. 3 to engineering services agreement with LJA ENGINEERING, INC., Austin, Texas, in order to modify the scope of work and reallocate contract funding without changing the total contract amount for the Bunton Creek Road improvement project. ~ *Leon Barba, P.E., City Engineer*

    Attachments

12. Consider and possible action to Approve First Amendment to Economic Development

Agreement with RR HPI, LLP. ~ *James Earp, Assistant City Manager*

Attachments

VI. Consider and Possible Action

13. (*First Reading*) An Ordinance of the City of Kyle continuing with Curfew for Minors under seventeen years of age per Sections 23-23 through 23-30; entitled Triennial Review; Providing For Enforcement; Establishing Criminal Penalties; and Setting an Effective Date. ~ *Jeff Barnett, Chief of Police*

    - **PUBLIC HEARING**

    Attachments

14. (*First Reading*) An Ordinance of the City of Kyle, Texas, Amending and Replacing Provisions of the City Personnel Policy; and Providing for Related Matters. ~ *Sandra Duran, Director of Human Resources*

    Attachments

VII. Council Requested Agenda Items

15. Discussion and possible action regarding future ordinance against large trailers and boats being parked for extended periods of time on city streets. ~ *Damon Fogley, Council Member*

    Attachments

16. Overview of City's share of costs for Phase I water supply associated capital improvement projects planned to be incurred by the Hays Caldwell Public Utility Agency (HCPUA) during fiscal years 2016 through 2020. ~ *Daphne Tenorio, Council Member*

    Attachments

17. Status report on all five road bond projects including latest project cost estimates. ~ *Daphne Tenorio, Council Member*

    Attachments

18. Update on Goforth Road repairs. ~ *Daphne Tenorio, Council Member*

    Attachments

19. Discussion regarding setting agenda review workshop meetings. ~ *Diane Hervol, Council Member*

    Attachments

VIII. City Managers Report

20. Update on various capital improvement projects, road projects, building program, and/or general operational activities. ~ *Scott Sellers, City Manager*

    Attachments

IX. Executive Session

21. Pursuant to Chapter 551, Texas Government Code, the City Council reserves the right to convene into Executive Session(s) from time to time as deemed necessary during this meeting. The City Council may convene into Executive Session pursuant to any lawful exception contained in Chapter 551 of the Texas Government Code including any or all of the following topics.

    1. Pending or contemplated litigation or to seek the advice of the City Attorney pursuant to Section 551.071.
        - Aqua litigation update
    2. Possible purchase, exchange, lease, or value of real estate pursuant to Section 551.072.
    3. Personnel matters pursuant to Section 551.074.
    4. Economic Development negotiations pursuant to Section 551.087.

    Attachments

22. Take action on items discussed in Executive Session.

    Attachments

X. ADJOURN

At any time during the Regular City Council Meeting, the City Council may adjourn into an Executive Session, as needed, on any item listed on the agenda for which state law authorizes Executive Session to be held

*Per Texas Attorney General Opinion No. JC-0169; Open Meeting & Agenda Requirements, Dated January 24, 2000: The permissible responses to a general member communication at the meeting are limited by 551.042, as follows: "SEC.551.042. Inquiry Made at Meeting. (a) If, at a meeting of a government body, a member of the public or of the governmental body inquires about a subject for which notice has not been given as required by the subchapter, the notice provisions of this subchapter, do not apply to:(1) a statement of specific factual information given in response to the inquiry; or (2) a recitation of existing policy in response to the inquiry. (b) Any deliberation of or decision about the subject of the inquiry shall be limited to a proposal to place the subject on the agenda for a subsequent meeting.

CITY OF KYLE, TEXAS

July 21, 2015 Council Meeting Minutes

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: City Council Regular Meeting - July 21, 2015. ~ *Amelia Sanchez, City Secretary*

Other Information:

Legal Notes:

Budget Information:

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Attachments / click to download

- City Council Regular Meeting Minutes 7-21-15

REGULAR CITY COUNCIL MEETING

The City Council of the City of Kyle, Texas met in Regular Session on July 21, 2015 at 7:00 p.m. at Kyle City Hall, with the following persons present:

Mayor Todd Webster
Mayor Pro Tem Diane Hervol
Council Member Becky Selbera
Council Member Shane Arabie
Council Member David Wilson
Council Member Damon Fogley
Scott Sellers, City Manager
James Earp, Assistant City Manager
Cody Faulk, City Attorney
Diana Blank, Director of Economic Development
Howard Koontz, Planning Director
Leon Barba, City Engineer
Harper Wilder, Public Works Director
Danielle Harvey, IT
Jeff Barnett, Chief of Police

Dustin Inderman
Penny Krug
Lynn Cohee
Tracy Scheel
Michele Christie
Mike Wilson
Mike Fulton
Dan Ryan
Sylvia Gallo

CALL MEETING TO ORDER

Mayor Webster called the meeting to order at 7:07 p.m.

ROLL CALL

Mayor Webster called for roll call. Present were Mayor Webster, Council Member Hervol, Council Member Selbera, Council Member Arabie, Mayor Pro Tem Wilson, and Council Member Fogley,

Mayor Webster stated that Council Member Daphne Tenorio was absent attending to a family matter. Mayor Pro Tem David Wilson moved to excuse Council Member Daphne Tenorio's absence. Council Member Arabie seconds the motion. All aye. Motion carried 6-0.

APPROVAL OF MINUTES

CITY COUNCIL REGULAR MEETING – JULY 7, 2015 ~ *AMELIA SANCHEZ, CITY SECRETARY*

Council Member Hervol moved to approve the minutes of the City Council Regular Meeting – July 7, 2015. Council Member Fogley seconds the motion. All aye. Motion carried 6-0.

CITIZEN COMMENT PERIOD WITH CITY COUNCIL

THE CITY COUNCIL WELCOMES COMMENTS FROM CITIZENS EARLY IN THE AGENDA OF REGULAR MEETINGS. THOSE WISHING TO SPEAK MUST SIGN IN BEFORE THE MEETING BEGINS AT THE KYLE CITY HALL. SPEAKERS MAY BE PROVIDED WITH AN OPPORTUNITY TO SPEAK DURING THIS TIME PERIOD, AND THEY MUST OBSERVE THE THREE-MINUTE TIME LIMIT.

Mayor Webster opened the Citizens Comments at 7:09 p.m. Mayor Webster called Diana Torres, Economic Development Director for a recognition. Mrs. Torres stated she was recognizing an outgoing Economic Development and Tourism Committee member and called Mr. Dustin Inderman. She stated they wanted to recognize him for his commitment and volunteer work on the committee. Mayor Webster presented him with a plaque and thanked him for his service. Penny Krug spoke about the parking realignment being planned for Burleson Road and stated that there was space for more parking in front of her house and that the city had an easement on their property where more parking could be added to make up for some that were being lost with the realignment. Lynn Cohee spoke about the agenda item regarding roundabouts and that he preferred a trafiic light, and felt that a roundabout was not needed at this time and could be more costly. Tracy Scheel, Vice President of the Waterleaf HOA spoke on the agenda item concerning traffic in Waterleaf and the three entrances to the subdivision. She said there was no speed bumps and people sped through this area and asked that something be done to slow down the traffic and add stop signs as well as doing the warrant studies in the subdivision. Michele Christie spoke on the Charter Review Commission and thanked council for appointing these people and that they did a wonderful job. She also spoke against the roundabout and asked the council to consider the safety of the residents. Susan Meckle spoke and thanked council and staff for considering the agreement for wastewater services for Crosswinds and stated it was a step in the right direction for responsible management of water for the Kyle area and asked that it be approved. Mike Wilson spoke in support of the roundabout and about a report on a sturdy done on roundabouts that said when changing from lights to roundabouts there was a 90% reduction in fatalities at those intersections. Dan Ryan spoke on the roundabout item and stated that if designed right and educate people this would be a good thing and be progressive and strongly suggested the roundabouts. Mike Fulton stated he agreed with everything Mike Wilson said because he was very smart on traffic issues. He stated he attended the presentation by TXDOT on roundabouts and they convinced him they were large enough for all vehicles and have a much safer intersection. Sylvia Gallo spoke about the roundabout and was skeptical at first but after becoming more informed she felt it would be a good thing for future growth. With no one else wishing to speak Mayor Webster closed Citizens Comments at 7:05 p.m.

Mayor Webster moved to item #4.

PRESENTATION

SUBMISSION OF PROPOSED CHARTER AMENDMENTS. ~ *JOE BACON, CHAIRMAN CHARTER REVIEW COMMISSION*

Joe Bacon, Chairman of the Charter Review Commission gave a brief presentation on the process they followed and the work they felt they accomplished. He handed out their recommendations to the Council and asked them to contact the Commission if they had any questions.

Mayor Webster asked if there were any objections to placing item 5 on the table. No objection made.

PRESENTATION ON DEVELOPMENT AT 225 S. MAIN ST. ~ *Phil Howry*

Mayor Webster stated that this item had been withdrawn at the request of the owner and moved to table the item. Mayor Pro Tem seconds the motion. All aye. Motion carried 6-0.

Mayor Webster moved to item # 21 and asked if there were any objections to placing item 21 on the table. No objection made.

COUNCIL REQUESTED AGENDA ITEMS

REQUEST FOR TRAFFIC WARRANT IN THE WATERLEAF SUBDIVISION. ~ *DAMON FOGLEY, COUNCIL MEMBER*

Council Member Fogley stated there was concern with speeders in the Waterleaf subdivision that has over a thousand homes and growing fast. He stated while he was on the Safety Committee they were able to conduct a warrant study for a stop sign in Plum Creek at Wetzel and it reduced the speeders in that area without speed bumps or police patrols, prevented accidents and would like a warrant study at the roads mentioned during citizens comments. Mr. Sellers, City Manager stated they would be happy to conduct a warrant study and the he had already asked the Police Chief to take the lead on this and the study had actually begun. Council Member Fogley moved to table the item until further information provided after the warrant study. Council Member Selbera seconds the motion. All aye. Motion carried 6-0.

REQUEST FOR COUNCIL RESOLUTION TO SUPPORT A ROUNDABOUT AT FM 1626 AND KOHLERS CROSSING. ~ *SHANE ARABIE, COUNCIL MEMBER*

Mayor Webster moved to item # 22 and asked if there were any objections to placing item 22 on the table. No objection made.

Council Member Arabie stated his support for the roundabout and that a decision needed to be made to send to TXDOT before the deadline set by them for the city's recommendation. After some discussion Mayor Webster stated that it seemed the majority wanted to move forward with continuing the plan and have staff bring back a resolution and answers to the questions Council had.

FOLLOW-UP PRESENTATION ON PROPOSED PARKING IMPROVEMENTS ALONG N. BURLESON STREET FROM MILLER STREET TO LOCKHART STREET. ~ *LEON BARBA, CITY ENGINEER*

Mayor Webster moved to item # 6 and asked if there were any objections to placing item 6 on the table. No objection made.

Leon Barba, City Engineer provided a follow-up presentation on other proposals regarding further research for parking spaces along Burleson Road. Council recommended contacting Penny Krug for parking spaces she offered in front of her home that the city had easement on.

Mayor Webster asked if there were any objections to placing Consent Agenda on the table. No objection made.

CONSENT AGENDA

APPROVE CONTRACT TASK ORDER NO. 1 TO HDR ENGINEERING, INC., AUSTIN, TEXAS, IN AN AMOUNT NOT TO EXCEED $38,776.00 FOR THE PURPOSE OF PROVIDING ENGINEERING SERVICES FOR REPLACEMENT OF AN EXISTING WASTEWATER LINE UNDER OLD HWY. 81 ~ *LEON BARBA, P.E., CITY ENGINEER*

APPROVE AN AMENDMENT TO TASK ORDER NO. 2 (MORENO ST. SEWER CROSSING) TO NEPTUNE-WILKINSON ASSOCIATES, INC., AUSTIN, TEXAS, IN AN AMOUNT OF $13,250.00 FOR ADDITIONAL ENGINEERING SERVICES FOR ACQUIRING A PUBLIC WASTEWATER LINE EASEMENT, ACQUISITION OF A TXDOT PERMIT AND EXTENDING THE SCOPE OF THE WORK FOR THE MORENO STREET WASTEWATER IMPROVEMENTS. ~ *LEON BARBA, P.E., CITY ENGINEER*

CONSIDER AND POSSIBLE ACTION REGARDING AUTHORIZING THE CITY MANAGER TO EXECUTE A LETTER OF PARTICIPATION TO HAYS COUNTY FOR THE HAYS COUNTY HAZARD MITIGATION PLAN REQUIRED FOR HAYS COUNTY'S FEMA GRANT APPLICATION; AUTHORIZING THE CITY MANAGER TO APPOINT A REPRESENTATIVE AND ALTERNATE REPRESENTATIVE TO THE COUNTY TASK FORCE; AND, DIRECTING A FUTURE BUDGET AMENDMENT TO COVER THE CITY'S PORTION OF LOCAL MATCH EXPECTED NOT TO EXCEED $10,000. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

CONSIDER AND POSSIBLE ACTION REGARDING PROPOSED AMENDMENTS TO THE CYPRESS FOREST DEVELOPMENT AGREEMENT. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

APPROVING A CONSENT AND DEVELOPMENT AGREEMENT WITH DEVELOPMENT SOLUTIONS CW FOR CROSSWINDS MUD, REPEALING PREVIOUS AGREEMENTS AND ASSOCIATED ITEMS. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

APPROVAL OF A RETAIL WATER AND WASTEWATER SERVICES AGREEMENT BETWEEN THE CITY OF KYLE AND CROSSWINDS MUNICIPAL UTILITY DISTRICT. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

CONSIDER AND POSSIBLE ACTION APPROVING AN AGREEMENT BETWEEN THE CITY OF KYLE, TEXAS AND COUNTY LINE SPECIAL UTILITY DISTRICT IN RELATION TO TRANSFERRING 640 ACRES FROM COUNTY LINE CCN TO CITY OF KYLE, AND ESTABLISHING A FEE TO BE COLLECTED FROM THE AFFECTED PROPERTY AS DEVELOPED AND PAID TO COUNTY LINE. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

Council Member Hervol asked to pull items # 10, 11, 12, and 13 from Consent.

Mayor Pro Tem Wilson moved to approve Consent Agenda items #7 ~ Approve contract Task Order No. 1 to HDR ENGINEERING, INC., Austin, Texas, in an amount not to exceed $38,776.00 for the purpose of providing engineering services for replacement of an existing wastewater line under Old Hwy. 81; #8 ~ Approve an Amendment to Task Order No. 2 (Moreno St. Sewer Crossing) to NEPTUNE-WILKINSON ASSOCIATES, INC., Austin, Texas, in an amount of $13,250.00 for additional engineering services for acquiring a public wastewater line easement, acquisition of a TxDOT permit and extending the scope of the work for the Moreno Street Wastewater Improvements; #9 ~ Consider and possible action regarding authorizing the City Manager to execute a letter of participation to Hays County for the Hays County Hazard Mitigation Plan required for Hays County's FEMA grant application; authorizing the City Manager to appoint a representative and alternate representative to the County task force; and, directing a future budget amendment to cover the City's portion of local match expected not to exceed $10,000. Council Member Hervol seconds the motion. All aye. Motion carried 6-0.

EXECUTIVE SESSION

PURSUANT TO CHAPTER 551, TEXAS GOVERNMENT CODE, THE CITY COUNCIL RESERVES THE RIGHT TO CONVENE INTO EXECUTIVE SESSION(S) FROM TIME TO TIME AS DEEMED NECESSARY DURING THIS MEETING. THE CITY COUNCIL MAY CONVENE INTO EXECUTIVE SESSION PURSUANT TO ANY LAWFUL EXCEPTION CONTAINED IN CHAPTER 551 OF THE TEXAS GOVERNMENT CODE INCLUDING ANY OR ALL OF THE FOLLOWING TOPICS.

Council Member Hervol moved to convene into Executive Session at 9:15 p.m. pursuant to any lawful exception contained in Chapter 551 of the Texas Government Code on all of the following topics.

Pending or contemplated litigation or to seek the advice of the City Attorney pursuant to Section 551.071.

- Wastewater Model
- Aqua litigation update
- Meinzer Lawsuit
- Open Records

Economic Development negotiations pursuant to Section 551.087.

- Economic Development Update
- Deliberate offers of financial or other incentives and economic development negotiations with prospects that the city council seeks to have locate, stay or expand in or near the territory of the City Council

Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 5-0 with Council Member Selbera off the dais.

TAKE ACTION ON ITEMS DISCUSSED IN EXECUTIVE SESSION.

Council Member Hervol moved to reconvene into open session at 11:15 p.m. Council Member Arabie seconds the motion. All aye. Motion carried 6-0.

Council Member Hervol stated that no action was taken during Executive Session and none would be taken now.

Mayor Webster moved to item # 10 and asked if there was any objection to placing it on the table. There was no objection.

CONSENT AGENDA

CONSIDER AND POSSIBLE ACTION REGARDING PROPOSED AMENDMENTS TO THE CYPRESS FOREST DEVELOPMENT AGREEMENT. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

Council Member Hervol moved to approve the proposed amendments to the Cypress Forest Development Agreement. Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 6-0.

Mayor Webster asked if there was any objection to placing item 11 on the table. There was no objection.

APPROVING A CONSENT AND DEVELOPMENT AGREEMENT WITH DEVELOPMENT SOLUTIONS CW FOR CROSSWINDS MUD, REPEALING PREVIOUS AGREEMENTS AND ASSOCIATED ITEMS. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

Council Member Hervol moved to approve a Consent and Development Agreement with Development Solutions CW for Crosswinds MUD, repealing previous agreements and associated items. Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 6-0.

Mayor Webster asked if there was any objection to placing item 12 on the table. There was no objection.

APPROVAL OF A RETAIL WATER AND WASTEWATER SERVICES AGREEMENT BETWEEN THE CITY OF KYLE AND CROSSWINDS MUNICIPAL UTILITY DISTRICT. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

Council Member Hervol moved to approve a Retail Water and Wastewater Services Agreement between the City of Kyle and Crosswinds Municipal Utility District. Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 6-0.

Mayor Webster asked if there was any objection to placing item 13 on the table. There was no objection.

CONSIDER AND POSSIBLE ACTION APPROVING AN AGREEMENT BETWEEN THE CITY OF KYLE, TEXAS AND COUNTY LINE SPECIAL UTILITY DISTRICT IN RELATION TO TRANSFERRING 640 ACRES FROM COUNTY LINE CCN TO CITY OF KYLE, AND ESTABLISHING A FEE TO BE COLLECTED FROM THE AFFECTED PROPERTY AS DEVELOPED AND PAID TO COUNTY LINE. ~ *JAMES EARP, ASSISTANT CITY MANAGER*

Council Member Hervol moved to approve an agreement between the City of Kyle, Texas and County Line Special Utility District in relation to transferring 640 acres from County Line CCN to City of Kyle, and establishing a fee to be collected from the affected property as developed and paid to County Line. Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 6-0.

CONSIDER AND POSSIBLE ACTION

Mayor Webster asked if there was any objection to placing item 14 on the table. There was no objection.

(*FIRST READING*) AN ORDINANCE AMENDING CHAPTER 53 (ZONING) OF THE CITY OF KYLE, TEXAS, FOR THE PURPOSE OF ASSIGNING ORIGINAL ZONING TO APPROXIMATELY 5.125 ACRES OF LAND FROM AGRICULTURE "AG" TO RETAIL SERVICE DISTRICT "RS", ON PROPERTY LOCATED AT 400 E. RR 150, IN HAYS COUNTY, TEXAS. (MNT & S DEVELOPMENT, LTD, Z-15-006). ~ *HOWARD J. KOONTZ, AICP, DIRECTOR OF PLANNING AND COMMUNITY DEVELOPMENT*

Planning and Zoning Commission voted 6-0 to recommend approval of the request.

PUBLIC HEARING

Mayor Webster opened the Public Hearing at 11:19 p.m. to hear comments on an ordinance amending Chapter 53 for the purpose of assigning original zoning to approximately 5.125 acres from AG to RS. With no one wishing to speak Mayor Webster closed the Public Hearing at 11:19 p.m.

Council Member Hervol moved to approve (*First Reading*) An ordinance amending Chapter 53 (Zoning) of the City of Kyle, Texas, for the purpose of assigning original zoning to approximately 5.125 acres of land from Agriculture "AG" to Retail Service District "RS", on property located at 400 E. RR 150, in Hays County, Texas. (MNT & S Development, LTD, Z-15-006). Council Member Fogley seconds the motion. All aye. Motion carried 6-0.

Mayor Webster asked if there was any objection to placing item 15 on the table. There was no objection.

A RESOLUTION TO PROVIDE FOR THE POSSIBLE EXTENSION OF THE KYLE MUNICIPAL BOUNDARIES BY THE ANNEXATION OF APPROXIMATELY 135.78 ACRES; SETTING THE DATES AND TIMES OF TWO PUBLIC HEARINGS FOR THE PURPOSE OF ANNEXING PROPERTY AND SETTING AN EFFECTIVE DATE. ~ *HOWARD J. KOONTZ, AICP, DIRECTOR OF PLANNING AND COMMUNITY DEVELOPMENT*

Council Member Hervol moved to approve a Resolution to provide for the possible extension of the Kyle municipal boundaries by the annexation of approximately 135.78 acres; setting the dates and times of two public hearings for the purpose of annexing property and setting an effective date. Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 6-0.

COUNCIL REQUESTED AGENDA ITEMS

DISCUSSION CONCERNING FREQUENCY OF CITY COUNCIL REQUESTS FOR STAFF REPORTS AND DIRECTION GIVEN TO CITY STAFF. ~ *TODD WEBSTER, MAYOR*

CONSIDER AND TAKE POSSIBLE ACTION TO AMEND, EXTEND, OR RESCIND THE ILA WITH MOUNTAIN CITY AND HAYS COUNTY. ~ *TODD WEBSTER,*

OVERVIEW OF CITY'S SHARE OF COSTS FOR PHASE I WATER SUPPLY ASSOCIATED CAPITAL IMPROVEMENT PROJECTS PLANNED TO BE INCURRED BY THE HAYS CALDWELL PUBLIC UTILITY AGENCY (HCPUA) DURING FISCAL YEARS 2016 THROUGH 2020. ~ *DAPHNE TENORIO, COUNCIL MEMBER*

STATUS REPORT ON SOUTHSIDE WASTEWATER LINE CAPITAL IMPROVEMENT PROJECT. ~ *DIANE HERVOL, COUNCIL MEMBER*

STATUS REPORT ON ALL FIVE ROAD BOND PROJECTS INCLUDING LATEST PROJECT COST ESTIMATES. ~ *DAPHNE TENORIO, COUNCIL MEMBER*

DISCUSSION ON ELECTRONIC DEVICE POLICY. ~ *TODD WEBSTER, MAYOR*

DISCUSSION REGARDING SETTING AGENDA REVIEW WORKSHOP MEETINGS. ~ *DIANE HERVOL, COUNCIL MEMBER*

UPDATE ON GOFORTH ROAD REPAIRS. ~ *DAPHNE TENORIO, COUNCIL MEMBER*

Council Member Hervol moved to table items # 16, 17, 18, 19, 20, 23, 24, and 25.

Mayor Webster stated that first did anyone have any objections to putting items 16 through 25 on the table for discussion. There was an objection by Council Member Fogley on item 23 and he stated that was going to be discussed. Mayor Webster stated he was fine with tabling this item.

Council Member Hervol moved to table items # 16, 17, 18, 19, 20, 23, 24, and 25. Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 6-0.

CITY MANAGERS REPORT

UPDATE ON VARIOUS CAPITAL IMPROVEMENT PROJECTS, ROAD PROJECTS, BUILDING PROGRAM, AND/OR GENERAL OPERATIONAL ACTIVITIES. ~ *J. SCOTT SELLERS, CITY MANAGER*

- Budget Calendar

Mr. Sellers, City Manager stated that the budget calendar was before them and wanted to make sure they had all the upcoming meeting dates on the calendar with the budget being provided on July 27.

GENERAL DISCUSSION

Mayor Webster asked if there was any objection to placing item 27 on the table. There was no objection.

DISCUSSION ONLY REGARDING COUNCIL REQUESTS FOR FUTURE AGENDA ITEMS

Discussion related to HOA meeting with Silverado related to traffic calming devices on speed for the second meeting in August.

Mayor Webster asked the ILA not be put back on the agenda until further notice.

ADJOURN

With no further business to discuss, Mayor Pro Tem Wilson moves to adjourn. Council Member Fogley seconds the motion. All votes aye. Motion carried 6-0.

The City Council meeting adjourned at 11:30 p.m.

____
R. Todd Webster, Mayor

____
Attest: Amelia Sanchez, City Secretary

CITY OF KYLE, TEXAS

Meeting Date: 8/4/2015
Date time: 7:00 PM

Approval of minutes

Subject/Recommendation: City Council Workshop Meeting - July 21, 2015 ~ *Amelia Sanchez, City Secretary*

Other Information:

Legal Notes:

Budget Information:

Viewing Attachments Requires Adobe Acrobat. Click here to download.

Attachments / click to download

- City Council Workshop Minutes 7-21-15
- Transportation Presentation

CITY OF KYLE

CITY COUNCIL WORKSHOP

The governing body of the City of Kyle, Texas held a Workshop Meeting at 11:30 p.m. on July 21, 2015, at Kyle City Hall, 100 West Center, Kyle, Texas for the purpose of discussing the following agenda with the following persons present:

Mayor Todd Webster
Council Member Hervol
Council Member Fogley
Council Member Selbera
Council Member Arabie
Mayor Pro Tem Wilson
Scott Sellers, City Manager
James Earp, Assistant City Manager
Perwez Moheet, Finance Director
Leon Barba, City Engineer
Howard Koontz, Planning Director
Diana Blank, Director Economic Development

CALL MEETING TO ORDER

Mayor Webster called the meeting to order at 11:34 p.m.

ROLL CALL:

Present were Mayor Webster, Council Member Hervol, Council Member Fogley, Council Member Selbera, Council Member Arabie ,and Mayor Pro Tem Wilson.

Mayor Webster moved to excuse Council Member Tenorio. Mayor Pro Tem Wilson seconds the motion. All aye. Motion carried 6-0.

CITIZEN COMMENT PERIOD WITH CITY COUNCIL

THE CITY COUNCIL WELCOMES COMMENTS FROM CITIZENS EARLY IN THE AGENDA OF REGULAR MEETINGS. THOSE WISHING TO SPEAK ARE ENCOURAGED TO SIGN IN BEFORE THE MEETING BEGINS. SPEAKERS MAY BE PROVIDED WITH AN OPPORTUNITY TO SPEAK DURING THIS TIME PERIOD ON ANY AGENDA ITEM OR ANY OTHER MATTER CONCERNING CITY BUSINESS, AND THEY MUST OBSERVE THE THREE-MINUTE TIME LIMIT.

Mayor Webster opened Citizen’s Comments at 11:35 p.m. With no one wishing to speak Mayor Webster closed Citizen’s Comments at 11:35 p.m.

GENERAL DISCUSSION

TRANSPORTATION MASTER PLAN UPDATE WORKSHOP. ~ *LOCKWOOD, ANDREWS, AND NEWNAM, INC.*

Susan Fraser, Project Manager for the Transportation Master Plan, of Lockwood, Andrews, and Newnam, Inc introduced two of her team members, David Manuel, Deputy Project Manager and Lead Planner, and Jeff Barton with GAP Strategies who was leading the public outreach program. She stated also on the team was Prime Strategies providing the financial strategies and continued with brief summary of the plan:

1. Schedule update.
2. Review of typical sections.
3. Review of draft network.
4. Request for prioritization and ranking considerations.
5. Financial implementation strategies.
6. Public Outreach

Complete presentation attached.

Discussion only. No action taken.

ADJOURN

With no further business to discuss

Council Member Hervol moves to adjourn. Mayor Pro Tem Wilson seconds the motion. All votes aye. Motion carried.

The City Council Workshop meeting adjourned at 12:10 a.m.

____

Todd Webster, Mayor

____

Amelia Sanchez, City Secretary

KyleConnected
TRANSPORTATION MASTER PLAN 2040

1

Kyle Transportation Master Plan (KTMP)

City Council Update

Tuesday, July 21, 2015

Project Team

Lockwood, Andrews & Newnam, Inc.

Prime Strategies, Inc.

Gap Strategies

Kimley-Horn Associates

KyleConnected
TRANSPORTATION MASTER PLAN 2040

2

Presentation Agenda

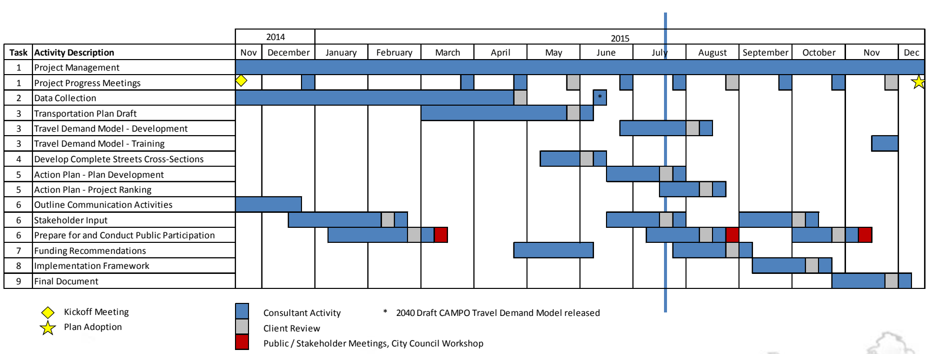
1. Schedule Update
2. Review of Products to Date
   - Typical sections / cost estimates
   - Draft network
3. Financial Strategies
4. Implementation
   - Prioritization Criteria
   - Corridor Preservation
5. Public Outreach

KyleConnected
TRANSPORTATION MASTER PLAN 2040

3

Schedule Update

- Analyzing CAMPO Model (Released)
- Survey and Public Meetings



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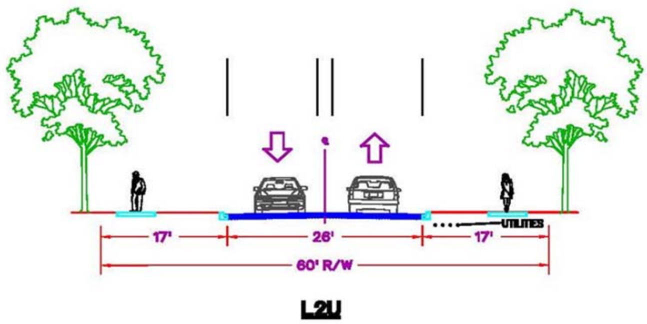
4

Review of Products to Date

- Typical Sections
  - Local, Collector, Arterial—various versions
  - Utilities, Parking, Trails as appropriate



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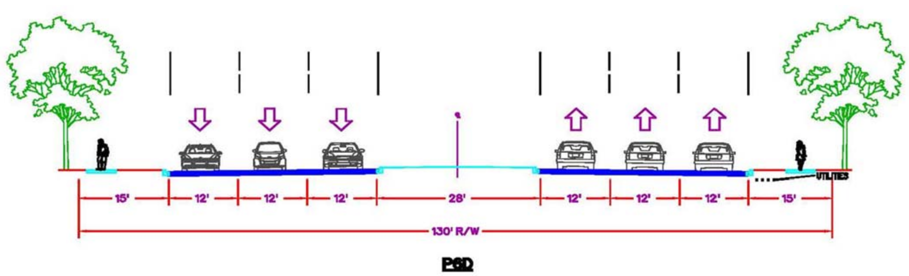
5

Review of Products to Date

- Typical Sections
  - Local, Collector, Arterial—various versions
  - Utilities, Parking, Trails as appropriate



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Review of Products to Date

Cost Estimates:

- 10% Construction Oversight
- 10% Contingency
- 20% Pre-Construction costs

Classifications	Typical Section	Cost Estimate (per Mile)*	
		w/o ROW Cost	w/ ROW Cost
Multi-Use Path	MUP	$900,000	$3,400,000
Local	L2U	$5,500,000	$11,800,000
Local/ Collector / Major & Minor Arterial	R2U	$3,600,000	$7,400,000
Collector	C2U	$6,100,000	$12,400,000
Collector	C2U – Bike or Parking	$6,200,000	$12,500,000
Collector	C3U	$6,300,000	$12,600,000
Collector	C4U	$6,700,000	$14,100,000
Collector	C4U – Bike or Parking	$7,700,000	$16,100,000
Collector & Minor Arterial	C4D	$7,400,000	$15,800,000
Collector & Minor Arterial	C4D – Bike or Parking	$8,500,000	$18,000,000
Collector & Minor Arterial	C5U	$7,600,000	$16,000,000
Minor Arterial	P4D	$8,700,000	$19,800,000
Minor Arterial	P4D – Bike	$9,000,000	$20,600,000
Minor & Major Arterial	P6D	$10,300,000	$24,000,000
Minor & Major Arterial	P8D	$11,800,000	$27,600,000

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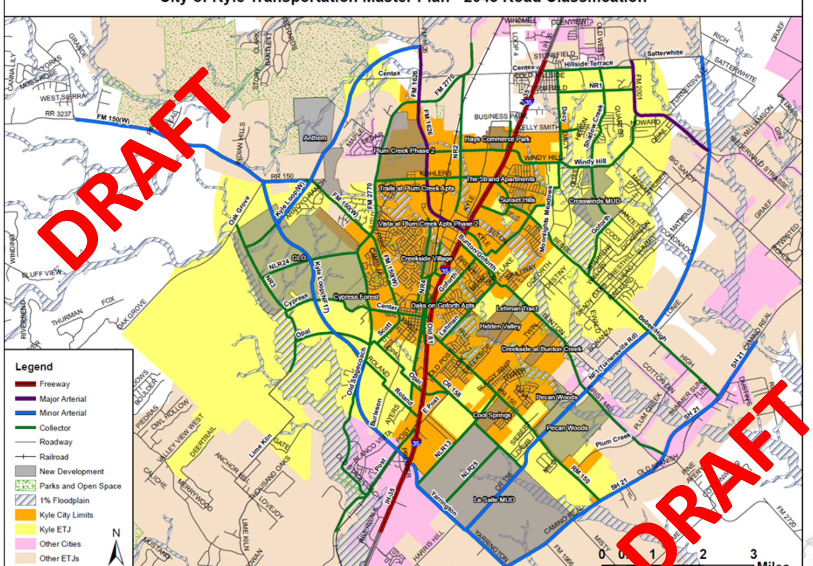
City of Kyle Transportation Master Plan - 2045 Road Classification



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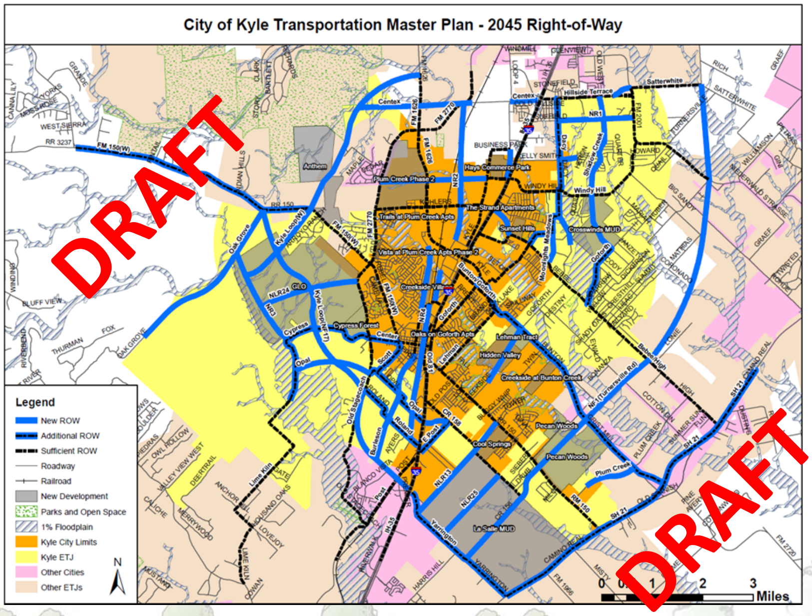

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Review of Products to Date

- Draft Network Discussion
  - List of Existing / In-Process Subdivisions

Project Name	Status
Anthem	In Design
Brookside Phase 2	Approved
Bunton Creek remaining phases	In Review
Cool Springs	In Review
Creekside at Bunton Creek	Concept
Creekside Village	In Review
Crosswinds MUD	In Review
Cypress Forest	Concept
GLO	Concept
Hays Commerce Park	In Review
Hidden Valley	Concept

Project Name	Status
La Salle MUD	Concept
Lehman Tract	Concept
Oaks of Kyle Apts	Under Construction
Pecan Woods	Concept
Plum Creek Phase 2	Concept
Sunset Hills	In Review
The Strand Apartments	Under Construction
Trails at Plum Creek Apts	Under Construction
Vista at Plum Creek Apts Phase 2	Under Construction
Villas at Creekside Phase 2	Approved

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Review of Products to Date

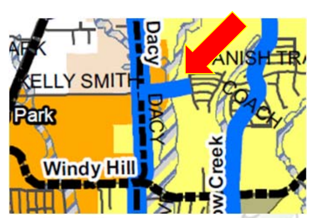
- Draft Network Discussion
  - Overall CIP Cost Estimate for Impact Fees

Cost Estimate Total by Road Owner		
Owner		Price Total
Kyle	$	540,640,000
Hays-ETJ	$	481,460,000
Hays-non-ETJ	$	378,880,000
TxDOT	$	1,820,100,000
TOTAL	**$**	**3,221,080,000**

  - Definition of Network to West
    - Includes Relocated FM 150
    - Kyle Loop around Mountain City to FM 1626 at Robert S. Light Blvd. in Buda
  - Expansions of Needed Corridors

Review of Products to Date

- Draft Network Discussion
  - “Missed Connections” within Developed Areas
  - Short-Distance *Local* cross-sections
  - Sunrise and Kelly Smith are good examples:
    A short roadway can add a second access route to an area taking access off another corridor



Financial Strategies: Funding Commitments

- Operations & Maintenance/City Services (98% of Ad Valorem tax revenues)
- New sewer plant for current needs; future sewer capacity
- $113 million current debt (includes recent $42.5 million road bond issue)
- $15 million Chapter 380 agreement obligations
- $60 million Hays County PUA obligation - PENDING
- Downtown revitalization program
- Dedicated economic development grant program - $10 million grant in 2014
- Drainage improvements
- Lone Star Rail - PENDING

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Financial Strategies: Available Funding in Use

- Property tax
- General Obligation Bonds
- Certificates of Obligation
- Sales Tax
- Tax Increment Financing/Reinvestment Zones (TIF's/TIRZ's)
- Chapter 380 Agreements
- Utility/Permit Fees
- Plat filing/Subdivision Fees
- Fines

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Financial Strategies: Potential Funding

- Transportation Reinvestment Zones (TRZ's)
- 4A, 4B Sales Tax Corporation - only if Council elects to seek re-dedication of current sales tax use(s)
- Competitive funding opportunities (e.g., CAMPO, Federal programs, etc.)
- Development Impact Fees
- Transportation Utility Fees

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Financial Strategies: Enhancing City Competitiveness

- Competitive Funding Opportunities
  - Local/Regional
  - CAMPO STP-MM
- State
  - Proposition 1
  - Proposition 7 (if voter referendum successful in November)
- Federal
  - Transportation Investment Generating Economic Recovery (TIGER) grant
  - Other US DOT grant programs as authorized

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Financial Strategies: Enhancing City Competitiveness

- Identify and fund development of local and regionally significant projects to be "shovel-ready" for future competitive funding opportunities
- Create grant review team to review grant criteria and work with Council and City Engineer to identify the most competitive project(s) that match grant criteria
- Develop regional partnerships to identify list of regionally significant projects in each partner area that are highly competitive; cooperatively fund development of projects to be "shovel-ready" for future competitive funding opportunities

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Implementation Recommendations

- Prioritization Criteria
  - Congestion / Connectivity Benefit
  - Safety Issues
  - Cost / Right-of-Way Need
  - Economic Development
  - Community Impact / Project Readiness
  - Environmental / Constructability Issues
  - Drainage Needs / Other Elements

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Post-Project Plan Implementation

- Corridor Preservation Ordinance
  - Needed for Implementation of TMP
  - Should dedicate Ultimate ROW
  - Could be Included in Unified Development Code
  - Could be Codified as Plat Requirement
  - Could be a Check by Planning & Zoning

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Public Involvement So Far

- Kick off meeting
  - March 9
  - Advertised around town, through neighborhood groups, social media, and in the Hays Free Press

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Public Involvement So Far

- Outreach online via the website, Facebook page, and Twitter
  - KyleConnected.com
  - Facebook.com/KyleConnected
  - Twitter.com/KyleConnected

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Next Steps for Citizens

1. Town Hall Meeting
2. Community Survey

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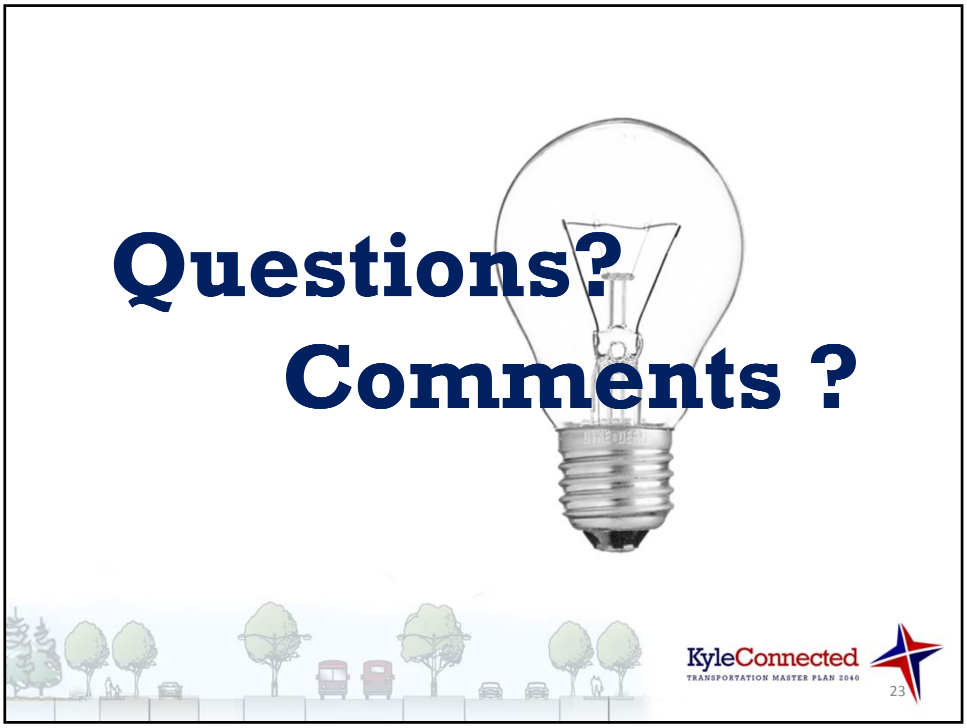
Questions?
Comments ?
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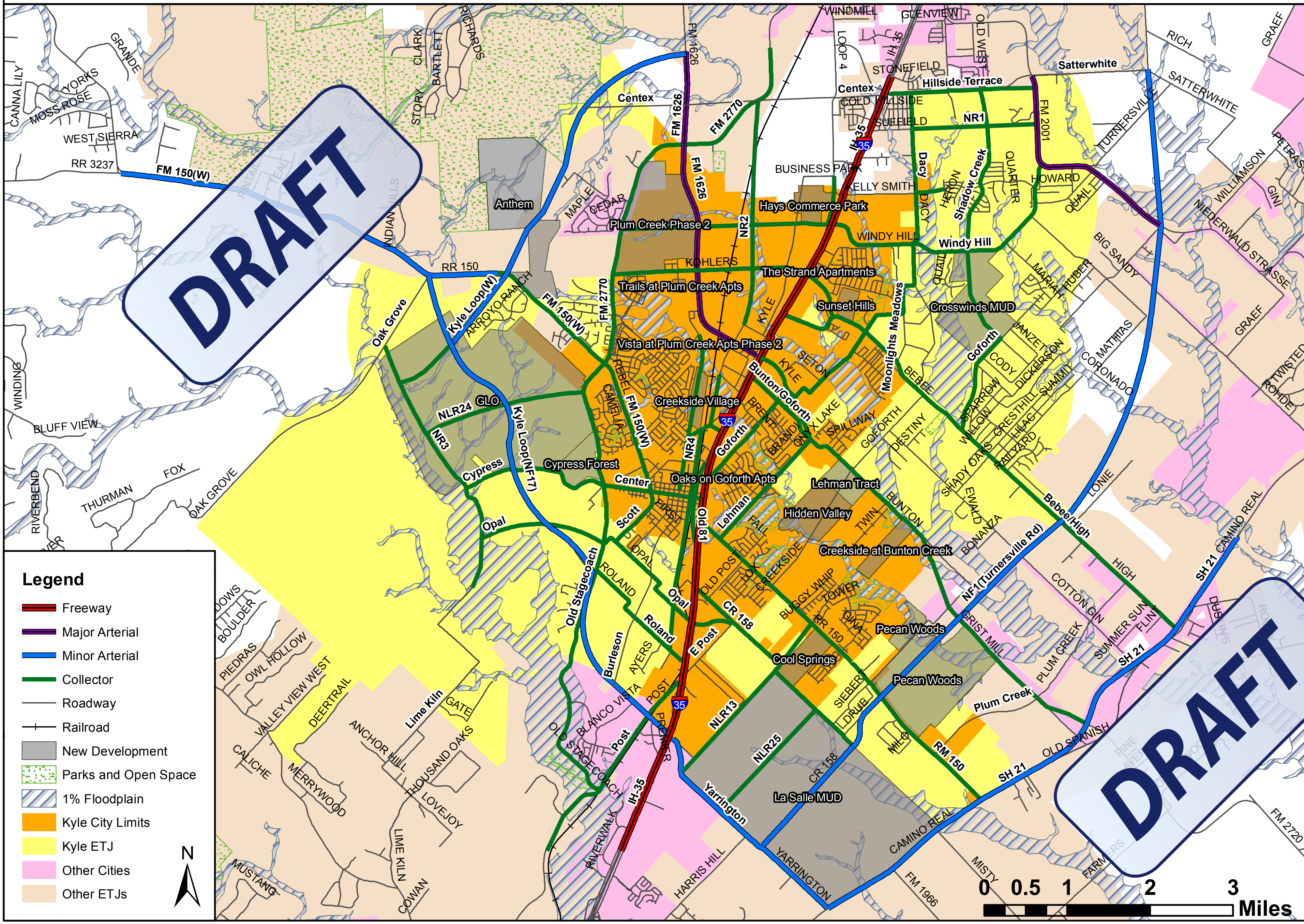
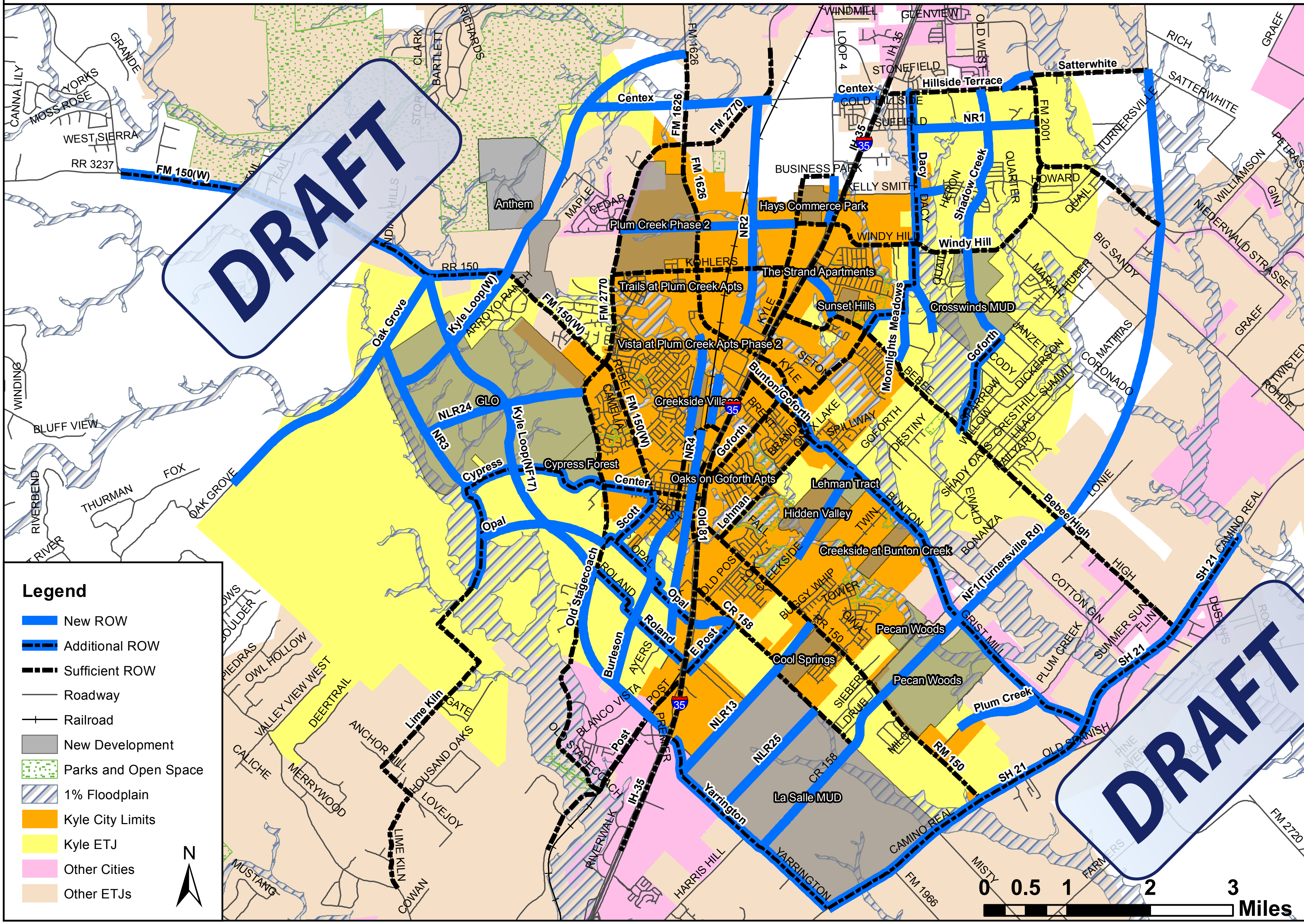
City of Kyle Transportation Master Plan - 2045 Road Classification



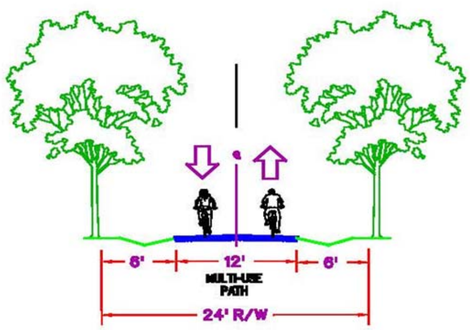
City of Kyle Transportation Master Plan - 2045 Right-of-Way



City of Kyle Transportation Master Plan - 2015 Update					
Proposed Typical Sections					
Classifications	Typical Section	ROW	Description	Cost Estimate (per Mile)*	
				w/o ROW Cost	w/ ROW Cost
Multi-Use Path	MUP	24'	12’ bi-directional multi-use path	$900,000	$3,400,000
Local	L2U	60'	Basic 2-lane section for direct lot access	$5,500,000	$11,800,000
Local/ Collector / Major & Minor Arterial	R2U	60'	Existing sections without sidewalks or curb/gutter. Not permitted for new construction within Kyle	$3,600,000	$7,400,000
Collector	C2U	60'	Wider section for commercial areas; bike and parking are optional	$6,100,000	$12,400,000
Collector	C2U – Bike or Parking	60'	Wider section for residential areas; two striped outside lanes for bikes or parking	$6,200,000	$12,500,000
Collector	C3U	60'	3-lane section with two-way left-turn lane	$6,300,000	$12,600,000
Collector	C4U	70'	Basic 4-lane collector section	$6,700,000	$14,100,000
Collector	C4U – Bike or Parking	80'	Two striped outside lanes for bikes or parking	$7,700,000	$16,100,000
Collector & Minor Arterial	C4D	80'	Basic 4-lane arterial section	$7,400,000	$15,800,000
Collector & Minor Arterial	C4D – Bike or Parking	90'	Two striped outside lanes for bikes or parking	$8,500,000	$18,000,000
Collector & Minor Arterial	C5U	80'	5-lane section with two-way left-turn lane	$7,600,000	$16,000,000
Minor Arterial	P4D	105'	Basic 4-lane arterial section for high speed roads (>40 mph)	$8,700,000	$19,800,000
Minor Arterial	P4D – Bike	110'	12’ lanes, with 12’ multi-use path for Hike and Bike Trail Segments	$9,000,000	$20,600,000
Minor & Major Arterial	P6D	130'	Basic 6-lane arterial section with 12’ lanes	$10,300,000	$24,000,000
Minor & Major Arterial	P8D	150'	Basic 8-lane arterial section with 12’ lanes	$11,800,000	$27,600,000

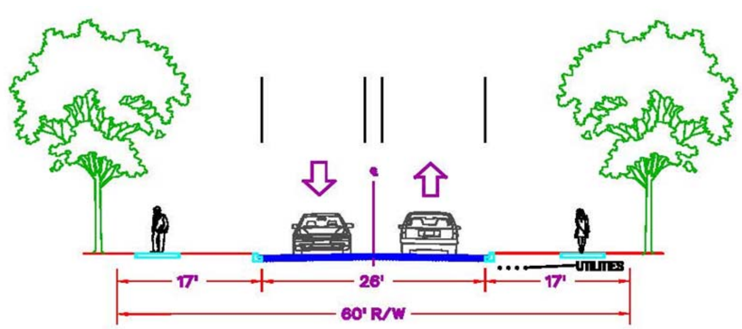
*Cost estimates include 10% Construction Oversight, 10% Contingency, and 20% Pre-Construction costs

MUP (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	24.0	$2,500.00	$60,000.00
110 6001	EXCAVATION (ROADWAY)	CY	3,520.0	$10.00	$35,200.00
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	528.0	$10.00	$5,280.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	3,520.0	$1.50	$5,280.00
162 6002	BLOCK SODDING	SY	352.0	$3.00	$1,056.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	126.7	$148.72	$18,842.82
260 2006	LIME TRT (EXST MATL) (6")	SY	7,040.0	$1.68	$11,827.20
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	7,040.0	$8.30	$58,432.00
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	2,904.0	$65.00	$188,760.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	1,161.6	$123.00	$142,876.80
500 6001	MOBILIZATION	LS	1.0	-	$61,308.28
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$10,000.00	$10,000.00
UTILITIES		MI	1.0	$50,000.00	$50,000.00
1122 2037	TEMPORARY SEDIMENT CONTROL FENCE INSTL	LF	10,560.0	$2.00	$21,120.00
				TOTAL	**$674,392.00**
Pre-Construction				20%	$134,878.40
Construction Oversight				10%	$67,439.20
Contingency				10%	$67,439.20
				TOTAL	**$900,000**
				ROW TOTAL	**$2,500,000**



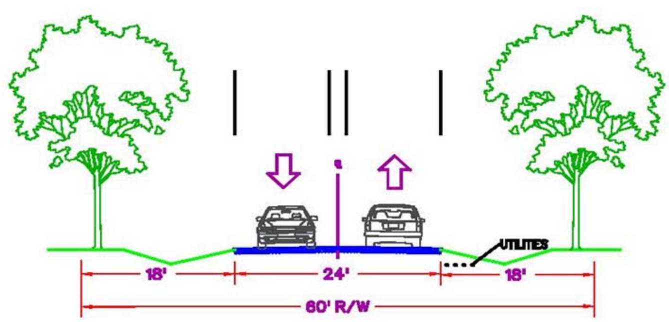
MUP

L2U (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	60.0	$2,500.00	$150,000.00
110 6001	EXCAVATION (ROADWAY)	CY	7,626.7	$10.00	$76,266.67
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	1,144.0	$10.00	$11,440.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	7,626.7	$1.50	$11,440.00
162 6002	BLOCK SODDING	SY	762.7	$3.00	$2,288.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	274.6	$148.72	$40,838.51
260 2006	LIME TRT (EXST MATL) (6")	SY	15,253.3	$1.68	$25,625.60
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	15,253.3	$8.30	$126,602.67
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	6,292.0	$65.00	$408,980.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	2,516.8	$123.00	$309,566.40
500 6001	MOBILIZATION	LS	1.0	-	$358,832.78
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$40,000.00	$40,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$3,947,161.00**
Pre-Construction				20%	$789,432.20
Construction Oversight				10%	$394,716.10
Contingency				10%	$394,716.10
				TOTAL	**$5,500,000**
				ROW TOTAL	**$6,300,000**



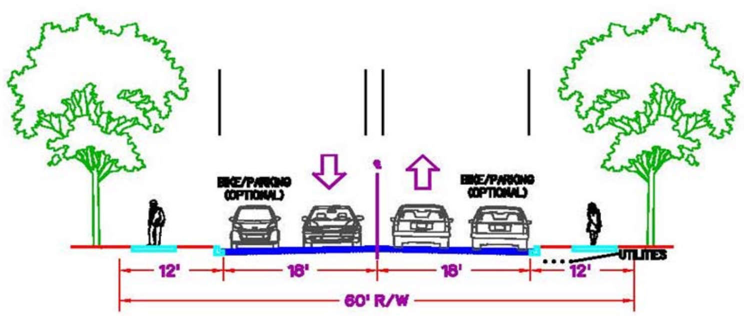
L2U

R2U (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	60.0	$2,500.00	$150,000.00
105 6005	REMOVING STAB BASE AND ASPH PAV (2")	SY	14,080.0	$10.00	$140,800.00
110 6001	EXCAVATION (ROADWAY)	CY	7,040.0	$10.00	$70,400.00
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	1,056.0	$10.00	$10,560.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	7,040.0	$1.50	$10,560.00
162 6002	BLOCK SODDING	SY	704.0	$3.00	$2,112.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	253.4	$148.72	$37,685.65
260 2006	LIME TRT (EXST MATL) (6")	SY	14,080.0	$1.68	$23,654.40
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	14,080.0	$8.30	$116,864.00
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	5,808.0	$65.00	$377,520.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	2,323.2	$123.00	$285,753.60
500 6001	MOBILIZATION	LS	1.0	-	$233,210.96
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
DRAINAGE		MI	1.0	$500,000.00	$500,000.00
TRAFFIC CONTROL		MI	1.0	$50,000.00	$50,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$40,000.00	$40,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$2,565,321.00**
Pre-Construction				20%	$513,064.20
Construction Oversight				10%	$256,532.10
Contingency				10%	$256,532.10
				TOTAL	**$3,600,000**
				ROW TOTAL	**$3,800,000**



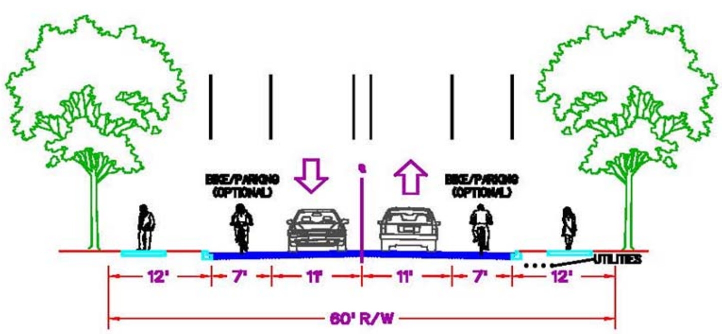
R2U

C2U (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	60.0	$2,500.00	$150,000.00
110 6001	EXCAVATION (ROADWAY)	CY	10,560.0	$10.00	$105,600.00
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	1,584.0	$10.00	$15,840.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	10,560.0	$1.50	$15,840.00
162 6002	BLOCK SODDING	SY	1,056.0	$3.00	$3,168.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	380.2	$148.72	$56,543.34
260 2006	LIME TRT (EXST MATL) (6")	SY	21,120.0	$1.68	$35,481.60
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	21,120.0	$8.30	$175,296.00
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	8,712.0	$65.00	$566,280.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	3,484.8	$123.00	$428,630.40
500 6001	MOBILIZATION	LS	1.0	-	$397,795.93
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$40,000.00	$40,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$4,375,756.00**
Pre-Construction				20%	$875,151.20
Construction Oversight				10%	$437,575.60
Contingency				10%	$437,575.60
				TOTAL	**$6,100,000**
				ROW TOTAL	**$6,300,000**



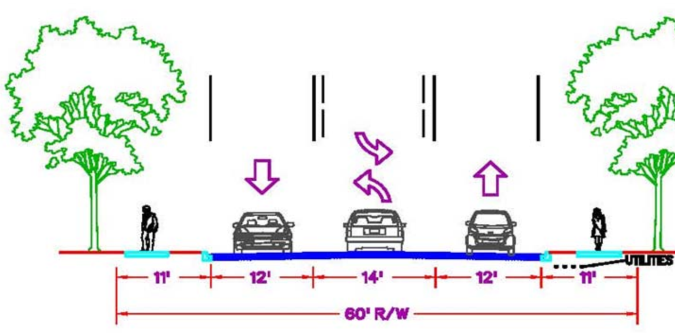
C2U

C2U (B/P) (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	60.0	$2,500.00	$150,000.00
110 6001	EXCAVATION (ROADWAY)	CY	10,560.0	$10.00	$105,600.00
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	1,584.0	$10.00	$15,840.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	10,560.0	$1.50	$15,840.00
162 6002	BLOCK SODDING	SY	1,056.0	$3.00	$3,168.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	380.2	$148.72	$56,543.34
260 2006	LIME TRT (EXST MATL) (6")	SY	21,120.0	$1.68	$35,481.60
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	21,120.0	$8.30	$175,296.00
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	8,712.0	$65.00	$566,280.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	3,484.8	$123.00	$428,630.40
500 6001	MOBILIZATION	LS	1.0	-	$399,795.93
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$60,000.00	$60,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$4,397,756.00**
Pre-Construction				20%	$879,551.20
Construction Oversight				10%	$439,775.60
Contingency				10%	$439,775.60
				TOTAL	**$6,200,000**
				ROW TOTAL	**$6,300,000**



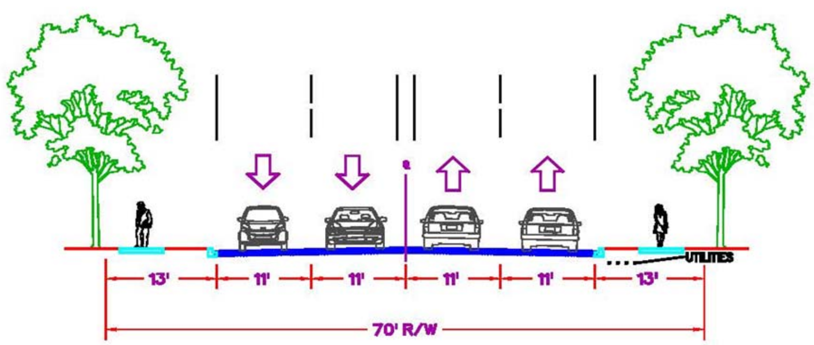
C2U (B/P)

C3U (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	60.0	$2,500.00	$150,000.00
110 6001	EXCAVATION (ROADWAY)	CY	11,146.7	$10.00	$111,466.67
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	1,672.0	$10.00	$16,720.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	11,146.7	$1.50	$16,720.00
162 6002	BLOCK SODDING	SY	1,114.7	$3.00	$3,344.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	401.3	$148.72	$59,681.34
260 2006	LIME TRT (EXST MATL) (6")	SY	22,293.3	$1.68	$37,452.80
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	22,293.3	$8.30	$185,034.67
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	9,196.0	$65.00	$597,740.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	3,678.4	$123.00	$452,443.20
500 6001	MOBILIZATION	LS	1.0	-	$408,588.27
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$70,000.00	$70,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$4,494,471.00**
Pre-Construction				20%	$898,894.20
Construction Oversight				10%	$449,447.10
Contingency				10%	$449,447.10
				TOTAL	**$6,300,000**
				ROW TOTAL	**$6,300,000**



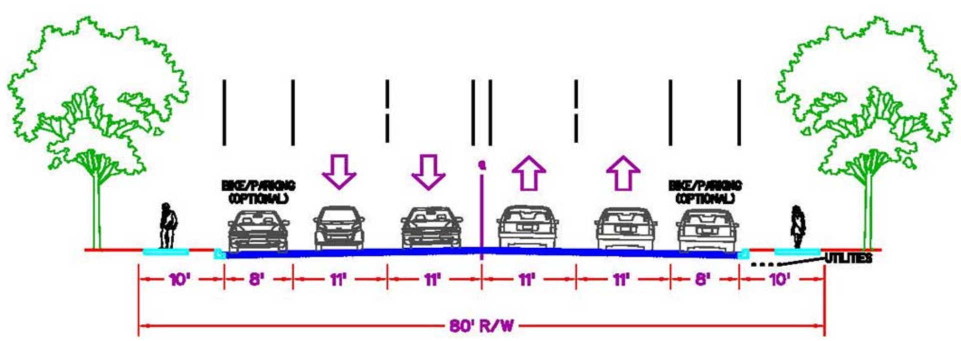
C3U

C4U (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	70.0	$2,500.00	$175,000.00
110 6001	EXCAVATION (ROADWAY)	CY	12,906.7	$10.00	$129,066.67
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	1,936.0	$10.00	$19,360.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	12,906.7	$1.50	$19,360.00
162 6002	BLOCK SODDING	SY	1,290.7	$3.00	$3,872.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	464.6	$148.72	$69,095.31
260 2006	LIME TRT (EXST MATL) (6")	SY	25,813.3	$1.68	$43,366.40
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	25,813.3	$8.30	$214,250.67
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	10,648.0	$65.00	$692,120.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	4,259.2	$123.00	$523,881.60
500 6001	MOBILIZATION	LS	1.0	-	$433,465.26
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$60,000.00	$60,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$4,768,118.00**
Pre-Construction				20%	$953,623.60
Construction Oversight				10%	$476,811.80
Contingency				10%	$476,811.80
				TOTAL	**$6,700,000**
				ROW TOTAL	**$7,400,000**



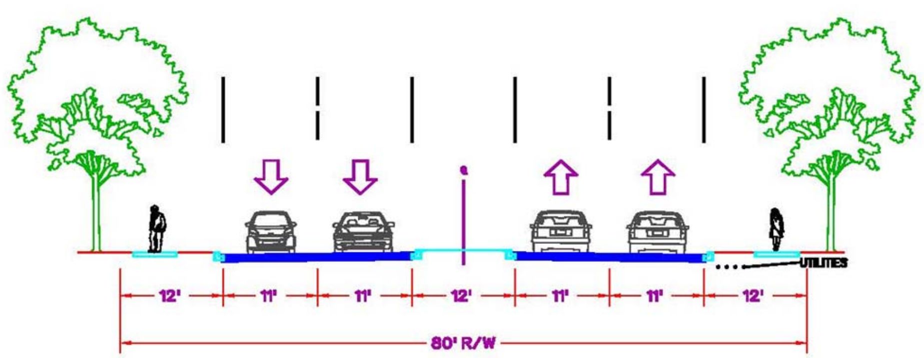
C4U

C4U (B/P) (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	80.0	$2,500.00	$200,000.00
110 6001	EXCAVATION (ROADWAY)	CY	17,600.0	$10.00	$176,000.00
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	2,640.0	$10.00	$26,400.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	17,600.0	$1.50	$26,400.00
162 6002	BLOCK SODDING	SY	1,760.0	$3.00	$5,280.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	633.6	$148.72	$94,228.99
260 2006	LIME TRT (EXST MATL) (6")	SY	35,200.0	$1.68	$59,136.00
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	35,200.0	$8.30	$292,160.00
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	14,520.0	$65.00	$943,800.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	5,808.0	$123.00	$714,384.00
500 6001	MOBILIZATION	LS	1.0	-	$500,306.90
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$80,000.00	$80,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$5,503,376.00**
Pre-Construction				20%	$1,100,675.20
Construction Oversight				10%	$550,337.60
Contingency				10%	$550,337.60
				TOTAL	**$7,700,000**
				ROW TOTAL	**$8,400,000**



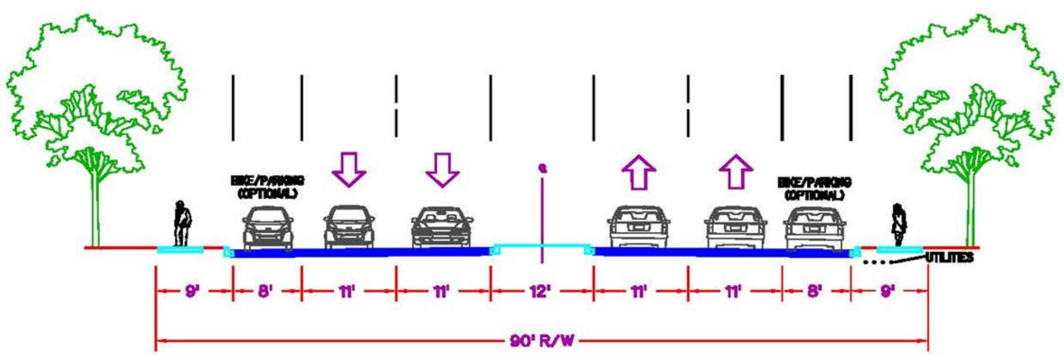
C4U (B/P)

C4D (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	80.0	$2,500.00	$200,000.00
110 6001	EXCAVATION (ROADWAY)	CY	16,426.7	$10.00	$164,266.67
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	2,464.0	$10.00	$24,640.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	16,426.7	$1.50	$24,640.00
162 6002	BLOCK SODDING	SY	1,642.7	$3.00	$4,928.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	591.4	$148.72	$87,953.01
260 2006	LIME TRT (EXST MATL) (6")	SY	32,853.3	$1.68	$55,193.60
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	32,853.3	$8.30	$272,682.67
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	13,552.0	$65.00	$880,880.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	5,420.8	$123.00	$666,758.40
500 6001	MOBILIZATION	LS	1.0	-	$482,722.23
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$60,000.00	$60,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$5,309,945.00**
Pre-Construction				20%	$1,061,989.00
Construction Oversight				10%	$530,994.50
Contingency				10%	$530,994.50
				TOTAL	**$7,400,000**
				ROW TOTAL	**$8,400,000**



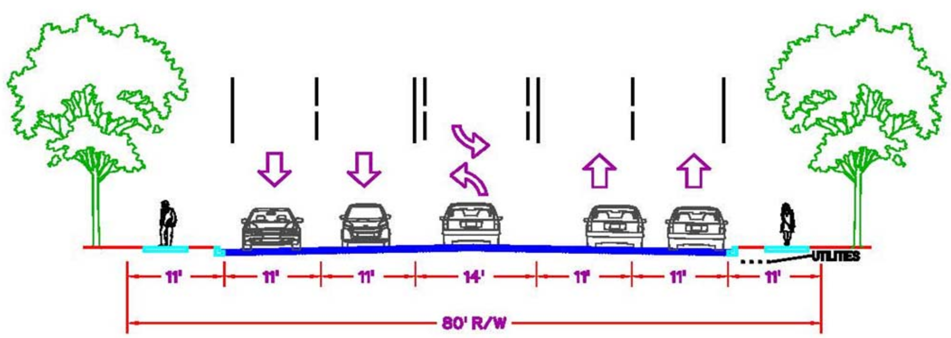
C4D

C4D (B/P) (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	90.0	$2,500.00	$225,000.00
110 6001	EXCAVATION (ROADWAY)	CY	21,120.0	$10.00	$211,200.00
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	3,168.0	$10.00	$31,680.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	21,120.0	$1.50	$31,680.00
162 6002	BLOCK SODDING	SY	2,112.0	$3.00	$6,336.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	760.3	$148.72	$113,071.82
260 2006	LIME TRT (EXST MATL) (6")	SY	42,240.0	$1.68	$70,963.20
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	42,240.0	$8.30	$350,592.00
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	17,424.0	$65.00	$1,132,560.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	6,969.6	$123.00	$857,260.80
500 6001	MOBILIZATION	LS	1.0	-	$549,562.38
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$80,000.00	$80,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$6,045,187.00**
Pre-Construction				20%	$1,209,037.40
Construction Oversight				10%	$604,518.70
Contingency				10%	$604,518.70
				TOTAL	**$8,500,000**
				ROW TOTAL	**$9,500,000**



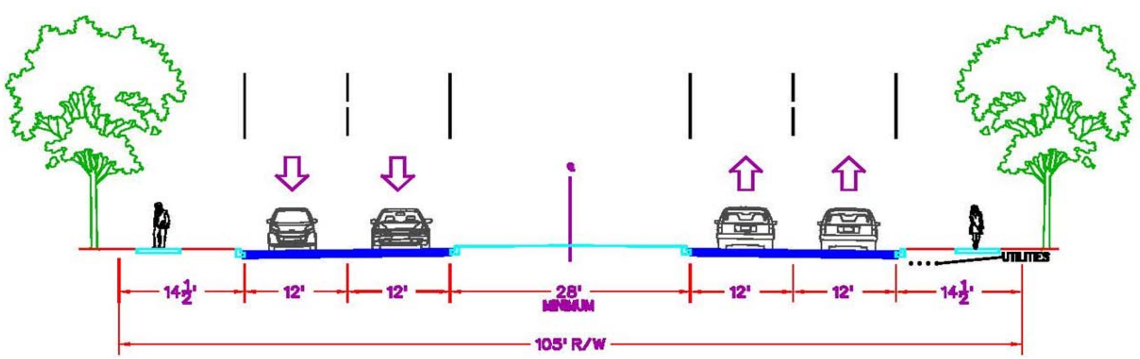
C4D (B/P)

C5U (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	80.0	$2,500.00	$200,000.00
110 6001	EXCAVATION (ROADWAY)	CY	17,013.3	$10.00	$170,133.33
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	2,552.0	$10.00	$25,520.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	17,013.3	$1.50	$25,520.00
162 6002	BLOCK SODDING	SY	1,701.3	$3.00	$5,104.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	612.5	$148.72	$91,091.00
260 2006	LIME TRT (EXST MATL) (6")	SY	34,026.7	$1.68	$57,164.80
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	34,026.7	$8.30	$282,421.33
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	14,036.0	$65.00	$912,340.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	5,614.4	$123.00	$690,571.20
500 6001	MOBILIZATION	LS	1.0	-	$493,514.57
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	2.0	$1,500.00	$3,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$90,000.00	$90,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$5,428,661.00**
Pre-Construction				20%	$1,085,732.20
Construction Oversight				10%	$542,866.10
Contingency				10%	$542,866.10
				TOTAL	**$7,600,000**
				ROW TOTAL	**$8,400,000**



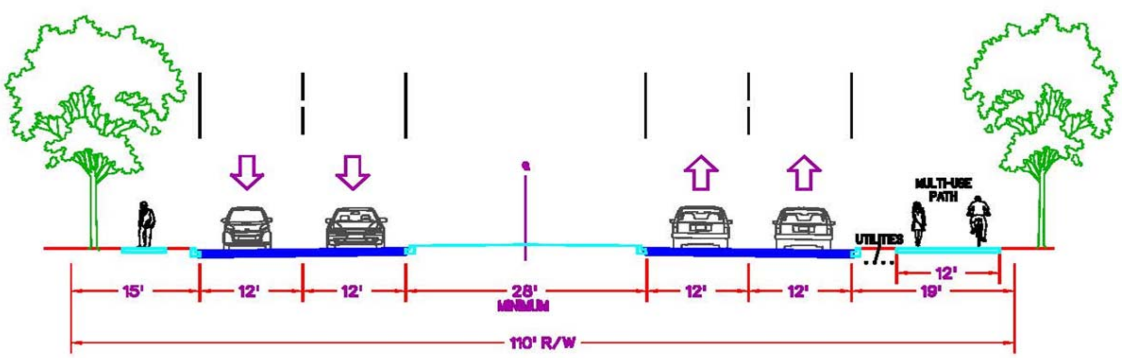
C5U

P4D (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	105.0	$2,500.00	$262,500.00
110 6001	EXCAVATION (ROADWAY)	CY	22,293.3	$10.00	$222,933.33
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	3,344.0	$10.00	$33,440.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	22,293.3	$1.50	$33,440.00
162 6002	BLOCK SODDING	SY	2,229.3	$3.00	$6,688.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	802.6	$148.72	$119,362.67
260 2006	LIME TRT (EXST MATL) (6")	SY	44,586.7	$1.68	$74,905.60
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	44,586.7	$8.30	$370,069.33
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	18,392.0	$65.00	$1,195,480.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	7,356.8	$123.00	$904,886.40
500 6001	MOBILIZATION	LS	1.0	-	$567,198.53
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	4.0	$1,500.00	$6,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$60,000.00	$60,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$6,239,184.00**
Pre-Construction				20%	$1,247,836.80
Construction Oversight				10%	$623,918.40
Contingency				10%	$623,918.40
				TOTAL	**$8,700,000**
				ROW TOTAL	**$11,100,000**



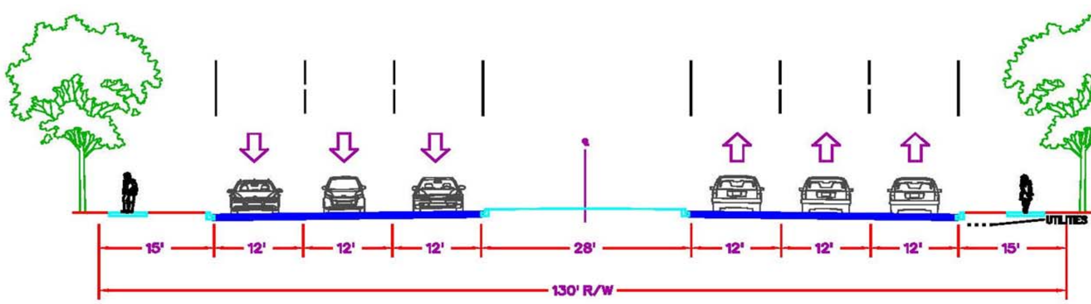
P4D

P4D (B) (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	110.0	$2,500.00	$275,000.00
110 6001	EXCAVATION (ROADWAY)	CY	22,293.3	$10.00	$222,933.33
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	3,344.0	$10.00	$33,440.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	22,293.3	$1.50	$33,440.00
162 6002	BLOCK SODDING	SY	2,229.3	$3.00	$6,688.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	802.6	$148.72	$119,362.67
260 2006	LIME TRT (EXST MATL) (6")	SY	44,586.7	$1.68	$74,905.60
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	44,586.7	$8.30	$370,069.33
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	18,392.0	$65.00	$1,195,480.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	7,356.8	$123.00	$904,886.40
500 6001	MOBILIZATION	LS	1.0	-	$586,752.53
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	4.0	$1,500.00	$6,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	10,560.0	$52.00	$549,120.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$60,000.00	$60,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$6,454,278.00**
Pre-Construction				20%	$1,290,855.60
Construction Oversight				10%	$645,427.80
Contingency				10%	$645,427.80
				TOTAL	**$9,000,000**
				ROW TOTAL	**$11,600,000**



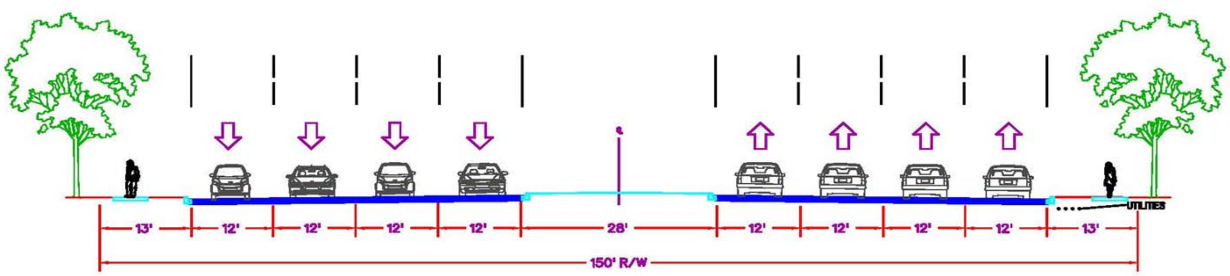
P4D (B)

P6D (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	130.0	$2,500.00	$325,000.00
110 6001	EXCAVATION (ROADWAY)	CY	29,333.3	$10.00	$293,333.33
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	4,400.0	$10.00	$44,000.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	29,333.3	$1.50	$44,000.00
162 6002	BLOCK SODDING	SY	2,933.3	$3.00	$8,800.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	1,056.0	$148.72	$157,048.32
260 2006	LIME TRT (EXST MATL) (6")	SY	58,666.7	$1.68	$98,560.00
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	58,666.7	$8.30	$486,933.33
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	24,200.0	$65.00	$1,573,000.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	9,680.0	$123.00	$1,190,640.00
500 6001	MOBILIZATION	LS	1.0	-	$668,959.50
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	4.0	$1,500.00	$6,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$80,000.00	$80,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$7,358,555.00**
Pre-Construction				20%	$1,471,711.00
Construction Oversight				10%	$735,855.50
Contingency				10%	$735,855.50
				TOTAL	**$10,300,000**
				ROW TOTAL	**$13,700,000**



P6D

P8D (Cost/Mile)					
Item No, Descrip Code	Description	Unit	Est	Avg Unit Cost	COST
100 6002	PREPARING ROW	STA	150.0	$2,500.00	$375,000.00
110 6001	EXCAVATION (ROADWAY)	CY	36,373.3	$10.00	$363,733.33
132 6003	EMBANKMENT (FINAL) (ORD CONT) (TY B)	CY	5,456.0	$10.00	$54,560.00
160 6003	FURNISHING AND PLACING TOPSOIL (4")	SY	36,373.3	$1.50	$54,560.00
162 6002	BLOCK SODDING	SY	3,637.3	$3.00	$10,912.00
168 6001	VEGETATIVE WATERING	MG	250.0	$12.00	$3,000.00
192 2020	PLANT MATERIAL (1 GAL) (TREE)	EA	176.0	$8.00	$1,408.00
260 2001	LIME (HYDRATED LIME(DRY))	TON	1,309.4	$148.72	$194,733.97
260 2006	LIME TRT (EXST MATL) (6")	SY	72,746.7	$1.68	$122,214.40
276 2224	CEM TRT (PLNT MX) (CL N) (TY E) (GR 4) (6")	SY	72,746.7	$8.30	$603,797.33
341 6008	D-GR HMA TY-B PG 64-22 (7.5 IN)	TON	30,008.0	$65.00	$1,950,520.00
341 6047	D-GR HMA TY-D SAC-A PG 76-22 (3 IN)	TON	12,003.2	$123.00	$1,476,393.60
500 6001	MOBILIZATION	LS	1.0	-	$769,470.46
502 2125	BARRICADES, SIGNS AND TRAFFIC HANDLING	EA	4.0	$1,500.00	$6,000.00
529 6005	CONC CURB (MONO) (TY II)	LF	10,560.0	$6.00	$63,360.00
530 6004	DRIVEWAYS (CONC)	SY	288.0	$64.00	$18,432.00
531 6003	CONC SIDEWALKS (6")	SY	7,040.0	$52.00	$366,080.00
DRAINAGE		MI	1.0	$1,500,000.00	$1,500,000.00
PAVEMENT MARKINGS AND SIGNS		MI	1.0	$100,000.00	$100,000.00
UTILITIES		MI	1.0	$400,000.00	$400,000.00
SW3P		MI	1.0	$30,000.00	$30,000.00
				TOTAL	**$8,464,176.00**
Pre-Construction				20%	$1,692,835.20
Construction Oversight				10%	$846,417.60
Contingency				10%	$846,417.60
				TOTAL	**$11,800,000**
				ROW TOTAL	**$15,800,000**



P8D

City of Kyle 2015 Transportation Master Plan - Draft 7/15/15																	
No.	Project	Owner	Pr. Classification	Improvement	Length (Miles)	From	To	Construction Cost	Pre-Construction Cost	Oversight Cost	Contingency Cost	ROW Cost	Total Cost	Source	Pr. ROW (FT)	Ex. ROW (FT)
1	Arterial streets	Kyle	IMP	Improvement program--various repaving/reconstruction	-			$16,900,000	$3,380,000	$1,690,000	$1,690,000	$0	**$23,700,000**	CAMPO 2040	-	-
2	Bebee	Kyle	C3U	New 2-lane divided road with TWLTL	0.61	IH-35	Bebee	$2,700,000	$540,000	$270,000	$270,000	$3,800,000	**$7,580,000**	Kyle 2015	60	0
3	Bebee/High	Kyle	C3U	Widen to a 2-lane divided road with TWLTL	6.38	IH-35	SH 21	$2,900,000	$580,000	$290,000	$290,000	$0	**$4,060,000**	CAMPO 2040	60	80
4	Bunton/Goforth	Kyle	C3U	Widen to a 3-lane divided road with TWLTL up to 900' W of Brandi Circle	1.05	IH-35	Lehman	$2,700,000	$540,000	$270,000	$270,000	$0	**$3,800,000**	CAMPO 2040	60	60
5	Burleson	Kyle	C3U	Widen to a 3-lane divided road with TWLTL, sidewalk on 1 side at a minimum	1.08	Lockhart	IH-35 frontage	$5,100,000	$1,020,000	$510,000	$510,000	$0	**$7,100,000**	CAMPO 2040	60	60
6	Burleson	Kyle	L2U	Widen to a 2-lane road	0.25	South	Lockhart	$1,000,000	$200,000	$100,000	$100,000	$0	**$1,400,000**	Kyle 2005	60	80
7	Burleson	Kyle	L2U	NLR6: New 2-lane road	2.25	Yarrington	South	$8,900,000	$1,780,000	$890,000	$890,000	$14,300,000	**$26,760,000**	Kyle 2005	60	0
8	Burleson (Cromwell)	Kyle	C4D	NLR10: New 4-lane divided road	1.27	Spring Branch	Cromwell	$6,700,000	$1,340,000	$670,000	$670,000	$10,700,000	**$20,080,000**	Kyle 2005	80	0
9	Center	Kyle	TS	Install traffic signal	-	at FM 150		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	CAMPO 2040	-	-
10	Center	Kyle	IMP	Widen parking /pedestrian safety	-	at Downtown		$1,400,000	$280,000	$140,000	$140,000	$0	**$1,900,000**	CAMPO 2040	-	-
11	Center	Kyle	TS	Install traffic signal	-	at Old Stagecoach		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	CAMPO 2040	-	-
12	Center	Kyle	TS	S6: Install traffic signal	-	at Old 81		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	Kyle 2005	-	-
13	Center	Kyle	C4U	Widen to a 4-lane road	0.56	Old Stagecoach	FM 150	$2,800,000	$560,000	$280,000	$280,000	$600,000	**$4,520,000**	CAMPO 2040	70	60
14	Centex	Hays-ETJ	L2U	New 2-lane road	0.54	Kyle Loop	ETJ boundary	$2,200,000	$440,000	$220,000	$220,000	$3,500,000	**$6,580,000**	Buda 2013	60	0
15	Centex	Hays-non-ETJ	L2U	New 2-lane road	2.24	ETJ boundary	IH-35	$8,900,000	$1,780,000	$890,000	$890,000	$14,200,000	**$26,660,000**	Buda 2013	60	0
16	CR 158	Hays-ETJ	IMP	Eliminate intersection skew; not all turns currently possible	-	at CR 134		$70,000	$14,000	$7,000	$7,000	$0	**$100,000**	CAMPO 2040	-	-
17	CR 158	Hays-non-ETJ	C2U	Widen to a 2-lane road with optional bike or parking lanes	2.77	IH-35	Turnersville Extension	$12,800,000	$2,560,000	$1,280,000	$1,280,000	$0	**$17,920,000**	CAMPO 2040	60	75
18	Creekside	Kyle	L2U	New 2-lane road	1.27	Creekside	Bunton	$5,000,000	$1,000,000	$500,000	$500,000	$8,000,000	**$15,000,000**	Kyle 2015	60	0
19	Cypress	Kyle	C4U	R27: Widen to a 4-lane road	3.15	Old Stagecoach	Blanco River	$16,000,000	$3,200,000	$1,600,000	$1,600,000	$6,600,000	**$29,000,000**	Kyle 2005	70	50
20	Dacy	Hays-ETJ	C4U	Widen to a 4-lane road	3.38	Hillside Terrace	Bebee	$17,200,000	$3,440,000	$1,720,000	$1,720,000	$7,100,000	**$31,180,000**	CAMPO 2040	70	50
21	E Post	Kyle	L2U	R29: Widen to a 2-lane road	0.81	NLR 19	Opal	$3,400,000	$680,000	$340,000	$340,000	$900,000	**$5,660,000**	Kyle 2005	60	50
22	FM 150	TxDOT	RND	New 2-lane roundabout	-	at Kyle Loop		$500,000	$100,000	$50,000	$50,000	$300,000	**$1,000,000**	Kyle 2015	180	90
23	FM 150 (W)	TxDOT	C3U	Widen to a 2-lane divided road with TWLTL	1.67	FM 2770	W Center @ Rebel	$8,000,000	$1,600,000	$800,000	$800,000	$0	**$11,200,000**	CAMPO 2040	60	80
24	FM 150 (W)	TxDOT	C3U	Widen to a 2-lane divided road with TWLTL	0.64	IH-35	Rebel Dr	$3,000,000	$600,000	$300,000	$300,000	$0	**$4,200,000**	CAMPO 2040	60	80
25	FM 150 (W)	TxDOT	P5U	Widen to a 4-lane divided road with TWLTL	4.81	FM 3237	Kyle Loop (SW)	$28,000,000	$5,600,000	$2,800,000	$2,800,000	$5,100,000	**$44,300,000**	CAMPO 2040	80	70
26	FM 150 (W)	TxDOT	C5U	Widen to a 4-lane divided road with TWLTL	1.73	Kyle Loop (SW)	FM 2770	$10,100,000	$2,020,000	$1,010,000	$1,010,000	$0	**$14,140,000**	CAMPO 2040	80	90
27	FM 1626	TxDOT	P6D	Widen to a 6-lane divided road over UPRR	2.94	FM 2770	IH-35	$25,500,000	$5,100,000	$2,550,000	$2,550,000	$0	**$35,700,000**	Hays 2013	130	200
28	FM 1626	TxDOT	TS	S13: Install traffic signal	-	at Kohlers Cr		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	Kyle 2005	-	-
29	FM 1626	TxDOT	P6D	Widen to a 6-lane divided road	1.12	FM 967	FM 2770	$9,000,000	$1,800,000	$900,000	$900,000	$0	**$12,600,000**	Hays 2013	130	130
30	FM 2770	TxDOT	C4U B/P	Widen to a 4-lane road with optional bike or parking lanes	3.05	FM 1626	FM 150	$18,000,000	$3,600,000	$1,800,000	$1,800,000	$0	**$25,200,000**	CAMPO 2040	80	105
31	FM 2770	TxDOT	C4D	Widen to a 4-lane divided road	1.82	FM 967	FM 1626	$10,300,000	$2,060,000	$1,030,000	$1,030,000	$0	**$14,420,000**	Hays 2013	80	90
32	Goforth	Hays-ETJ	C3U	Widen to a 2-lane divided road with TWLTL	1.26	Shadow Creek	Bebee	$6,000,000	$1,200,000	$600,000	$600,000	$2,700,000	**$11,100,000**	CAMPO 2040	60	40
33	Goforth	Kyle	C4D	New 4-lane divided road	0.22	Bunton Creek	Kyle Pkwy	$1,200,000	$240,000	$120,000	$120,000	$2,100,000	**$3,780,000**	Kyle 2015	90	0
34	Goforth	Kyle	C4U	Widen to a 4-lane; sidewalk on 1 side	0.33	Brent	Bunton Creek	$5,400,000	$1,080,000	$540,000	$540,000	$0	**$7,600,000**	CAMPO 2040	70	70
35	Goforth	Kyle	C3U	Widen to a 3-lane divided road with TWLTL	0.86	IH-35 frontage	Brent	-	-	-	-	-	-	CAMPO 2040	60	60
36	Goforth	Kyle	IMP	I5: Right turn lane	-	at school		-	-	-	-	-	-	Kyle 2005	-	-
37	Goforth	Kyle	TS	Install traffic signal	-	at Bunton		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	CAMPO 2040	-	-
38	Goforth	Kyle	TS	Install traffic signal; improve sight distance in east quadrant	-	at Lehman		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	CAMPO 2040	-	-
39	Grist Mill	Kyle	TS	Install traffic signal	-	at Turnersville Extension		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	Kyle 2015	-	-
40	Hillside Terrace	Hays-ETJ	C2U	Widen to a 2-lane road with optional bike or parking lanes	1.77	IH-35	FM 2001	$8,200,000	$1,640,000	$820,000	$820,000	$0	**$11,480,000**	CAMPO 2040	60	60
41	IH-35	TxDOT	IMP	Improvements	-	SH 45	Posey Rd	$1,071,000,000	$214,200,000	$107,100,000	$107,100,000	$0	**$1,500,000,000**	CAMPO 2040	-	-
42	IH-35	TxDOT	IMP	Express Bus on HOV/HOT ramps on IH-35	-			$25,700,000	$5,140,000	$2,570,000	$2,570,000	$0	**$36,000,000**	CAMPO 2040	-	-
43	IH-35	TxDOT	IMP	Operational improvements; reversing ramps and adding shared use paths	-	RM 150	N of Blanco River	$20,500,000	$4,100,000	$2,050,000	$2,050,000	$0	**$28,700,000**	CAMPO 2040	-	-
44	IH-35	TxDOT	IMP	I3: Eliminate intersection skew	-	at CR 131		$70,000	$14,000	$7,000	$7,000	$0	**$100,000**	Kyle 2005	-	-
45	Kelly Smith	Kyle	C2U	New 2-lane road with optional bike or parking lanes	0.36	Dacy Ln	Marsh Ln	$1,600,000	$320,000	$160,000	$160,000	$2,300,000	**$4,540,000**	Buda 2013	60	0
46	Kohlers Crossing	Kyle	TS	Install traffic signal	-	at Kyle Crossing		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	CAMPO 2040	-	-
47	Kohlers Crossing	Kyle	BRD	New bridge; grade separation over UPRR	0.09	at UPRR		$2,200,000	$440,000	$220,000	$220,000	$600,000	**$3,680,000**	Kyle 2015	70	0
48	Kohlers Crossing	Kyle	BRD	New bridge; grade separation over IH-35	0.04	at IH-35		$1,100,000	$220,000	$110,000	$110,000	$300,000	**$1,840,000**	Kyle 2015	72	0
49	Kyle Crossing	Kyle	C2U	New 2-lane road over UPRR	2.11	FM 2770	Kohler Xing	$10,300,000	$2,060,000	$1,030,000	$1,030,000	$13,400,000	**$27,820,000**	Kyle 2015	60	0
50	Kyle Crossing	Kyle	L2U	Widen to a 2-lane road	1.48	IH-35 @ Old Bridge Trail	Kohler Xing	$6,100,000	$1,220,000	$610,000	$610,000	$0	**$8,540,000**	CAMPO 2040	60	75
51	Kyle Loop (NF17)	Hays-ETJ	P4D	New 4-lane divided road	4.30	FM 150	Old Stagecoach Rd	$22,800,000	$4,560,000	$2,280,000	$2,280,000	$36,300,000	**$68,220,000**	Hays 2013	80	0
52	Kyle Loop (West)	Hays-ETJ	P4D	New 4-lane divided road	0.41	NF 17 (Kyle)	Old Stagecoach Rd	$2,200,000	$440,000	$220,000	$220,000	$3,400,000	**$6,480,000**	CAMPO 2040	80	0
53	Kyle Loop (West)	Hays-ETJ	P4D	New 4-lane divided road	1.94	Old Stagecoach Rd	IH-35 @ Yarrington	$10,300,000	$2,060,000	$1,030,000	$1,030,000	$16,400,000	**$30,820,000**	CAMPO 2040	80	0
54	Kyle Loop (West)	Hays-ETJ	P5U	New 4-lane divided road with TWLTL	5.52	FM 1626	NF 17	$29,900,000	$5,980,000	$2,990,000	$2,990,000	$46,600,000	**$88,460,000**	CAMPO 2040	80	0
55	Kyle Loop (West)	Hays-non-ETJ	C5U	New 4-lane divided road with TWLTL	1.14	NF17	NR3	$6,200,000	$1,240,000	$620,000	$620,000	$9,600,000	**$18,280,000**	Kyle 2015	80	0
56	Kyle Loop (West)	Kyle	TS	Install traffic signal	-	at FM 1626		$210,000	$42,000	$21,000	$21,000	$0	**$300,000**	Kyle 2015	-	-
57	Kyle Loop (West)	Kyle	RND	New 2-lane roundabout	-	at Roland		$500,000	$100,000	$50,000	$50,000	$500,000	**$1,200,000**	Kyle 2015	180	60
58	Kyle Marketplace frontage	Kyle	C3U	New 2-lane divided road with TWLTL	0.61	N Burleson (E of UPRR)	City Lights	$2,160,000	$720,000	$360,000	$360,000	$3,900,000	**$7,500,000**	CAMPO 2040	60	0
59	Kyle Pkwy/Bunton/Grist Mill	Kyle	C4D	Widen to a 4-lane divided road; connect with FM 2720 @ SH 21	5.61	IH-35 @ FM 1626	SH 21	$31,900,000	$6,380,000	$3,190,000	$3,190,000	$20,800,000	**$65,460,000**	CAMPO 2040	80	45
60	Lehman	Kyle	C3U	Widen to a 2-lane road with left turn lanes and sidewalk on 1 side	1.60	Goforth	FM 150	$4,400,000	$880,000	$440,000	$440,000	$0	**$6,100,000**	CAMPO 2040	60	80
61	Lime Kiln	Hays-ETJ	L2U	Widen to MAU2; connect over Blanco river to Cypress Rd	4.71	Cypress	Hilliard	$20,500,000	$4,100,000	$2,050,000	$2,050,000	$0	**$28,700,000**	CAMPO 2040	60	60
62	Loop 4	Kyle	C3U	New 2-lane divided road with TWLTL	0.58	Business Park	Kyle Crossing	$2,600,000	$520,000	$260,000	$260,000	$3,700,000	**$7,340,000**	Kyle 2015	60	0
63	Marketplace Ave	Kyle	C4D	New 4-lane divided road	0.69	FM967	IH-35 @ Burleson	$3,700,000	$740,000	$370,000	$370,000	$5,800,000	**$10,980,000**	CAMPO 2040	80	0
64	Moonlight Meadows	Hays-ETJ	L2U	New 2-lane road	0.58	Dacy Ln	Bebee	$2,300,000	$460,000	$230,000	$230,000	$3,700,000	**$6,920,000**	Kyle 2015	60	0
65	NF1 (Turnersville Rd)	Hays-non-ETJ	P6D	New 6-lane divided road	11.10	SH 45	FM 110	$81,700,000	$16,340,000	$8,170,000	$8,170,000	$152,400,000	**$266,780,000**	Hays 2013	130	0
66	NLR13	Kyle	C4U	New 4-lane road	2.35	Yarrington	FM 150	$11,200,000	$2,240,000	$1,120,000	$1,120,000	$17,400,000	**$33,080,000**	Kyle 2005	70	0
67	NLR24	Hays-ETJ	C4U	New 4-lane road	1.97	Old Stagecoach	NR3	$9,400,000	$1,880,000	$940,000	$940,000	$14,500,000	**$27,660,000**	Kyle 2005/2015	70	0
68	NLR25	Hays-non-ETJ	C4U	New 4-lane road	1.63	FM 110	CR 158	$7,800,000	$1,560,000	$780,000	$780,000	$12,000,000	**$22,920,000**	Kyle 2005	70	0
69	NR1	Hays-ETJ	C2U	New 2-lane road with optional bike or parking lanes	1.51	Dacy Ln	FM 2001	$6,600,000	$1,320,000	$660,000	$660,000	$9,600,000	**$18,840,000**	Buda 2013	60	0
70	NR2	Kyle	C3U	New 2-lane divided road with TWLTL over UPRR	2.02	Centex	Marketplace	$11,100,000	$2,220,000	$1,110,000	$1,110,000	$12,800,000	**$28,340,000**	Kyle 2015	60	0
71	NR3	Hays-ETJ	C3U	New 2-lane divided road with TWLTL	1.98	Oak Grove	Cypress	$8,900,000	$1,780,000	$890,000	$890,000	$12,600,000	**$25,060,000**	Kyle 2015	60	0
72	NR4	Kyle	C2U	New 2-lane road with optional bike or parking lanes	2.67	Burleson	Roland	$11,700,000	$2,340,000	$1,170,000	$1,170,000	$16,900,000	**$33,280,000**	Kyle 2015	60	0
73	Oak Grove	Hays-ETJ	L2U	New 2-lane road over Blanco River	3.52	Oak Grove	FM 150	$14,900,000	$2,980,000	$1,490,000	$1,490,000	$22,300,000	**$43,160,000**	Kyle 2015	60	0
74	Old 81	Kyle	C2U	R16: Widen to a 2-lane divided road with optional bike or parking lanes	0.98	at W IH-35 frontage road		$4,500,000	$900,000	$450,000	$450,000	$0	**$6,300,000**	Kyle 2005	60	100
75	Old Stagecoach	Kyle	C2U	Widen to a 2-lane road with optional bike or parking lanes	5.72	Post	FM 150	$26,500,000	$5,300,000	$2,650,000	$2,650,000	$0	**$37,100,000**	CAMPO 2040	60	60
76	Opal	Kyle	BRD	New bridge; grade separation over IH-35	0.04	at IH-35		$900,000	$180,000	$90,000	$90,000	$0	**$1,260,000**	CAMPO 2040	58	50
77	Opal	Kyle	C4U	R24: Widen to a 4-lane road	1.54	Old Stagecoach	IH-35	$7,800,000	$1,560,000	$780,000	$780,000	$3,200,000	**$14,120,000**	Kyle 2005	70	50
78	Opal	Kyle	C4U	New 4-lane road	0.46	IH-35	CR 158	$2,200,000	$440,000	$220,000	$220,000	$3,400,000	**$6,480,000**	Kyle 2015	70	0
79	Opal	Hays-ETJ	C4U	NLR21: New 4-lane road	1.54	Old Stagecoach	Blanco	$7,400,000	$1,480,000	$740,000	$740,000	$11,400,000	**$21,760,000**	Kyle 2005	70	0
80	Plum Creek	Hays-non-ETJ	L2U	New 2-lane road	1.04	Grist Mill	CR 202	$4,100,000	$820,000	$410,000	$410,000	$6,600,000	**$12,340,000**	Kyle 2015	60	0
81	Post	Kyle	C4U	Widen to a 4-lane road over Blanco river	2.64	IH-35	Aquarena Springs	$14,400,000	$2,880,000	$1,440,000	$1,440,000	$0	**$20,160,000**	Hays 2013	70	70
82	RM 150	TxDOT	C3U	Widen to a 2-lane divided road with TWLTL	3.64	Creekside	SH 21	$14,000,000	$2,800,000	$1,400,000	$1,400,000	$0	**$19,600,000**	Hays 2013	60	90
83	RM 150	TxDOT	IMP	Improve sight distance	-	at CR 202		$70,000	$14,000	$7,000	$7,000	$0	**$100,000**	Kyle 2015	-	0
84	Roland	Kyle	C4U	R26: Widen to a 4-lane road	1.57	Old Stagecoach	IH-35	$8,000,000	$1,600,000	$800,000	$800,000	$2,500,000	**$13,700,000**	Kyle 2005	70	55
85	Satterwhite	Hays-non-ETJ	L2U	Widen to a 2-lane road	1.38	FM 2001	Turnersville Extension	$5,700,000	$1,140,000	$570,000	$570,000	$0	**$7,980,000**	Hays 2013	60	60

DRAFT
DRAFT

City of Kyle 2015 Transportation Master Plan - Draft 7/15/15

No.	Project	Owner	Pr. Classification	Improvement	Length (Miles)	From	To	Construction Cost	Pre-Construction Cost	Oversight Cost	Contingency Cost	ROW Cost	Total Cost	Source	Pr. ROW (FT)	Ex. ROW (FT)
86	Satterwhite	Hays-non-ETJ	L2U	New 2-lane road	0.41	FM 2001	Hillside Terrace	$1,600,000	$320,000	$160,000	$160,000	$2,600,000	**$4,840,000**	Kyle 2015	60	0
87	Scott	Kyle	C4U	R31: Widen to a 4-lane road, realign with FM 150 (1,100 ft)	0.77	Center	Opal	$3,900,000	$780,000	$390,000	$390,000	$800,000	**$6,260,000**	Kyle 2005	70	60
88	SH 21	TxDOT	P6D	Widen to a 6-lane divided road	6.83	Caldwell County	CR 159	$54,600,000	$10,920,000	$5,460,000	$5,460,000	$21,700,000	**$98,140,000**	CAMPO 2040	130	100
89	Shadow Creek	Hays-ETJ	C3U	New 2-lane divided road with TWLTL	3.23	Hillside Terrace	Bebee	$14,500,000	$2,900,000	$1,450,000	$1,450,000	$20,400,000	**$40,700,000**	CAMPO 2040	60	0
90	Sunrise	Hays-ETJ	L2U	New 2-lane road	0.62	Dacy Ln	Sunrise	$2,500,000	$500,000	$250,000	$250,000	$3,900,000	**$7,400,000**	Kyle 2015	60	0
91	Windy Hill	Kyle	C3U	Widen to a 2-lane divided road with TWLTL	3.36	IH-35	Turnersville Extension	$16,000,000	$3,200,000	$1,600,000	$1,600,000	$0	**$22,400,000**	CAMPO 2040	60	90
92	Yarrington	Kyle	P4D	Widen to a 4-lane divided road	2.85	FM 110	SH 21	$16,200,000	$3,240,000	$1,620,000	$1,620,000	$6,000,000	**$28,680,000**	CAMPO 2040	80	60
Total		-	-	-	**148.96**	-	-	**$1,897,960,000**	**$379,880,000**	**$189,940,000**	**$189,940,000**	**$600,200,000**	**$3,258,540,000**	-	**5,400**	**2,895**

	Bond Project
	Not shown on exhibit

Cost Estimate Total by Road Owner		
Owner	**Price Total**	
Kyle	$	560,500,000
Hays-ETJ	$	474,620,000
Hays-non-ETJ	$	377,720,000
TxDOT	$	1,845,700,000
TOTAL	**$**	**3,258,540,000**

DRAFT

CITY OF KYLE, TEXAS

KAYAC "Year in Review" presentation

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: KAYAC "Year in Review" presentation. ~ *Terrah Friesenhahn (Chair) and James Collins (Vice Chair)*

Other Information:

Legal Notes:

Budget Information:

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Attachments / click to download

- KAYAC Year in Review Presentation

"Bringing the Youth of Kyle Front and Center"

CITY OF KYLE TEXAS

KAYAC

Kyle Area Youth Advisory Council

2014-2015 Year in Review

Our Purpose

"KAYAC shall be advisory in nature and has been created for the purpose of providing a youthful Point of view for the Kyle City Council on community affairs and issues."

~KAYAC By-Laws

KAYAC Members

TOP: Supreme Hinton, Alex Moore, Hannah Malott, Terrah Friesenhahn, Rob Brown, Aiden O'Keefe, Ryan Leal

BOTTOM: Melysa Alvarez, Neriah Sosa, Jonathan Lopez, Andy Garza, Lila Ramos, Alexus Denen

NOT PICTURED: James Collins

KAYAC Leadership 2014-2015

- CHAIR
  Terrah Friesenhahn
- VICE CHAIR
  James Collins
- TREASURER
  Andy Garza
- SECRETARY
  Melysa Alvarez
- CITY COUNCIL LIAISON
  James Collins
- ECONOMIC DEVELOPMENT COMMITTEE
  Terrah Friesenhahn

Meetings

- Meetings every two weeks
- Youth run, By-Laws
- Open Meetings Act Compliant
- Parliamentary Procedure
- Discussion on City Council Items
- Reports on City Committee meetings
- Workshops to develop Goals, Motto, Vision, and Mission


KAYAC Meeting

Accomplishments *and* Projects

Community Involvement

- Hays County Food Bank
- City Tour and Staff Presentations
- Santa's Arrival
- Lake Kyle Jubilee
- Kyle Teen Night
- Kyle Founders Parade
- Boy Scouts of America came to observe-community participation

Kyle Easter Eggstravaganza


Family Bike Ride

E-Cigarette Ordinance

- Continued to work with State Representative Jason Isaac on the bill.
- Six members testified on HB647 before House Public Health Committee
- Interviewed with KEYE, KVUE, and Huffington Post Live
- Version of the bill was passed


Preparing to testify on the bill

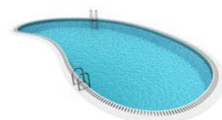

Filing HB647

TML Youth Summit attendees

2015 Texas YAC Summit

- Guest speakers
- Group icebreakers
- Topic presentations on pollution, social media safety, and more
- Meeting with representatives from other cities
- Fun Activities and breaks to interact with other members

Teen Night Luau



- Beach Luau theme
- Hosted at Kyle Pool
- Annual event
- Catered to middle school students
- Developed sponsorship letter to solicit prize donations

- Included …
  - -Prizes
  - -Photo booth
  - -Volleyball
  - -Games
  - -Food
- Participation has increased each year

Other Accomplishments

- Membership Increase
- Raised funds from Santa's Arrival, Jubilee, Teen Night
- Involved in the Economic Development Strategic Planning Summit
- Community and Student Awareness
- Revision of By-Laws

Other Accomplishments cont'd.

- Motto
  - "Bringing the youth of Kyle Front and Center"
- Vision Statement
  - KAYAC strives to incorporate the youths' voice and presence within the community and with City matters. We continue to promote community, service, cooperation, and awareness among the youth of Kyle while elevating interest and involvement in City matters
- Mission Statement
  - KAYAC's mission is to provide the means for direct representation of the youth view-points, to incite collaborative communication between peers, and to promote community involvement among the youth.

2015-2016 KAYAC Leadership

- Chair: Jonathan Lopez
- Vice Chair: Andy Garza
- Secretary: Melysa Alvarez
- City Council Liaison: Andy Garza

Looking Ahead

- Annual Kyle Teen Night Luau
- Continue to Expand Representation
- 5-Year Plan
- Capstone project
- Volunteer regularly with selected organizations – Voter Education, Food Bank, City Departments, etc.
- Department liaisons
- By-Law revisions to expand membership to other schools and parts of community
- Continuing to take leadership roles in the community and among peers
- Continue to build team

A Special Thank You

The future of Kyle will be a bright one, and, thanks to the continued support of our City Council, City Staff, and citizens, that dream is becoming more of a reality every day.

We thank you so much for the incredible opportunities you have afforded us and appreciate your interest and investment in our efforts and accomplishments.

CITY OF KYLE TEXAS

KAYAC

Kyle Area Youth Advisory Council

2014-2015 Year in Review

CITY OF KYLE, TEXAS

Presentation regarding Electronic Billboards

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Presentation on summarized findings from existing studies on electronic billboards related to driver distraction and review of methods used for the study of distraction due to electronic billboard presence. ~ *Mario Perez, Building Official*

Other Information: This presentation reports a summary of three studies that identified a relationship between the presence of electronic billboards and driver distractions.

Due to differences in study methods and definitions of distraction, each study conducted arrived at different results and conclusions with respect to the involvement of driver distraction during a crash.

Legal Notes:

Budget Information:

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Attachments / click to download

- Summary Presentation
- Federal Highway Administration Study
- Swedish Study
- Virginia Tech Study

Cover Memo

STAFF REPORT
City Council Presentation Agenda Item

MEETING DATE: August 4, 2015

TO: Honorable Mayor and Council Members

FROM: Mario Perez, Building Official

SUBJECT: Presentation of information with regard to the proposed relationship between electronic billboards and driver distraction

RECOMMENDATION ACTION:
Staff recommends that the City Council receive this report and provide direction as necessary

ITEM SUMMARY:
This presentation reports a summary of three studies that identified a relationship between the presence of electronic billboards and driver distractions.

Due to differences in study methods and definitions of distraction, each study conducted arrived at different results and conclusions with respect to the involvement of driver distraction during a crash.

A study (*Driver Visual Behavior In The Presence Of Commercial Variable Message (CEVMS), September 2012)* concluded that there was no substantial distraction caused by the electronic billboards and that gaze duration towards signs decreases as driving complexity increased. However, two other studies listed below provided evidence of increased number of glances per billboard and longer gazes in the presence of electronic billboards compared to static counterparts. These two studies conclude longer gazes caused driver distraction.

There is competing and contracting research over the issue of safety electronic billboards, which shows that it is reasonably debatable.

ATTACHMENT:
The studies regarding electronic billboards and driver distraction are the following:

1. *Driver Visual Behavior In The Presence Of Commercial Variable Message (CEVMS), September 2012*
2. *Effects Of Electronic Billboards On Driver Distraction, July 2012*
3. *The Impact Of Driver Inattention On Near-Crash/Crash Risk, September 2012*

DRIVER VISUAL BEHAVIOR IN THE PRESENCE OF COMMERCIAL ELECTRONIC VARIABLE MESSAGE SIGNS (CEVMS)

SEPTEMBER 2012

U.S. Department of Transportation
Federal Highway Administration

FHWA-HEP-

FOREWORD

The advent of electronic billboard technologies, in particular the digital Light-Emitting Diode (LED) billboard, has necessitated a reevaluation of current legislation and regulation for controlling outdoor advertising. In this case, one of the concerns is possible driver distraction. In the context of the present report, outdoor advertising signs employing this new advertising technology are referred to as Commercial Electronic Variable Message Signs (CEVMS). They are also commonly referred to as Digital Billboards and Electronic Billboards.

The present report documents the results of a study conducted to investigate the effects of CEVMS used for outdoor advertising on driver visual behavior in a roadway driving environment. The report consists of a brief review of the relevant published literature related to billboards and visual distraction, the rationale for the Federal Highway Administration research study, the methods by which the study was conducted, and the results of the study, which used an eye tracking system to measure driver glances while driving on roadways in the presence of CEVMS, standard billboards, and other roadside elements. The report should be of interest to highway engineers, traffic engineers, highway safety specialists, the outdoor advertising industry, environmental advocates, Federal policymakers, and State and local regulators of outdoor advertising.

Monique R. Evans
Director, Office of Safety
Research and Development

Nelson Castellanos
Director, Office of Real Estate
Services

TECHNICAL DOCUMENTATION PAGE

1. Report No. FHWA-HRT-	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Driver Visual Behavior in the Presence of Commercial Electronic Variable Message Signs (CEVMS)		5. Report Date 6. Performing Organization Code
7. Author(s) William A. Perez, Mary Anne Bertola, Jason F. Kennedy, and John A. Molino		8. Performing Organization Report No.
9. Performing Organization Name and Address SAIC 6300 Georgetown Pike McLean, VA 22101		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Real Estate Services Federal Highway Administration 1200 New Jersey Avenue SE Washington, DC 20590		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes The Contracting Officer's Technical Representatives (COTR) were Christopher Monk and Thomas Granda.		

16. Abstract

This study was conducted to investigate the effect of CEVMS on driver visual behavior in a roadway driving environment. An instrumented vehicle with an eye tracking system was used. Roads containing CEVMS, standard billboards, and control areas with no off-premise advertising were selected. Data were collected on arterials and freeways in the day and nighttime. Field studies were conducted in two cities where the same methodology was used but there were differences in the roadway visual environment. The gazes to the road ahead were high across the conditions; however, the CEVMS and billboard conditions resulted in a lower probability of gazes as compared to the control conditions (roadways not containing off-premise advertising) with the exception of arterials in Richmond where none of the conditions differed from each other. Examination of where drivers gazed in the CEVMS and standard billboard conditions showed that gazes away from the road ahead were not primarily to the billboards. Average and maximum fixations to CEVMS and standard billboards were similar across all conditions. However, four long dwell times were found (sequential and multiple fixations) that were greater than 2,000 ms. One was to a CEVMS on a freeway in the day time, two were to the same standard billboard on a freeway once in the day and once at night; and one was to a standard billboard on an arterial at night. In Richmond, the results showed that drivers gazed more at CEVMS than at standard billboards at night; however, in Reading the drivers were equally likely to gaze towards CEVMS or standard billboards in day and night. The results of the study are consistent with research and theory on the control of gaze behavior in natural environments. The demands of the driving task tend to affect the driver's self-regulation of gaze behavior.

17. Key Words Driver visual behavior, visual environment, billboards, eye tracking system, commercial electronic variable message signs, CEVMS, visual complexity		18. Distribution Statement No restrictions.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ACRONYMS AND SYMBOLS

CEVMS	Commercial Electronic Variable Message Sign
EB	Empirical Bayes
DCZ	Data Collection Zone
ROI	Region of Interest
LED	Light-Emitting Diode
IR	Infra-Red
CCD	Charge-Coupled Device
MAPPS	Multiple-Analysis of Psychophysical and Performance Signals
GEE	Generalized Estimating Equations
FHWA	Federal Highway Administration
DOT	Department of Transportation

EXECUTIVE SUMMARY

This study examines where drivers look when driving past commercial electronic variable message signs (CEVMS), standard billboards, or no off-premise advertising. The results and conclusions are presented in response to the three research questions listed below:

1. Do CEVMS attract drivers' attention away from the forward roadway and other driving-relevant stimuli?

2. Do glances to CEVMS occur that would suggest a decrease in safety?

3. Do drivers look at CEVMS more than at standard billboards?

This study follows a Federal Highway Administration (FHWA) review of the literature on the possible distracting and safety effects of off-premise advertising and CEVMS in particular. The review considered laboratory studies, driving simulator studies, field research vehicle studies, and crash studies. The published literature indicated that there was no consistent evidence showing a safety or distraction effect due to off-premise advertising. However, the review also enumerated potential limitations in the previous research that may have resulted in the finding of no distraction effects for off-premise advertising. The study team recommended that additional research be conducted using instrumented vehicle research methods with eye tracking technology.

The eyes are constantly moving and they fixate (focus on a specific object or area), perform saccades (eye movements to change the point of fixation), and engage in pursuit movements (track moving objects). It is during fixations that we take in detailed information about the environment. Eye tracking allows one to determine to what degree off-premise advertising may divert attention away from the forward roadway. A finding that areas containing CEVMS result in significantly more gazes to the billboards at a cost of not gazing toward the forward roadway would suggest a potential safety risk. In addition to measuring the degree to which CEVMS may distract from the forward roadway, an eye tracking device would allow an examination of the duration of fixations and dwell times (multiple sequential fixations) to CEVMS and standard billboards. Previous research conducted by the National Highway Traffic Safety Administration (NHTSA) led to the conclusion that taking your eyes off the road for 2 seconds or more presents a safety risk. Measuring fixations and dwell times to CEVMS and standard billboards would also allow a determination as to the degree to which these advertising signs lead to potentially unsafe gaze behavior.

Most of the literature concerning eye gaze behavior in dynamic environments suggests that task demands tend to override visual salience (an object that stands out because of its physical properties) in determining attention allocation. When extended to driving, it would be expected that visual attention will be directed toward task-relevant areas and objects (e.g., the roadway, other vehicles, speed limit signs) and that other salient objects, such as billboards, would not necessarily capture attention. However, driving is a somewhat automatic process and conditions generally do not require constant, undivided attention. As a result, salient stimuli, such as CEVMS, might capture driver attention and produce an unwanted increase in driver distraction. The present study addresses this concern.

This study used an instrumented vehicle with an eye tracking system to measure where drivers were looking when driving past CEVMS and standard billboards. The CEVMS and standard billboards were measured with respect to luminance, location, size, and other relevant variables to characterize these visual stimuli extensively. Unlike previous studies on digital billboards, the present study examined CEVMS as deployed in two United States cities. These billboards did not contain dynamic video or other dynamic elements, but changed content approximately every 8 to 10 seconds. The eye tracking system had nearly a 2-degree level of resolution that provided significantly more accuracy in determining what objects the drivers were looking at compared to an earlier naturalistic driving study. This study assessed two data collection efforts that employed the same methodology in two cities.

In each city, the study examined eye glance behavior to four CEVMS, two on arterials and two on freeways. There were an equal number of signs on the left and right side of the road for arterials and freeways. The standard billboards were selected for comparison with CEVMS such that one standard billboard environment matched as closely as possible that of each of the CEVMS. Two control locations were selected that did not contain off-premise advertising, one on an arterial and the other on a freeway. This resulted in 10 data collection zones in each city that were approximately 1,000 feet in length (the distance from the start of the data collection zone to the point that the CEVMS or standard billboard disappeared from the data collection video).

In Reading, Pennsylvania, 14 participants drove at night and 17 drove during the day. In Richmond, Virginia, 10 participants drove at night and 14 drove during the day. Calibration of the eye tracking system, practice drive, and the data collection drive took approximately 2 hours per participant to accomplish.

The following is a summary of the study results and conclusions presented in reference to the three research questions the study aimed to address.

Do CEVMS attract drivers' attention away from the forward roadway and other driving relevant stimuli?

- On average, the drivers in this study devoted between 73 and 85 percent of their visual attention to the road ahead for both CEVMS and standard billboards. This range is consistent with earlier field research studies. In the present study, the presence of CEVMS did not appear to be related to a decrease in looking toward the road ahead.

Do glances to CEVMS occur that would suggest a decrease in safety?

- The average fixation duration to CEVMS was 379 ms and to standard billboards it was 335 ms across the two cities. The average fixation durations to CEVMS and standard billboards were similar to the average fixation duration to the road ahead.

- The longest fixation to a CEVMS was 1,335 ms and to a standard billboard it was 1,284 ms. The current widely accepted threshold for durations of glances away from the road ahead that result in higher crash risk is 2,000 ms. This value comes from a NHTSA naturalistic driving study that showed a significant increase in crash odds when glances away from the road ahead were 2,000 ms or longer.

- Four dwell times (aggregate of consecutive fixations to the same object) greater than 2,000 ms were observed across the two studies. Three were to standard billboards and one was to a CEVMS. The long dwell time to the CEVMS occurred in the daytime to a billboard viewable from a freeway. Review of the video data for these four long dwell times showed that the signs were not far from the forward view while participant's gaze dwelled on them. Therefore, the drivers still had access to information about what was in front of them through peripheral vision.

- The results did not provide evidence indicating that CEVMS, as deployed and tested in the two selected cities, were associated with unacceptably long glances away from the road. When dwell times longer than the currently accepted threshold of 2,000 ms occurred, the road ahead was still in the driver's field of view. This was the case for both CEVMS and standard billboards.

Do drivers look at CEVMS more than at standard billboards?

- When comparing the probability of a gaze at a CEVMS versus a standard billboard, the drivers in this study were generally more likely to gaze at CEVMS than at standard billboards. However, some variability occurred between the two locations and between the types of roadway (arterial or freeway).

- In Reading, when considering the proportion of time spent looking at billboards, the participants looked more often at CEVMS than at standard billboards when on arterials (63 percent to CEVMS and 37 percent to a standard billboard), whereas they looked more often at standard billboards when on freeways (33 percent to CEVMS and 67 percent to a standard billboard). In Richmond, the drivers looked at CEVMS more than standard billboards no matter the type of road they were on, but as in Reading, the preference for gazing at CEVMS was greater on arterials (68 percent to CEVMS and 32 percent to standard billboards) than on freeways (55 percent to CEVMS and 45 percent to standard billboards). When a gaze was to an off-premise advertising sign, the drivers were generally more likely to gaze at a CEVMS than at a standard billboard.

- In Richmond, the drivers showed a preference for gazing at CEVMS versus standard billboards at night, but in Reading the time of day did not affect gaze behavior. In Richmond, drivers gazed at CEVMS 71 percent and at standard billboards 29 percent at night. On the other hand, in the day the drivers gazed at CEVMS 52 percent and at standard billboards 48 percent.

- In Reading, the average gaze dwell time for CEVMS was 981 ms and for standard billboards it was 1,386 ms. The difference in these average dwell times was not statistically significant. In contrast, the average dwell times to CEVMS and standard billboards were significantly different in Richmond (1,096 ms and 674 ms, respectively).

The present data suggest that the drivers in this study directed the majority of their visual attention to areas of the roadway that were relevant to the task at hand (e.g., the driving task). Furthermore, it is possible, and likely, that in the time that the drivers looked away from the forward roadway, they may have elected to glance at other objects in the surrounding environment (in the absence of billboards) that were not relevant to the driving task. When billboards were present, the drivers in this study sometimes looked at them, but not such that overall attention to the forward roadway decreased.

It also should be noted that, like other studies in the available literature, this study adds to the knowledge base on the issues examined, but does not present definitive answers to the research questions investigated.

INTRODUCTION

"The primary responsibility of the driver is to operate a motor vehicle safely. The task of driving requires full attention and focus. Drivers should resist engaging in any activity that takes their eyes and attention off of the road for more than a couple of seconds. In some circumstances even a second or two can make all the difference in a driver being able to avoid a crash." – US Department of Transportation[(1)]

The advent of electronic billboard technologies, in particular the digital Light-Emitting Diode (LED) billboard, has prompted a reevaluation of regulations for controlling outdoor advertising. An attractive quality of these LED billboards, which are hereafter referred to as Commercial Electronic Variable Message Signs (CEVMS), is that advertisements can change almost instantly. Furthermore, outdoor advertising companies can make these changes from a central remote office. Of concern is whether or not CEVMS may attract drivers' attention away from the primary task (driving) in a way that compromises safety.

The current Federal Highway Administration (FHWA) guidance recommends that CEVMS should not change content more frequently than once every 8 seconds.[(2)] However, according to Scenic America, the basis of the safety concern is that the "…distinguishing trait…" of a CEVMS "… is that it can vary while a driver watches it, in a setting in which that variation is likely to attract the drivers' attention away from the roadway."[(3)]This study was conducted to provide the FHWA with data to determine if CEVMS capture visual attention differently than standard off-premise advertising billboards.

BACKGROUND

A 2009 review of the literature by Molino et al. for the FHWA failed to find convincing empirical evidence that CEVMS, as currently implemented, constitutes a safety risk greater than that of conventional vinyl billboards.[(4)] A great deal of work has been focused in this area, but the findings of these studies have been mixed.[(4,5)] A summary of the key past findings is presented here, but the reader is referred to Molino et al. for a comprehensive review of studies prior to 2008.[(4)]

Post-Hoc Crash Studies

Post-hoc crash studies use reviews of police traffic collision reports or statistical summaries of such reports in an effort to understand the causes of crashes that have taken place in the vicinity of some change to the roadside environment. In the present case, the change of concern is the introduction of CEVMS to the roadside or the replacement of conventional billboards with CEVMS.

The literature review conducted by Molino et al. did not find compelling evidence for a distraction effect attributable to CEVMS.[(4)] The authors concluded that all post-hoc crash studies are subject to certain weaknesses, most of which are difficult to overcome. For example, the vast majority of crashes are never reported to police; thus, such studies are likely to underreport crashes. Also, when crashes are caused by factors such as driver distraction or inattention, the involved driver may be unwilling or unable to report these factors to a police investigator.

Another weakness is that police, under time pressure, are rarely able to investigate the true root causes of crashes unless they involve serious injury, death, or extensive property damage. Furthermore, to have confidence in the results, such studies need to collect comparable data before and after the change, and, in the after phase, at equivalent but unaffected roadway sections. Since crashes are infrequent events, data collection needs to span extended periods of time both before and after introduction of the change. Few studies are able to obtain such extensive data.

Two recent studies by Tantala and Tantala examined the relationship between the presence of CEVMS and crash statistics in Richmond, Virginia, and Reading, Pennsylvania.(6,7) For the Richmond area, 7 years of crash data at 10 locations with CEVMS were included in the analyses. The study used a before-after methodology where most sites originally contained vinyl billboards (before) that were converted to CEVMS (after). The quantity of crash data was not the same for all locations and ranged from 1 year before/after to 3 years before/after. The study employed the Empirical Bayes (EB) method to analyze the data.(8) The results indicated that the total number of crashes observed was consistent with what would be statistically expected with or without the introduction of CEVMS. The analysis approach for Reading locations was much the same as for Richmond other than there were 20 rather than 10 CEVMS and 8 years of crash statistics. The EB method showed results for Reading that were very similar to those of Richmond.

The studies by Tantala and Tantala appear to address many of the concerns from Molino et al. regarding the weaknesses and issues associated with crash studies.(4,6,7) For example, they include crash comparisons for locations within multiple distances of each CEVMS to address concerns about the visual range used in previous analyses. They used EB analysis techniques to correct for regression-to-mean bias. Also, the EB method would better reflect crash rate changes due to changes in average daily traffic and the interactions of these with the roadway features that were coded in the model. The studies followed approaches that are commonly used in post-hoc crash studies, though the results would have been strengthened by including before-after results for non-CEVMS locations as a control group.

Field Investigations

Field investigations include unobtrusive observation, naturalistic driving studies, on-road instrumented vehicle investigations, test track experiments, driver interviews, surveys, and questionnaires. The following focuses on relevant studies that employed naturalistic driving and on-road instrumented vehicle research methods.

Lee, McElheny, and Gibbons undertook an on-road instrumented vehicle study on Interstate and local roads near Cleveland, Ohio.(9) The study looked at driver glance behavior in the vicinity of digital billboards, conventional billboards, comparison sites (sites with buildings and other signs, including digital signs), and control sites (those without similar signage). The results showed that there were no differences in the overall glance patterns (percent eyes-on-road and overall number of glances) between the different sites. Drivers also did not glance more frequently in the direction of digital billboards than in the direction of other event types (conventional billboards, comparison events, and baseline events) but drivers did take longer glances in the direction of digital billboards and comparison sites than in the direction of conventional billboards and baseline sites. However, the mean glance length toward the digital billboards was less than

1,000 ms. It is important to note that this study employed a video-based approach for examining drivers' visual behavior, which has an accuracy of no better than 20 degrees.(10) While this technique is likely to be effective in assessing gross eye movements and looks that are away from the road ahead, it may not have sufficient resolution to discriminate what specific object the driver is looking at outside of the vehicle.

Beijer, Smiley, and Eizenman evaluated driver glances toward four different types of roadside advertising signs on roads in the Toronto, Canada, area.(11) The four types of signs were: (a) billboard signs with static advertisements; (b) billboard advertisements placed on vertical rollers that could rotate to show one of three advertisements in succession; (c) scrolling text signs with a minor active component, which usually consisted of a small strip of lights that formed words scrolling across the screen or, in some cases, a larger area capable of displaying text but not video; and (d) signs with video images that had a color screen capable of displaying both moving text and moving images. The study employed an on-road instrumented vehicle with a head-mounted eye tracking device. The researchers found no significant differences in average glance duration or the maximum glance duration for the various sign types; however, the number of glances was significantly lower for billboard signs than for the roller bar, scrolling text, and video signs.

Smiley, Smahel, and Eizenman conducted a field driving study that employed an eye tracking system that recorded drivers' eye movements as participants drove past video signs located at three downtown intersections and along an urban expressway.(12) The study route included static billboards and video advertising. The results of the study showed that on average 76 percent of glances were to the road ahead. Glances at advertising, including static billboards and video signs, constituted 1.2 percent of total glances. The mean glance durations for advertising signs were between 500 ms and 750 ms, although there were a few glances of about 1,400 ms in duration. Video signs were not more likely than static commercial signs to be looked at when headways were short; in fact, the reverse was the case. Furthermore, the number of glances per individual video sign was small, and statistically significant differences in looking behavior were not found.

Kettwich, Kartsen, Klinger, and Lemmer conducted a field study where drivers' gaze behavior was measured with an eye tracking system.(13) Sixteen participants drove an 11.5 mile (18.5 km) route comprised of highways, arterial roads, main roads, and one-way streets in Karlsruhe, Germany. The route contained advertising pillars, event posters, company logos, and video screens. Mean gaze duration for the four types of advertising was computed for periods when the vehicle was in motion and when it was stopped. Gaze duration while driving for all types of advertisements was under 1,000 ms. On the other hand, while the vehicle was stopped, the mean gaze duration for video screen advertisements was 2,750 ms. The study showed a significant difference between gaze duration while driving and while stationary: gaze duration was affected by the task at hand. That is, drivers tended to gaze longer while the car was stopped and there were few driving task demands.

The previously mentioned studies estimated the duration of glances to advertising and computed mean values of less than 1,000 ms. Klauer et al., in his analysis of the 100-Car Naturalistic Driving Study, concluded that glances away from the roadway for any purpose lasting more than 2,000 ms increase near-crash/crash risk by at least two times that of normal, baseline driving.(14)

Klauer et al. also indicated that short, brief glances away from the forward roadway for the purpose of scanning the driving environment are safe and actually decrease near-crash/crash risk.[(14)] Using devices in a vehicle that draw visual attention away from the forward roadway for more than 2,000 ms (e.g., texting) is incompatible with safe driving. However, for external stimuli, especially those near the roadway, the evaluation of eye glances with respect to safety is less clear since peripheral vision would allow the driver to still have visual access to the forward roadway.

Laboratory Studies

Laboratory investigations related to roadway safety can be classified into several categories: driving simulations, non-driving-simulator laboratory testing, and focus groups. The review of relevant laboratory studies by Molino et al. did not show conclusive evidence regarding the distracting effects of CEVMS.[(4)] Moreover, the authors concluded that present driving simulators do not have sufficient visual dynamic range, image resolution, and contrast ratio capability to produce the compelling visual effect of a bright, photo-realistic LED-based CEVMS against a natural background scene. The following is a discussion of a driving simulator study conducted after the publication of Molino et al.[(4)] The study focused on the effects of advertising on driver visual behavior.

Chattington, Reed, Basacik, Flint, and Parkes conducted a driving simulator study in the United Kingdom (UK) to evaluate the effects of static and video advertising on driver glance behavior.[(15)] The researchers examined the effects of advertisement position relative to the road (left, right, center on an overhead gantry, and in all three locations simultaneously), type of advertisement (static or video), and exposure duration of the advertisement. (The paper does not provide these durations in terms of time or distance. The exposure duration had to do with the amount of time or distance that the sign would be visible to the driver.) For the advertisements presented on the left side of the road (recall that drivers travel in the left lane in the UK), mean glance durations for static and video advertisements were significantly longer (approximately 650 to 750 ms) when drivers experienced long advertisement exposure as opposed to medium and short exposures. Drivers looked more at video advertisements (about 2 percent on average of the total duration recorded) than at static advertisements (about 0.75 percent on average). In addition, the location of the advertisements had an effect on glance behavior. When advertisements were located in the center of the road or in all three positions simultaneously, the glance durations were about 1,000 ms and were significantly longer than for signs placed on the right or left side of the road. For advertisements placed on the left side of the road, there was a significant difference in glance duration between static (about 400 ms) and video (about 800 ms). Advertisement position also had an effect on the proportion of time that a driver spent looking at an advertisement. The percentage of time looking at advertisements was greatest when signs were placed in all three locations, followed by center location signs, then the left location signs, and finally the right location signs. Drivers looked more at the video advertisements relative to the static advertisements when they were placed in all three locations, placed on the left, and placed on the right side of the road. The center placement did not show a significant difference in percent of time spent looking between static and video.

Summary

The results from these key studies offer some insight into whether CEVMS pose a visual distraction threat. However, these same studies also reveal some inconsistent findings and potential methodological issues that are addressed in the current study. The studies conducted by Smiley et al. showed drivers glanced forward at the roadway about 76 percent of the time in the presence of video and dynamic signs where a few long glances of approximately 1,400 ms were observed.[(12)] However, the video and dynamic signs used in these studies portray moving objects that are not present in CEVMS as deployed in the United States. In another field study employing eye tracking, Kettwich et al. found that gaze duration while driving for all types of advertisements that they evaluated was less than 1,000 ms; however, when the vehicle was stopped, mean gaze duration for advertising was as high as 2,750 ms.[(16)] Collectively, these studies did not demonstrate that the advertising signs detracted from drivers' glances forward at the roadway in a substantive manner while the vehicle was moving.

In contrast, the simulator study by Chattington et al. demonstrated that dynamic signs showing moving video or other dynamic elements may draw attention away from the roadway.[(15)] Furthermore, the location of the advertising sign on the road is an important factor in drawing drivers' visual attention. Advertisements with moving video placed in the center of the roadway on an overhead gantry or in all three positions (right, left, and in the center) simultaneously are very likely to draw glances from drivers.

Finally, in a study that examined CEVMS as deployed in the United States, Lee et al. did not show any significant effects of CEVMS on driver glance behavior.[(9)] However, the methodology that was used likely did not employ sufficient sensitivity to determine at what specific object in the environment a driver was looking.

None of these studies combined all necessary factors to address the current CEVMS situation in the United States. Those studies that used eye tracking on real roads had animated and video-based signs, which are not reflective of current off-premise CEVMS practice in the United States.

STUDY APPROACH

Based on an extensive review of the literature, Molino et al. concluded that the most effective method to use in an evaluation of the effects of CEVMS on driver visual behavior was the instrumented field vehicle method that incorporated an eye tracking system.[(4)] The present study employed such an instrumented field vehicle with an eye tracking system and examined the degree to which CEVMS attract drivers' attention away from the forward roadway.

The following presents a brief overview and discussion of studies using eye tracking methodology with complex visual stimuli, especially in natural environments (walking, driving, etc.). The review by Molino et al. recommended the use of this type of technology and method; however, a discussion laying out technical and theoretical issues underlying the use of eye tracking methods was not presented.[(4)] This background is important for the interpretation of the results of the studies conducted here.

Standard and digital billboards are often salient stimuli in the driving environment, which may make them conspicuous. Cole and Hughes define attention conspicuity as the extent to which a stimulus is sufficiently prominent in the driving environment to capture attention. Further, Cole and Hughes state that attention conspicuity is a function of size, color, brightness, contrast relative to surroundings, and dynamic components such as movement and change.(17) It is clear that under certain circumstances image salience or conspicuity can provide a good explanation of how humans orient their attention.

At any given moment a large number of stimuli reach our senses, but only a limited number of them are selected for further processing. In general, attention can be focused on a stimulus because it is important for achieving some goal, or because the properties of the stimulus can attract the attention of the observer independent of their intentions (e.g., a car horn may elicit an orienting response). When the focus of attention is goal directed, it is referred to as top-down. When the focus of attention is principally a function of stimulus attributes, it is referred to as bottom-up.(18)

In general, billboards (either standard or CEVMS) are not relevant to the driving task but are presumably designed to be salient stimuli in the environment where they may draw a driver's attention. The question is to what degree CEVMS draw a driver's attention away from driving-relevant stimuli (e.g., road ahead, mirrors, and speedometer) and is this different from a standard billboard? In his review of the literature Wachtel leads one to consider CEVMS as stimuli in the environment where attention to them would be drawn in a bottom-up manner; that is, the salience of the billboards would make them stand out relative to other stimuli in the environment and drivers would reflexively look at these signs.(19) Wachtel's conclusions were in reference to research by Theeuwees who employed simple letter stimulus arrays in a laboratory task.(20) Research using simple visual stimuli in a laboratory environment are very useful for testing different theories of perception, but often lack direct application to tasks such as driving. The following discusses research using complex visual stimuli and tasks that are more relevant to natural vision as experienced in the driving task.

A recent review of stimulus salience and eye guidance by Tatler et al. shows that most of the evidence for the capture of attention by the conspicuity of stimuli comes from research in which the stimulus is a simple visual search array or in which the target is uniquely defined by simple visual features.(21) In other words, these are laboratory studies that use letters, arrays of letters, or simple geometric patterns as the stimuli. Pure salience-based models are capable of predicting eye movement endpoint in simple displays, but are less successful for more complex scenes that contain task-relevant and task-irrelevant salient areas.(22,23)

Research by Henderson et al. using photographs of actual scenes showed that subjects looked at non-salient scene regions containing a search target and rarely looked at salient non-task-relevant regions of the scenes.(24) Salience of the stimulus alone was not a good predictor of where participants looked. Additional research by Henderson using photographs of real world scenes also showed that subjects fixated on regions of the pictures that provided task-relevant information rather than visually salient regions with no task-relevant information. However, Henderson acknowledges that static pictures have many shortcomings when used as surrogates for real environments.(25)

Land's review of eye movements in dynamic environments concluded that the eyes are proactive and typically seek out information required in the second before each new activity commences.[26] Specific tasks (e.g., driving) have characteristic but flexible patterns of eye movement that accompany them, and these patterns are similar between individuals. Land concluded that the eyes rarely visit objects that are irrelevant to the task, and the conspicuity of objects is less important than the objects' roles in the task. In a subsequent review of eye movement and natural behavior, Land concluded that in a task that requires fixation on a sequence of specific objects, the capture of gaze by irrelevant salient objects would, in general, be an obtrusive nuisance.[22]

The literature examining gaze control under natural behavior suggests that it is principally top-down driven, or intentional.[24,25,26,22,21,27] However, top-down processing does not explain all gaze control or eye movements. For example, imagine driving down a two-lane country road and a deer jumps into the road. It is most likely that you will attend and react to this deer. Unplanned or unexpected stimuli capture our attention as we engage in complex natural tasks. Research by Jovancevic-Misic and Hayhoe showed that human gaze patterns are sensitive to the probabilistic nature of the environment.[28] In this study, participants' eye movement behavior was observed while walking among other pedestrians. The other pedestrians were confederates and were either safe, risky, or rogue pedestrians. When the study began, the risky pedestrian took a collision course with the participant 50 percent of the time, and the rogue pedestrian always assumed a collision course as he approached the participant, whereas the safe pedestrian never took a collision course. Midway through the study the rogue and safe pedestrians exchanged roles but the risky pedestrian role remained the same. The participants were not informed about the behavior of the other pedestrians. Participants were asked to follow a circular path for several laps and to avoid other pedestrians. The study showed that the participants modified their gaze behavior in response to the change in the other pedestrians' behavior. Jovancevic-Misic concluded that participants learned new priorities for gaze allocation within a few encounters and looked both sooner and longer at potentially dangerous pedestrians.[28]

Gaze behavior in natural environments is affected by expectations that are derived through long-term learning. Using a virtual driving environment, Shinoda et al. asked participants to look for stop signs while driving an urban route.[29] Approximately 45 percent of the fixations fell in the general area of intersections during the simulated drive, and participants were more likely to detect stop signs placed near intersections than those placed in the middle of a block. Over time, drivers have learned that stop signs are more likely to appear near intersections and, as a result, drivers prioritize their allocation of gazes to these areas of the roadway.

The Tatler et al. review of the literature concludes that in natural vision, a consistent set of principles underlies eye guidance. These principles include relevance or reward potential, uncertainty about the state of the environment, and learned models of the environment.[21] Salience of environmental stimuli alone typically does not explain most eye gaze behavior in naturalistic environments.

In sum, most of the literature concerning eye gaze behavior in dynamic environments suggests that task demands tend to override visual salience in determining attention allocation. When extended to driving, it would be expected that visual attention will be directed toward task-relevant areas and objects (e.g., the roadway, other vehicles, speed limit signs, etc.) and other salient objects, such as billboards, will not necessarily capture attention. However, driving is a somewhat automatic process and conditions generally do not require constant undivided attention. As a result, salient stimuli, such as CEVMS, might capture driver attention and provide an unwarranted increase in driver distraction. The present study addresses this concern.

Research Questions

The present research evaluated the effects of CEVMS on driver visual behavior under actual roadway conditions in the daytime and at night. Roads containing CEVMS, standard billboards, and areas not containing off-premise advertising were selected. The CEVMS and standard billboards were measured with respect to luminance, location, size, and other relevant visual characteristics. The present study examined CEVMS as deployed in two United States cities. Unlike previous studies, the signs did not contain dynamic video or other dynamic elements. In addition, the eye tracking system used in this study has approximately a 2-degree level of resolution. This provided significantly more accuracy in determining what objects the drivers were looking at than in previous on-road studies examining looking behavior (recall that Lee et al. used video recordings of drivers' faces that, at best, examined gross eye movements).[9]

Two studies are reported. Each study was conducted in a different city. The two studies employed the same methodology. The studies' primary research questions were:

1. Do CEVMS attract drivers' attention away from the forward roadway and other driving relevant stimuli?

2. Do glances to CEVMS occur that would suggest a decrease in safety?

3. Do drivers look at CEVMS more than at standard billboards?

EXPERIMENTAL APPROACH

The study used a field research vehicle equipped with a non-intrusive eye tracking system. The vehicle was a 2007 Jeep® Grand Cherokee Sport Utility Vehicle. The eye tracking system used (SmartEye® vehicle-mounted infrared (IR) eye-movement measuring system) is shown in figure 1.[(30)] The system consists of two IR light sources and three face cameras mounted on the dashboard of the vehicle. The cameras and light sources are small in size, and are not attached to the driver in any manner. The face cameras are synchronized to the IR light sources and are used to determine the head position and gaze direction of the driver.

Figure 1. Eye tracking system camera placement.

As a part of this eye tracking system, the vehicle was outfitted with a three-camera panoramic scene monitoring system for capturing the forward driving scene. The scene cameras were mounted on the roof of the vehicle directly above the driver's head position. The three cameras together provided an 80-degree wide by 40-degree high field of forward view. The scene cameras captured the forward view area available to the driver through the left side of the windshield and a portion of the right side of the windshield. The area visible to the driver through the rightmost area of the windshield was not captured by the scene cameras.

The vehicle was also outfitted with equipment to record GPS position, vehicle speed, and vehicle acceleration. The equipment also recorded events entered by an experimenter and synchronized those events with the eye tracking and vehicle data. The research vehicle is pictured in figure 2.

Figure 2. FHWA's field research vehicle.

EXPERIMENTAL DESIGN OVERVIEW

The approach entailed the use of the instrumented vehicle in which drivers navigated routes in cities that presented CEVMS and standard billboards as well as areas without off-premise advertising. The participants were instructed to drive the routes as they normally would. The drivers were not informed that the study was about outdoor advertising, but rather that it was about examining drivers' glance behavior as they followed route guidance directions.

Site Selection

More than 40 cities were evaluated in the selection of the test sites. Locations with CEVMS displays were identified using a variety of resources that included State department of transportation contacts, advertising company Web sites, and a popular geographic information system. A matrix was developed that listed the number of CEVMS in each city. For each site, the number of CEVMS along limited access and arterial roadways was determined.

One criterion for site selection was whether the location had practical routes that pass by a number of CEVMS as well as standard off-premise billboards and could be driven in about 30 minutes. Other considerations included access to vehicle maintenance personnel/facilities, proximity to research facilities, and ease of participant recruitment. Two cities were selected: Reading, and Richmond.

Table 1 presents the 16 cities that were included on the final list of potential study sites.

Table 1. Distribution of CEVMS by roadway classification for various cities.

State	*Area*	*Limited Access*	*Arterial*	*Other (1)*	*Total*
VA	Richmond	4	7	0	11
PA	Reading	7	11	0	18
VA	Roanoke	0	11	0	11
PA	Pittsburgh	0	0	15	15
TX	San Antonio	7	2	6	15
WI	Milwaukee	14	2	0	16
AZ	Phoenix	10	6	0	16
MN	St. Paul/Minneapolis	8	5	3	16
TN	Nashville	7	10	0	17
FL	Tampa-St. Petersburg	7	11	0	18
NM	Albuquerque	0	19	1	20
PA	Scranton-Wilkes Barre	7	14	1	22
OH	Columbus	1	22	0	23
GA	Atlanta	13	11	0	24
IL	Chicago	22	2	1	25
CA	Los Angeles	3	71	4	78

(1) Other includes roadways classified as both limited access and arterial or instances where the road classification was unknown. *Source:* www.lamar.com and www.clearchannel.com

In both test cities, the following independent variables were evaluated:

- **The type of advertising.** This included CEVMS, standard billboards, and no off-premise advertising. (It should be noted that in areas with no off-premise advertising, it was still possible to encounter on-premise advertising; e.g., for gas stations, restaurants, and other miscellaneous stores and shops.)

- **Time of day.** This included driving in the daytime and at night.

- **The functional class of roadways in which off-premise advertising signs were located.** Roads were classified as either freeway or arterial. It was observed that the different road classes were correlated with the presence of other visual information that could affect the driver's glance behavior. For example, the visual environment on arterials may be more complex or cluttered than on freeways because of the close proximity of buildings, driveways, and on-premise advertising, etc.

READING

The first on-road study was conducted in Reading. This study examined the type of advertising (CEVMS, standard billboard, or no off-premise advertising), time of day (day or night) and road type (freeway or arterial) as independent variables. Eye tracking was used to assess where participants gazed and for how long while driving. The luminance and contrast of the advertising signs were measured to characterize the billboards in the current study.

METHOD

Selection of Data Collection Zone Limits

Data collection zones (DCZ) were defined on the routes that participants drove where detailed analyses of the eye tracking data were planned. The DCZ were identified that contained a CEVMS, a standard billboard, or no off-premise advertising.

The rationale for selecting the DCZ limits took into account the geometry of the roadway (e.g., road curvature or obstructions that blocked view of billboards) and the capabilities of the eye tracking system (2 degrees of resolution). At a distance of 960 ft (292.61 m), the average billboard in Reading was 12.8 ft (3.90 m) by 36.9 ft (11.25 m) and would subtend a horizontal visual angle of 2.20 degrees and a vertical visual angle of 0.76 degrees, and thus glances to the billboard would just be resolvable by an eye tracking system with 2 degrees of accuracy. Therefore 960 ft was chosen as the maximum distance from billboards at which a DCZ would begin. If the target billboard was not visible from 960 ft (292.61 m) due to roadway geometry or other visual obstructions, such as trees or an overpass, the DCZ was shortened to a distance that prevented these objects from interfering with the driver’s vision of the billboard. In DCZs with target off-premise billboards, the end of the DCZ was marked when the target billboard left the view of the scene camera. If the area contained no off-premise advertising, the end of the DCZ was defined by a physical landmark leaving the view of the eye tracking systems’ scene camera.

Table 2 shows the data collection zone limits used in this study.

Advertising Conditions

The type of advertising present in DCZs was examined as an independent variable. DCZs fell into one of the following categories, which are listed in the second column of table 2:

- **CEVMS**. These were DCZs that contained one target CEVMS. Two CEVMS DCZs were located on freeways and two were located on arterials. Figure 3 and figure 4 show examples of CEVMS DCZs with the CEVMS highlighted in the pictures.

- **Standard billboard**. These were DCZs that contained one target standard billboard. Two standard billboard DCZs were located on freeways and two were located on arterials. Figure 5 and figure 6 show examples of standard billboard DCZs; the standard billboards are highlighted in the pictures.

- **No off-premise advertising conditions**. These DCZs contained no off-premise advertising. One of these DCZs was on a freeway (see figure 7) and the other was on an arterial (see figure 8).

Table 2. Inventory of target billboards with relevant parameters.

DCZ	*Advertising Type*	*Copy Dimensions (ft)*	*Side of Road*	*Setback from Road (ft)*	*Other Standard Billboards*	*Approach Length (ft)*	*Type of Roadway*
1	CONTROL	N/A	N/A	N/A	N/A	786	Freeway
6	CONTROL	N/A	N/A	N/A	N/A	308	Arterial
3	CEVMS	10'6" x 22'9"	L	12	0	375	Arterial
5	CEVMS	14'0" x 48'0"	L	133	1	853	Freeway
9	CEVMS	10'6" x 22'9"	R	43	0	537	Arterial
10	CEVMS	14'0" x 48'0"	R	133	1	991	Freeway
2	Standard	14'0" x 48'0"	L	20	0	644	Arterial
7	Standard	14'0" x 48'0"	R	35	1	774	Freeway
8	Standard	10'6" x 22'9"	R	40	1	833	Arterial
4	Standard	14'0" x 48'0"	L	10	0	770	Freeway

**N/A indicates that there were no off-premise advertising in these areas and these values are undefined.*

Figure 3. DCZ with a target CEVMS on a freeway.

Figure 4. DCZ with a target CEVMS on an arterial.

Figure 5. DCZ with a target standard billboard on a freeway.

Figure 6. DCZ with a target standard billboard on an arterial.

Figure 7. DCZ for the control condition on a freeway.

Figure 8. DCZ for the control condition on an arterial.

Photometric Measurement of Signs

Two primary metrics were used to describe the photometric characteristics of a sample of the CEVMS and standard billboards present at each location: luminance (cd/m^2) and contrast (Weber contrast ratio).

Photometric Equipment

Luminance was measured with a Radiant Imaging ProMetric 1600 Charge-Coupled Device (CCD) photometer with both a 50 mm and a 300 mm lenses. The CCD photometer provided a method of capturing the luminance of an entire scene at one time.

The photometric sensors were mounted in a vehicle of similar size to the eye tracking research vehicle. The photometer was located in the experimental vehicle as close to the driver's position as possible and was connected to a laptop computer that stored data as the images were acquired.

Measurement Methodology

Images of the billboards were acquired using the photometer manufacturer's software. The software provided the mean luminance of each billboard message. To prevent overexposure of images in daylight, neutral density filters were manually affixed to the photometer lens and the luminance values were scaled appropriately. Standard billboards were typically measured only once; however, for CEVMS multiple measures were taken to account for changing content.

Photometric measurements were taken during day and night. Measurements were taken by centering the billboard in the photometer's field of view with approximately the equivalent of the width of the billboard on each side and the equivalent of the billboard height above and below the sign. The areas outside of the billboards were included to enable contrast calculations.

Standard billboards were assessed at a mean distance of 284 ft (ranging from 570 ft to 43 ft). The CEVMS were assessed at a mean distance of 479 ft (ranging from 972 ft to 220 ft). To include the background regions of appropriate size, the close measurement distances required the use of the 50 mm lens whereas measurements made from longer distances required the 300 mm lens. A significant determinant of the measurement locations was the availability of accessible and safe places from which to measure.

The Weber contrast ratio was used because it characterizes a billboard as having negative or positive contrast when compared to its background area.(31) A negative contrast indicates the background areas have a higher mean luminance than the target billboard. A positive contrast indicates the target billboard has a higher mean luminance than the background. Overall, the absolute value of a contrast ratio simply indicates a difference in luminance between an item and its background. From a perceptual perspective luminance and contrast are directly related to the perception of brightness. For example, two signs with equal luminance may be perceived differently with respect to brightness because of differences in contrast.

Visual Complexity

Regan, Young, Lee and Gordon presented a taxonomic description of the various sources of driver distraction.(32) Potential sources of distraction were discussed in terms of: things brought into the vehicle; vehicle systems; vehicle occupants; moving objects or animals in the vehicle; internalized activity; and external objects, events, or activities. The external objects may include buildings, construction zones, billboards, road signs, vehicles, and so on. Focusing on the potential for information outside the vehicle to attract (or distract) the driver's attention, Horberry and Edquist developed a taxonomy for out-of-the-vehicle visual information. This suggested taxonomy includes four groupings of visual information: built roadway, situational entities, natural environment, and built environment.(33) These two taxonomies provide an organizational structure for conducting research; however, they do not currently provide a systematic or quantitative way of classifying the level of clutter or visual complexity present in a visual scene.

The method proposed by Rozenholtz, Li, and Nakano provides quantitative and perhaps reliable measures of visual clutter.(34) Their approach measures the feature congestion in a visual image. The implementation of the feature congestion measure involves four stages: (1) compute local feature covariance at multiple scales and compute the volume of the local covariance ellipsoid, (2) combine clutter across scale, (3) combine clutter across feature types, and (4) pool over space to get a single measure of clutter for each input image. The implementation that was used employed color, orientation and luminance contrast as features. Presumably, less cluttered images can be visually coded more efficiently than cluttered images. For example, visual clutter can cause decreased recognition performance and greater difficulty in performing visual search.[35]

Participants

In the present study participants were recruited at public libraries in the Reading area. A table was set up so that recruiters could discuss the requirements of the experiment with candidates. Individuals who expressed interest in participating were asked to complete a pre-screening form, a record of informed consent, and a department of motor vehicles form consenting to release of their driving record.

All participants were between 18 and 64 years of age and held a valid driver's license. The driving record for each volunteer was evaluated to eliminate drivers with excessive violations. The criteria for excluding drivers were as follows: (a) more than one violation in the preceding year; (b) more than three recorded violations; and (c) any driving while intoxicated violation.

Forty-three individuals were recruited to participate. Of these, five did not complete the drive because the eye tracker could not be calibrated to track their eye movements accurately. Data from an additional seven participants were excluded as the result of equipment failures (e.g., loose camera). In the end, usable data was collected from 31 participants (12 males, M = 46 years; 19 females, M = 47 years). Fourteen participants drove at night and 17 drove during the day.

Procedures

Data were collected from two participants per day (beginning at approximately 12:45 p.m. and 7:00 p.m.). Data collection began on September 18, 2009, and was completed on October 26, 2009.

Pre-Data Collection Activities

Participants were greeted by two researchers and asked to complete a fitness to drive questionnaire. This questionnaire focused on drivers' self-reports of alertness and use of substances that might impair driving (e.g., alcohol). All volunteers appeared fit.

Next, the participant and both researchers moved to the eye tracking calibration location and the test vehicle. The calibration procedure took approximately 20 minutes. Calibration of the eye tracking system entailed development of a profile for each participant. This was accomplished by taking multiple photographs of the participant's face as they slowly rotate their head from side to side. The saved photographs include points on the face for subsequent real-time head and eye tracking. Marked coordinates on the face photographs were edited by the experimenter as needed to improve the real-time face tracking. The procedure also included gaze calibration in which participants gazed at nine points on a wall. These points had been carefully plotted on the wall and correspond to the points in the eye tracking system's world model. Gaze calibration relates the individual participant's gaze vectors to known points in the real world. The eye tracking system uses two pulsating infrared sources mounted on the dashboard to create two corneal glints that are used to calculate gaze direction vectors. The glints were captured at 60 Hz. A second set of cameras (scene cameras), fixed on top of the car close to the driver's viewpoint, were used to produce a video scene of the area ahead. The scene cameras recorded at 25 Hz. A parallax correction algorithm compensated for the distance between the driver's viewpoint and the scene cameras so that later processing could use the gaze vectors to show where in the forward scene the driver was gazing.

If it was not possible to calibrate the eye tracking system to a participant, the participant was dismissed and paid for their time. Causes of calibration failure included reflections from eye glasses, participant height (which put their eyes outside the range of the system), and eyelids that obscure a portion of the pupil.

Practice

After eye-tracker calibration, a short practice drive was made. Participants were shown a map of the route and written turn-by-turn directions prior to beginning the practice drive. Throughout the drive, verbal directions were provided by a GPS device.

During the practice drive, a researcher in the rear seat of the vehicle monitored the accuracy of eye tracking. If the system was tracking poorly, additional calibration was performed. If the calibration could not be improved, the participant was paid for their time and dismissed.

Data Collection

Participants drove two test routes (referred to as route A and B). Each route required 25 to 30 minutes to complete and included both freeway and arterial segments. Route A was 13 miles long and contained 6 DCZs. Route B was 16 miles long and contained 4 DCZs. Combined, participants drove in a total of 10 DCZs. Similar to the practice drive, participants were shown a map of the route and written turn-by-turn directions. A GPS device provided turn-by-turn guidance during the drive. Roughly one half of the participants drove route A first and the remaining participants began with route B. A 5 minute break followed the completion of the first route.

During the drives, a researcher in the front passenger seat assisted the driver when additional route guidance was required. The researcher was also tasked with recording near misses and driver errors if these occurred. The researcher in the rear seat monitored the performance of the eye tracker. If the eye tracker performance became unacceptable (i.e., loss of calibration), then the researcher in the rear asked the participant to park in a safe location so that the eye tracker could be recalibrated. This recalibration typically took a minute or two to accomplish.

Debriefing

After driving both routes, the participants provided comments regarding their drives. The comments were in reference to the use of a navigation system. No questions were asked about billboards. The participants were given $120.00 in cash for their participation.

DATA REDUCTION

Eye Tracking Measures

The Multiple-Analysis of Psychophysical and Performance Signals (MAPPS™) software was used to reduce the eye tracking data.[36] The software integrates the video output from the scene cameras with the output from the eye tracking software (e.g., gaze vectors). The analysis software provides an interface in which the gaze vectors determined by the eye tracker can be related to areas or objects in the scene camera view of the world. Analysts can indicate regions of interest (ROIs) in the scene camera views and the analysis software then assigns gaze vectors to the ROIs.

Figure 9 shows a screen capture from the analysis software in which static ROIs have been identified. These static ROIs slice up the scene camera views into six areas. The software also allows for the construction of dynamic ROIs. These are ROIs that move in the video because of own-vehicle movement (e.g., a sign changes position on the display as it is approached by the driver) or because the object moves over time independent of own-vehicle movement (e.g., pedestrian walking along the road, vehicle entering or exiting the road).

Static ROIs need only be entered once for the scenario being analyzed whereas dynamic ROIs need to be entered several times for a given DCZ depending on how the object moves along the video scene; however, not every frame needs to be coded with a dynamic ROI since the software interpolates across frames using the 60-Hz data to compute eye movement statistics.

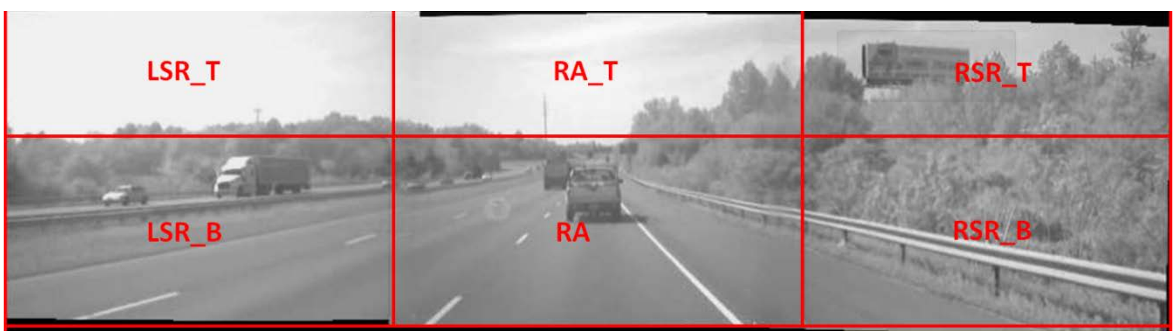


Figure 9. Screen capture showing static ROIs on a scene video output.

The following ROIs were defined with the analysis software:

Static ROIs

These ROIs were entered once into the software for each participant. The static ROIs for the windshield were divided into top and bottom to have more resolution during the coding process. The subsequent analyses in the report combines the top and bottom portion of these ROIs since it appeared that this additional level of resolution was not needed in order to address research questions:

- Road ahead: bottom portion (approximately 2/3) of the area of the forward roadway (center camera).

- Road ahead top: top portion (approximately 1/3) of the area of the forward roadway (center camera).

- Right side of road bottom: bottom portion (approximately 2/3) of the area to the right of the forward roadway (right camera).

- Right side of road top: top portion (approximately 1/3) of the area to the right of the forward roadway (right camera).

- Left side of road bottom (LSR_B): bottom portion (approximately 2/3) of the area to the left of the forward roadway (left camera).

- Left side of road bottom (LSR_T): top portion (approximately 1/3) of the area to the left of the forward roadway (left camera).

- Inside vehicle: below the panoramic video scene (outside of the view of the cameras, but eye tracking is still possible).

- Top: above the panoramic video scene (outside of the view of the cameras, but eye tracking is still possible).

Dynamic ROIs

These ROIs are created multiple times within a DCZ for stimuli that move relative to the driver:

- Driving-related safety risk: vehicle which posed a potential safety risk to the driver, defined as a car that is/may turn into the driver's direction of travel at a non-signalized or non-stop-controlled intersection (e.g., a car making a U-turn, a car waiting to turn right, or a car waiting to turn left). These vehicles were actively turning or entering the roadway or appeared to be in a position to enter the roadway.

- Target standard billboard: target standard billboard that defines the start and end of the DCZ.

- Other standard billboard: standard billboard(s) located in the DCZ, other than the target standard billboard or the target digital billboard.

- CEVMS: target digital billboard that defines the start and end of the DCZ.

The software determines the gaze intersection for each 60 Hz frame and assigns it to an ROI. In subsequent analyses and discussion, gaze intersections are referred to as gazes. Since ROIs may overlap, the software allows for the specification of priority for each ROI such that the ROI with the highest priority gets the gaze vector intersection assigned to it. For example, an ROI for a CEVMS may also be in the static ROI for the road ahead.

The 60 Hz temporal resolution of the eye tracking software does not provide sufficient information to make detailed analysis of saccade characteristics,[1] such as latency or speed. The analysis software uses three parameters in the determination of a fixation: a fixation radius, fixation duration, and a time out. The determination begins with a single-gaze vector intersection. Any subsequent intersection within a specified radius will be considered part of a fixation if the minimum fixation duration criterion is met. The radius parameter used in this study was 2 degrees and the minimum duration was 100 ms. The 2-degree selection was based on the estimated accuracy of the eye tracking system, as recommended by Recarte and Nunes.(37) The 100 ms minimum duration is consistent with many other published studies; however, some investigators use minimums of as little as 60 ms.(37,38) Because of mini-saccades and noise in the eye tracking system, it is possible to have brief excursions outside the 2 degree window for a fixation. In this study, an excursion time outside the 2-degree radius of less than 90 ms was ignored. Once the gaze intersection fell outside the 2-degree radius of a fixation for more than 90 ms, the process of identifying a fixation began anew.

Other Measures

Driving Behavior Measures

During data collection, the front-seat researcher observed the driver's behavior and the driving environment. The researcher used the following subjective categories in observing the participant's driving behavior:

- **Driver Error:** signified any error on behalf of the driver in which the researcher felt slightly uncomfortable, but not to a significant degree (e.g., driving on an exit ramp too quickly, turning too quickly).

- **Near Miss:** signified any event in which the researcher felt uncomfortable due to driver response to external sources (e.g., slamming on brakes, swerving). A near miss is the extreme case of a driver error.

- **Incident:** signified any event in the roadway which may have had a potential impact on the attention of the driver and/or the flow of traffic (e.g., crash, emergency vehicle, animal, construction, train).

These observations were entered into a notebook computer linked to the research vehicle data collection system.

Level of Service Estimates

For each participant and each DCZ the analyst estimated the level of service of the road as they reviewed the scene camera video. One location per DCZ was selected (approximately halfway through the DCZ) where the number of vehicles in front of the research vehicle was counted. The procedure entailed (1) counting the number of travel lanes visible in the video, (2) using the

[1] During visual scanning, the point of gaze alternates between brief pauses (ocular fixations) and rapid shifts (saccades).

skip lines on the road to estimate the approximate distance in front of the vehicle that constituted the analysis zone, and (3) counting the number of vehicles present within the analysis zone. Vehicle density was calculated with the formula:

> Vehicle Density = [(Number of Vehicles in Analysis Zone)/(Distance of Analysis Zone in ft/5280)]/Number of Lanes.

Vehicle density is the number of vehicles per mile per lane.

Vehicle Speed

The speed of the research vehicle was recorded with GPS and a distance measurement instrument. Vehicle speed was used principally to ensure that the eye tracking data was recorded while the vehicle was in motion.

RESULTS

Results are presented with respect to the photometric measures of signs, the visual complexity of the DCZs, and the eye tracking measures. Photometric measurements were taken and analyzed to characterize the billboards in the study based on their luminance and contrasts, which are related to how bright the signs are perceived to be by drivers.

Photometric Measurements

Luminance

The mean daytime luminance of both the standard billboards and CEVMS was greater than at night. Nighttime luminance measurements reflect the fact that CEVMS use illuminating LED components while standard billboards are often illuminated from below by metal halide lamps. At night, CEVMS have a greater average luminance than standard billboards. Table 3 presents summary statistics for luminance as a function of time of day for the CEVMS and standard billboards.

Contrast

The daytime and nighttime Weber contrast ratios for both types of billboards are shown in table 3. Both CEVMS and standard billboards had contrast ratios that were close to zero (the surroundings were about equal in brightness to the signs) during the daytime. On the other hand, at night the CEVMS and standard billboards had positive contrast ratios (the signs were brighter than the surrounding), with the CEVMS having higher contrast than the standard billboards.

Table 3. Summary of luminance (cd/m²) and contrast (Weber ratio) measurements.

	Luminance (cd/m²)		*Contrast*	
Day	*Mean*	*St. Dev.*	*Mean*	*St .Dev.*
CEVMS	2126	798.81	-0.10	0.54
Standard Billboard	2993	2787.22	-0.27	0.84
Night				
CEVMS	56.00	23.16	73.72	56.92
Standard Billboard	17.80	17.11	36.01	30.93

Visual Complexity

The DCZs were characterized by their overall visual complexity or clutter. For each DCZ, five pictures were taken from the driver's viewpoint at various locations within the DCZ. In Reading, the pictures were taken from 2:00 p.m. to 4:00 p.m. In Richmond, one route was photographed from 11:00 a.m. to noon and the other from 2:30 p.m. to 3:30 p.m. The pictures were taken at the start of the DCZ, quarter of the way through, half of the way through, three quarters of the way through, and at the end of the DCZ. The photographs were analyzed with MATLAB® routines that computed a measure of feature congestion for each image. Figure 10 shows the mean feature congestion measures for each of the DCZ environments. The arterial control condition was shown to have the highest level of clutter as measured by feature congestion. An analysis of variance was performed on the feature congestion measure to determine if the conditions differed significantly from each other. The four conditions with off-premise advertising did not differ significantly with respect to feature congestion; $F(3,36) = 1.25$, $p > 0.05$. Based on the feature congestion measure, the results indicate that the four conditions with off-premise advertising were equated with respect to the overall visual complexity of the driving scenes.

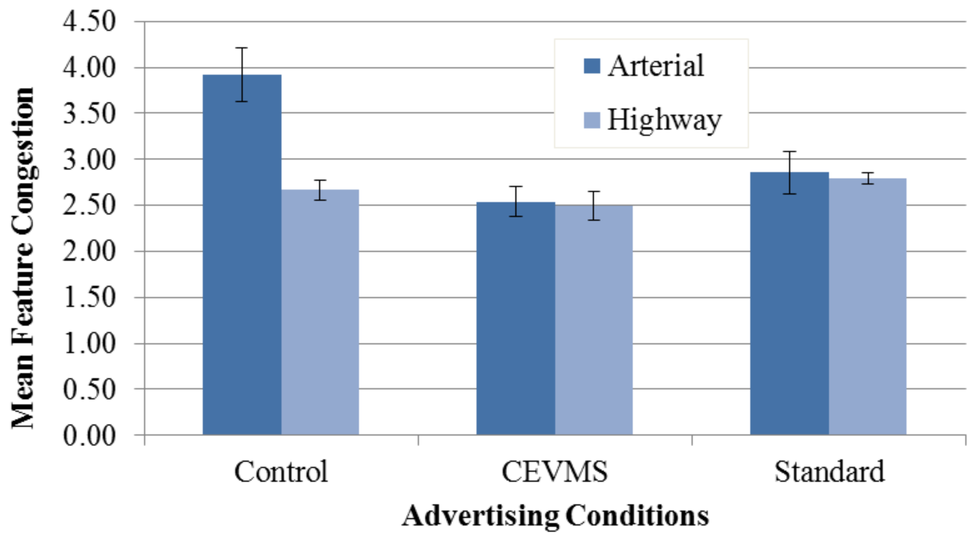


Figure 10. Mean feature congestion as a function of advertising condition and road type (standard errors for the mean are included in the graph).

Effects of Billboards on Gazes to the Road Ahead

For each 60 Hz frame, a determination was made as to the direction of the gaze vector. Previous research has shown that gazes do not need to be separated into saccades and fixations before calculating such measures as percent of time or the probability of looking to the road ahead.[39] This analysis examines the degree to which drivers gaze toward the road ahead across the different advertising conditions as a function of road type and time of day. Gazing toward the road ahead is critical for driving, and so the analysis examines the degree to which gazes toward this area are affected by the independent variables (advertising type, type of road, and time of day) and their interactions.

Generalized estimating equations (GEE) were used to analyze the probability of a participant gazing at driving-related information.[40,41] The data for these analyses were not normally distributed and included repeated measures. The GEE model is appropriate for these types of data and analyses. Note that for all results included in this report, Wald statistics were the chosen alternative to likelihood ratio statistics because GEE uses quasi-likelihood instead of maximum likelihood.[42] For this analysis, road ahead included the following ROIs (as previously described and displayed in figure 9): road ahead, road ahead top, and driving-related risks. A logistic regression model for repeated measures was generated by using a binomial response distribution and Logit (i.e., log odds) link function. Only two possible outcomes are allowed when selecting a binomial response distribution. Thus, a variable (RoadAhead) was created to classify a participant's gaze behavior. If the participant gazed toward the road ahead, road ahead top, or driving-related risks, then the value of RoadAhead was set to one. If the participant gazed at any other object in the panoramic scene, then the value of RoadAhead was set to zero. Logistic regression typically models the probability of a success. In the current analysis, a success would be a gaze to road ahead information (RoadAhead = 1) and a failure would be a gaze toward non-road ahead information (RoadAhead = 0). The resultant value was the probability of a participant gazing at road-ahead information.

Time of day (day or night), road type (freeway or arterial), advertising condition (CEVMS, standard billboard, or control), and all corresponding second-order interactions were explanatory variables in the logistic regression model. The interaction of advertising condition by road type was statistically significant, $\chi^2(2) = 6.3$, $p = 0.043$. Table 4 shows the corresponding probabilities for gazing at the road ahead as a function of advertising condition and road type.

Table 4. The probability of gazing at the road ahead as a function of advertising condition and road type.

Advertising Condition	*Arterial*	*Freeway*
Control	0.92	0.86
CEVMS	0.82	0.73
Standard	0.80	0.77

Follow-up analyses for the interaction used Tukey-Kramer adjustments with an alpha level of 0.05. The arterial control condition had the greatest probability of looking at the road ahead (M = 0.92). This probability differed significantly from the remaining five probabilities. On arterials, the probability of gazing at the road ahead did not differ between the CEVMS (M = 0.82) and the standard billboard (M = 0.80) DCZs. In contrast, there was a significant difference in this probability on freeways, where standard billboard DCZs yielded a higher probability (M = 0.77) than CEVMS DCZs (M = 0.73). The probability of gazing at the road ahead was also significantly higher in the freeway control DCZ (M = 0.86) than in either of the corresponding freeway off-premise advertising DCZs. The probability of gazing at road-ahead information in arterial CEVMS DCZs was not statistically different from the same probability in the freeway control DCZ.

Additional descriptive statistics were computed to determine the probability of gazing at the various ROIs that were defined in the panoramic scene. Some of the ROIs depicted in figure 9 were combined in the following fashion for ease of analysis:

- Road ahead, road ahead top, and driving-related risks combined to form *road ahead*.
- Left side of road bottom and left side of road top combined to form *left side of vehicle*.
- Right side of road bottom and right side of road top combined to form *right side of vehicle*.
- Inside vehicle and top combined to form *participant vehicle*.

Table 5 presents the probability of gazing at the different ROIs.

Table 5. Probability of gazing at ROIs for the three advertising conditions on arterials and freeways.

Road Type	*ROI*	*CEVMS*	*Standard Billboard*	*Control*
Arterial	*CEVMS*	0.07	N/A	N/A
	Left Side of Vehicle	0.06	0.06	0.02
	Road ahead	0.82	0.80	0.92
	Right Side of Vehicle	0.03	0.06	0.04
	Standard Billboard	N/A	0.03	N/A
	Participant Vehicle	0.03	0.05	0.02
Freeway	*CEVMS*	0.05	N/A	N/A
	Left Side of Vehicle	0.08	0.07	0.04
	Road ahead	0.73	0.77	0.86
	Right Side of Vehicle	0.09	0.02	0.05
	Standard Billboard	0.02*	0.09	N/A
	Participant Vehicle	0.04	0.05	0.05

* The CEVMS DCZs on freeways each contained one visible standard billboard.

The probability of gazing away from the forward roadway ranged from 0.08 to 0.27. In particular, the probability of gazing toward a CEVMS was greater on arterials (M = 0.07) than on freeways (M = 0.05). In contrast, the probability of gazing toward a target standard billboard was greater on freeways (M = 0.09) than on arterials (M = 0.03).

Fixations to CEVMS and Standard Billboards

About 2.4 percent of the fixations were to CEVMS. The mean fixation duration to a CEVMS was 388 ms and the maximum duration was 1,251 ms. Figure 11 shows the distribution of fixation durations to CEVMS during the day and night. In the daytime, the mean fixation duration to a CEVMS was 389 ms and at night it was 387 ms. Figure 12 shows the distribution of fixation durations to standard billboards. Approximately 2.4 percent of fixations were to standard billboards. The mean fixation duration to standard billboards was 341 ms during the daytime and 370 ms at night. The maximum fixation duration to standard billboards was 1,284 ms (which occurred at night). For comparison purposes, figure 13 shows the distribution of fixation durations to the road ahead (i.e., top and bottom road ahead ROIs) during the day and night. In the daytime, the mean fixation duration to the road ahead was 365 ms and at night it was 390 ms.

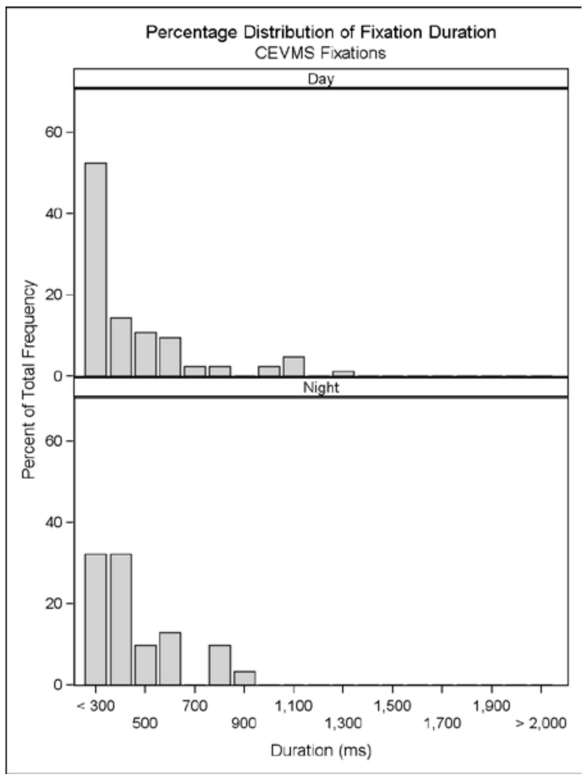


Figure 11. Distribution of fixation duration for CEVMS in the daytime and nighttime.

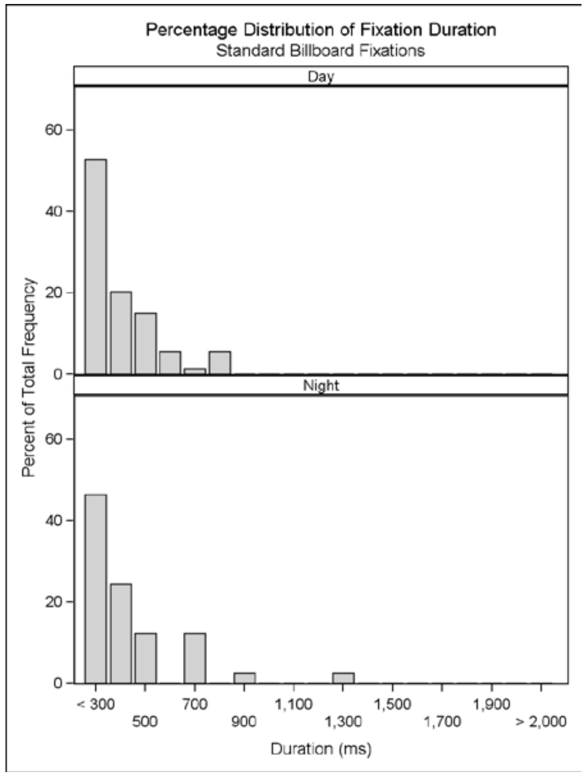


Figure 12. Distribution of fixation duration for standard billboards in the daytime and nighttime.

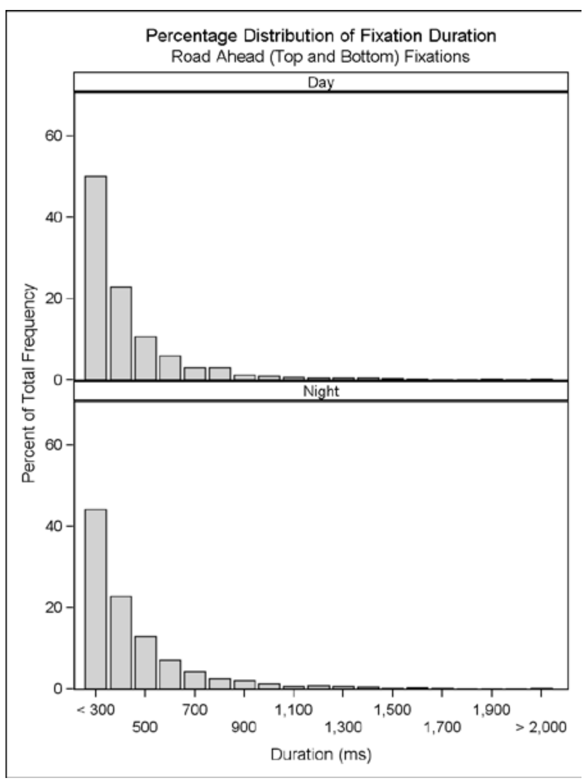


Figure 13. Distribution of fixation duration for road ahead (i.e., top and bottom road ahead ROIs) in the daytime and nighttime.

Dwell times on CEVMS and standard billboards were also examined. Dwell time is the duration of back-to-back fixations to the same ROI.[43,44] The dwell times represent the cumulative time for the back-to-back fixations. Whereas there may be no long, single fixation to a billboard, there might still be multiple fixations that yield long dwell times. There were a total of 25 separate instances of multiple fixations to CEVMS with a mean of 2.4 fixations (minimum of 2 and maximum of 5). The 25 dwell times came from 15 different participants distributed across four different CEVMS. The mean duration of these dwell times was 994 ms (minimum of 418 ms and maximum of 1,467 ms).

For standard billboards, there were a total of 17 separate dwell times with a mean of 3.47 sequential fixations (minimum of 2 fixations and maximum of 8 fixations). The 17 dwell times came from 11 different participants distributed across 4 different standard billboards. The mean duration of these multiple fixations was 1,172 ms (minimum of 418 ms and maximum of 3,319 ms). There were three dwell-time durations that were greater than 2,000 ms. These are described in more detail below.

In some cases several dwell times came from the same participant. In order to compute a statistic on the difference between dwell times for CEVMS and standard billboards, average dwell times were computed per participant for the CEVMS and standard billboard conditions. These average values were used in a t-test assuming unequal variances. The difference in average dwell time between CEVMS (M = 981 ms) and standard billboards (M= 1,386 ms) was not statistically significant, $t(12) = -1.40$, $p > .05$.

Figure 14 through figure 23 show heat maps for the dwell-time durations to the standard billboards that were greater than 2,000 ms. These heat maps are snapshots from the DCZ and attempt to convey in two dimensions the pattern of gazes that took place in a three dimensional world. The heat maps are set to look back approximately one to two seconds and integrate over time where the participant was gazing in the scene camera video. The green color in the heat map indicates the concentration of gaze over the past one to two seconds. The blue line indicates the gaze trail over the past one to two seconds.

Figure 14 through figure 16 are for a DCZ on an arterial at night. The standard billboard was on the right side of the road (indicated by a pink rectangle). There were eight fixations to this billboard, and the single fixations were between 200 to 384 ms in duration. The dwell time for this billboard was 2,019 ms. At the start of the DCZ (see figure 14), the driver was directing his/her gaze to the forward roadway. Approaching the standard billboard, the driver began to fixate on the billboard. However, the billboard was still relatively close to the road ahead ROI.

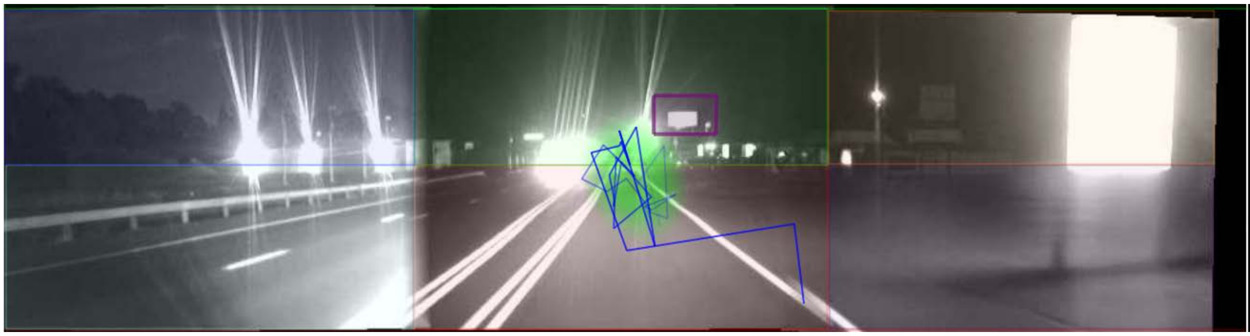


Figure 14. Heat map for the start of a DCZ for a standard billboard at night on an arterial.

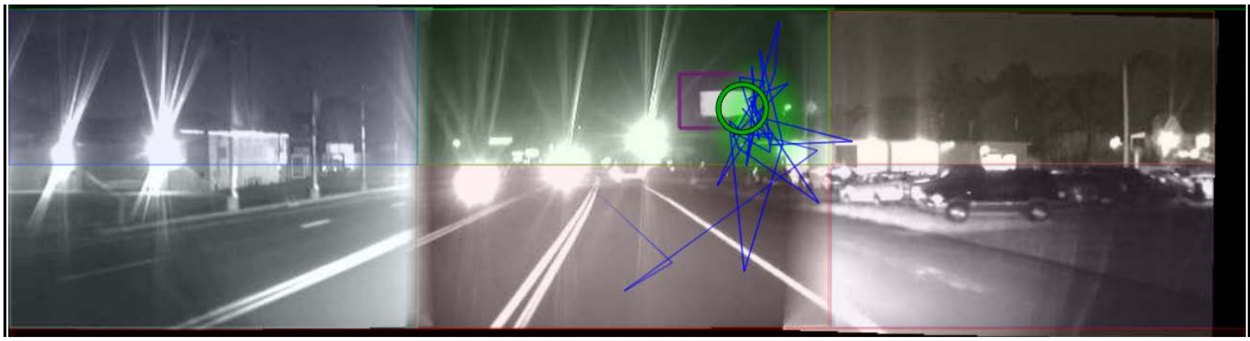


Figure 15. Heat map for the middle of a DCZ for a standard billboard at night on an arterial.

Figure 16. Heat map near the end of a DCZ for a standard billboard at night on an arterial.

Figure 17 through figure 19 are for a DCZ on a freeway at night. The standard billboard was on the right side of the road (indicated by a green rectangle). There were six consecutive fixations to this billboard, and the single fixations were between 200 and 801 ms in duration. The dwell time for this billboard was 2,753 ms. At the start of the DCZ (see figure 17), the driver was directing his/her gaze to a freeway guide sign in the road ahead and the standard billboard was to the left of the freeway guide sign. As the driver approached the standard billboard, his/her gaze was directed toward the billboard. The billboard was relatively close to the top and bottom road ahead ROIs. Near the end of the DCZ (see figure 19), the billboard was accurately portrayed as being on the right side of the road.

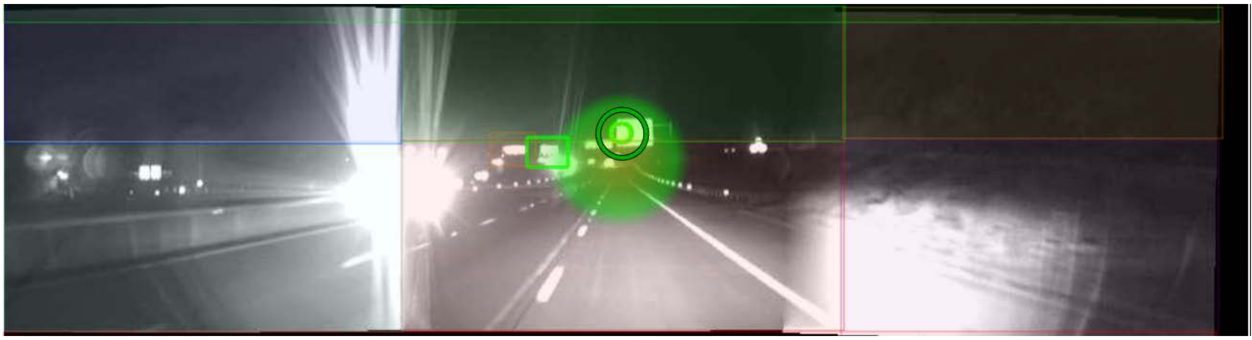


Figure 17. Heat map for start of a DCZ for a standard billboard at night on a freeway.

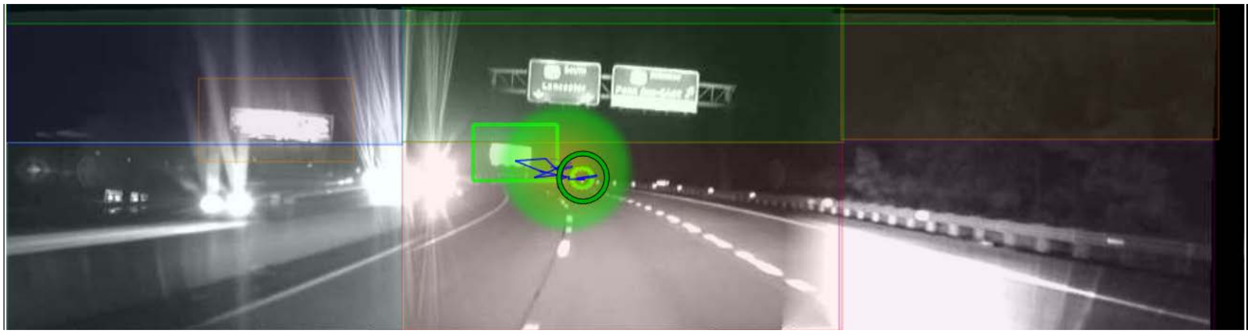


Figure 18. Heat map for middle of a DCZ for a standard billboard at night on a freeway.

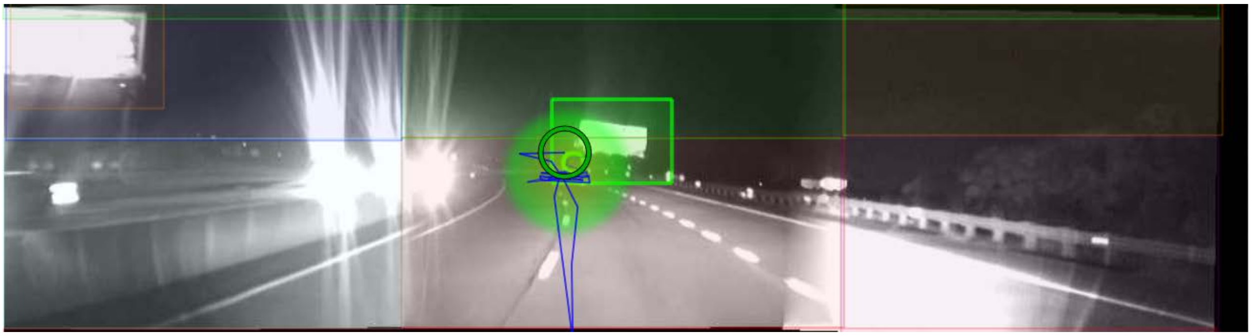


Figure 19. Heat map near the end of a DCZ for a standard billboard at night on a freeway.

Figure 20 through figure 23 are for a DCZ on a freeway during the day. The standard billboard was on the right side of the road (indicated by a pink rectangle). This is the same DCZ that was discussed in figure 17 through figure 19. There were six consecutive fixations to this billboard, and the single fixations were between 217 and 767 ms in duration. The dwell time for this billboard was 3,319 ms. At the start of the DCZ (see figure 20), the driver was principally directing his/her gaze to the road ahead. Figure 21 and figure 22 show the location along the DCZ where gaze was directed toward the standard billboard. The billboard was relatively close to the top and bottom road-ahead ROIs. As the driver passed the standard billboard, his/her gaze returned to the road ahead (see figure 23).

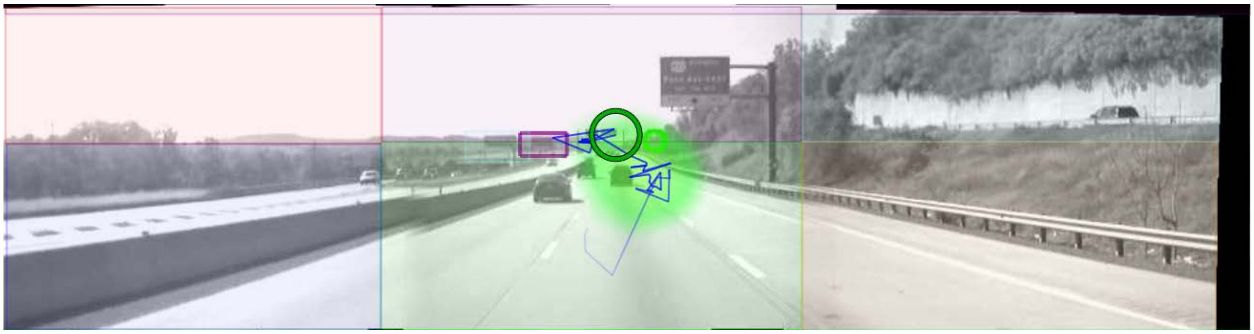


Figure 20. Heat map for the start of a DCZ for a standard billboard in the daytime on a freeway.

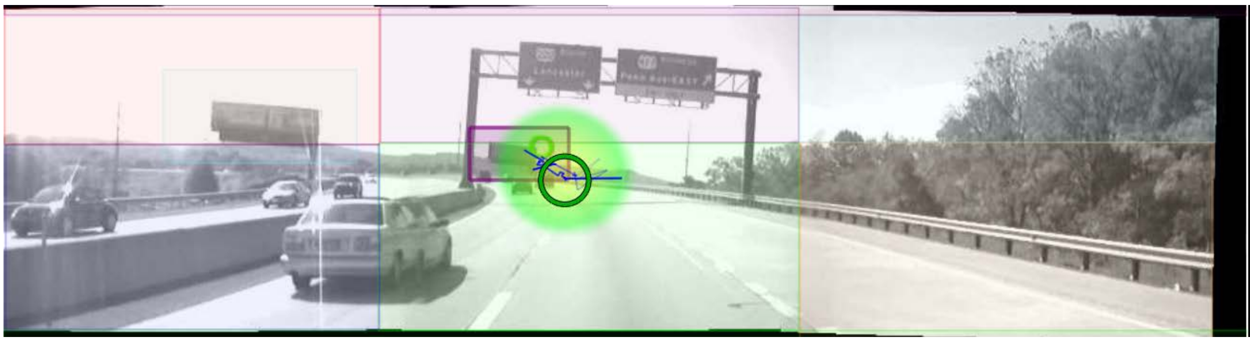


Figure 21. Heat map near the middle of a DCZ for a standard billboard in the daytime on a freeway.

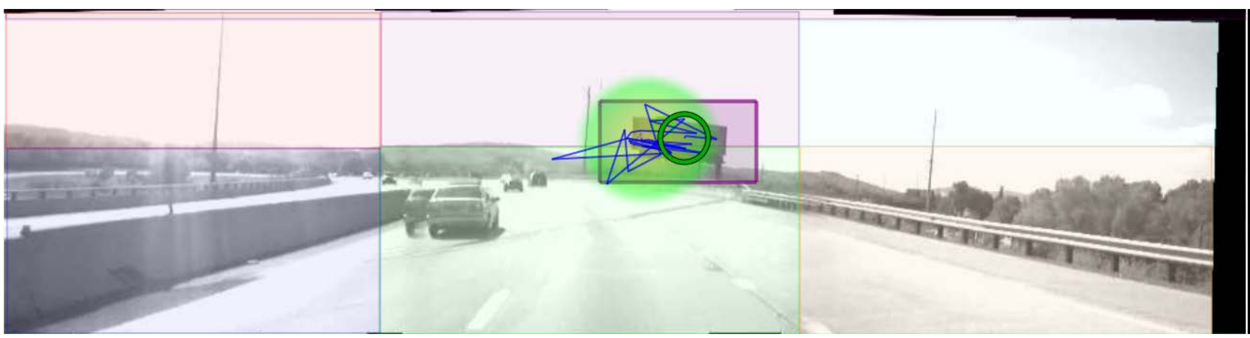


Figure 22. Heat map near the end of DCZ for standard billboard in the daytime on a freeway.

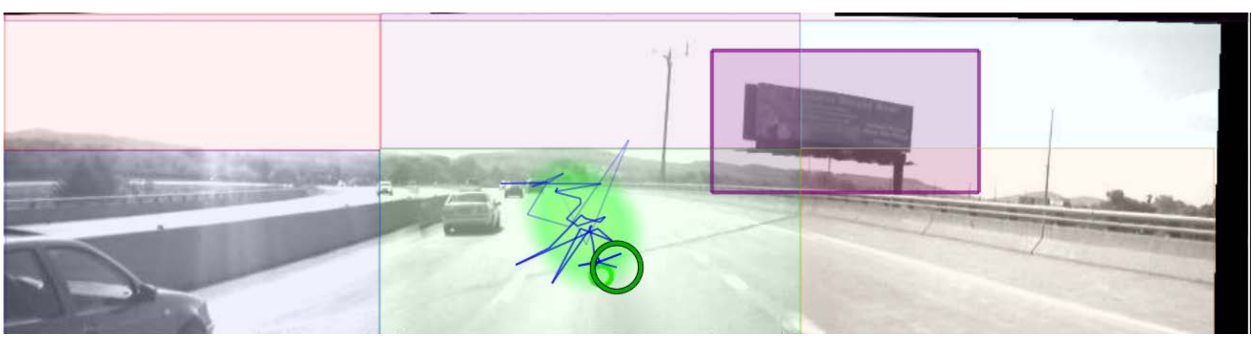


Figure 23. Heat map at the end of DCZ for standard billboard in the daytime on a freeway.

Comparison of Gazes to CEVMS and Standard Billboards

The GEE were used to analyze whether a participant gazed more toward CEVMS than toward standard billboards, given that the participant was gazing at off-premise advertising. With this analysis method, a logistic regression model for repeated measures was generated by using a binomial response distribution and Logit link function. First, the data was partitioned to include only those instances when a participant was gazing toward off-premise advertising (either to a CEVMS or to a standard billboard); all other gaze behavior was excluded from the input data set. Only two possible outcomes are allowed when selecting a binomial response distribution. Thus, a variable (SBB_CEVMS) was created to classify a participant's gaze behavior. If the participant gazed toward a CEVMS, the value of SBB_CEVMS was set to one. If the participant gazed toward a standard billboard, then the value of SBB_CEVMS was set to zero.

Logistic regression typically models the probability of a success. In the current analysis, a success would be a gaze to a CEVMS (SBB_CEVMS = 1) and a failure would be a gaze to a standard billboard (SBB_CEVMS = 0).[2] A success probability greater than 0.5 indicates there were more successes than failures in the sample. Therefore, if the sample probability of the response variable (i.e., SBB_CEVMS) was greater than 0.5, this would show that participants gazed more toward CEVMS than toward standard billboards when the participants gazed at off-premise advertising. In contrast, if the sample probability of the response variable was less than 0.5, then participants showed a preference to gaze more toward standard billboards than toward CEVMS when directing gazes to off-premise advertising.

Time of day (i.e., day or night), road type (i.e., freeway or arterial), and the corresponding interaction were explanatory variables in the logistic regression model. Road type was the only predictor to have a significant effect, $\chi^2(1) = 13.17$, $p < 0.001$. On arterials, participants gazed more toward CEVMS than toward standard billboards (M = 0.63). In contrast, participants gazed more toward standard billboards than toward CEVMS when driving on freeways (M = 0.33).

Observation of Driver Behavior

No near misses or driver errors were observed in Reading.

Level of Service

The mean vehicle densities were converted to level of service as shown in table 6.[45] As expected, less congestion occurred at night than in the day. In general, there was traffic during the data collection runs. Review of the scene camera data verified that all eye tracking data within the DCZs were recorded while the vehicle was in motion.

[2] Success and failure are not used to reflect the merits of either type of sign, but only for statistical purposes.

Table 6. Level of service as a function of advertising type, road type, and time of day.

	Arterial		*Freeway*	
	Day	Night	Day	Night
Control	B	A	C	B
CEVMS	C	A	B	A
Standard	A	A	B	A

DISCUSSION OF READING RESULTS

Overall the probability of gazing at the road ahead was high and similar in magnitude to what has been found in other field studies addressing billboards.[11,9,12] For the DCZs on freeways, CEVMS showed a lower proportion of gazes to the road ahead than the standard billboard condition, and both off-premise advertising conditions had lower probability of gazes to the road ahead than the control. On the other hand, on the arterials, the CEVMS and standard billboard conditions did not differ from each other but were significantly different from their respective control condition. Though the CEVMS condition on the freeway had the lowest proportion of gazes to the road ahead, in this condition there was a lower proportion of gazes to CEVMS as compared to the arterials (see table 5 for the trade-off of gazes to the different ROIs). A greater proportion of gazes to other ROIs (left side of the road, right side of the road, and participant vehicle) contributed to the decrease in proportion of gazes to the road ahead. Also, for the CEVMS on freeways, there were a few gazes to a standard billboard located in the same DCZ and there were more gazes distributed to the left and right side of the road than in standard billboard and control conditions. The gazes to ROIs other than CEVMS contributed to the lower probability of gazes to the road ahead in this condition.

The control condition on the arterial had buildings along the sides of the road and generally presented a visually cluttered area. As was presented earlier, the feature congestion measure computed on a series of photographs from each DCZ showed a significantly higher feature congestion score for the control condition on arterials as compared to all of the other DCZs. Nevertheless, the highest probability for gazing at the road ahead was seen in the control condition on the arterial.

The area with the highest feature congestion, especially on the sides of the road, had the highest probability for drivers looking at the road ahead. Bottom-up or stimulus driven measures of salience or visual clutter have been useful in predicting visual search and the effects of visual salience in laboratory tasks.[34,46] These measures of salience basically consider the stimulus characteristics (e.g., size, color, brightness) independent of the requirements of the task or plans that an individual may have. Models of visual salience may predict that buildings and other prominent features on the side of the road may be visually salient objects and thus would attract a driver's attention.[47] Figure 24 shows an example of a roadway photograph that was analyzed with the Salience Toolbox based on the Itti et al. implementation of a saliency based model of bottom-up attention.[48,49] The numbered circles in figure 24 are the first through fifth salient areas selected by the software. Based on this software, the most salient areas in the photographs are the buildings on the sides of the road where the road ahead (and a car) is the fifth selected salient area.

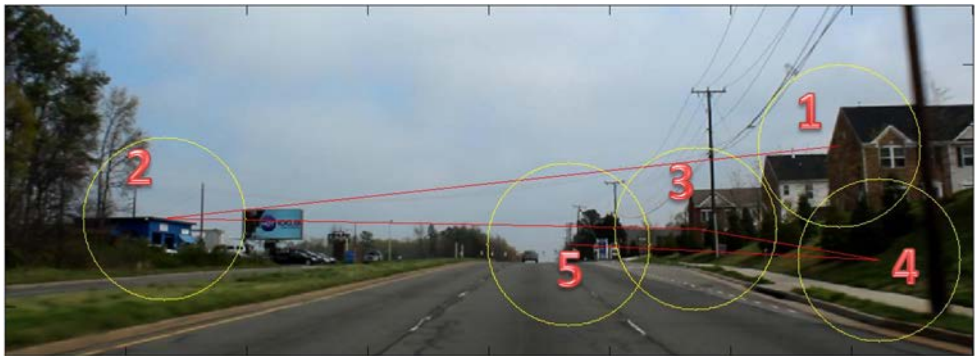


Figure 24. Example of identified salient areas in a road scene based on bottom-up analysis.

It appears that in the present study participants principally kept their eyes on the road even in the presence of visual clutter on the sides of the road, which supports the hypothesis that drivers tend to look toward information relevant to the task at hand.(50,26,22) In the case of the driving task, visual clutter may be more of an issue with respect to crowding that may affect the driver's ability to detect visual information in the periphery.(51) Crowding is generally defined as the negative effect of nearby objects or features on visual discrimination of a target.(52) Crowding impairs the ability to recognize objects in clutter and principally affects perception in peripheral vision. However, crowing effects were not analyzed in the present study.

Stimulus salience, clutter, and the nature of the task at hand interact in visual perception. For tasks such as driving, the task demands tend to outweigh stimulus salience when it comes to gaze control. Clutter may be more of an issue with the detection and recognition of objects in peripheral vision (e.g., detecting a sign on the side of the road) that are surrounded by other stimuli that result in a crowding effect.

The mean fixation durations to CEVMS, standard billboards, and the road ahead were found to be very similar. Also, there were no long fixations (greater than 2,000 ms) to CEVMS or standard billboards. The examination of multiple sequential fixations to CEVMS yielded average dwell times that were less than 1,000 ms. However, when examining the tails of the distribution, there were three dwell times to standard billboards that were in excess of 2,000 ms (the three dwell times came from three different participants to two different billboards). These three standard billboards were dwelled upon when they were near the road ahead area but drivers quit gazing at the signs as they neared them and the signs were no longer near the forward field of view. Though there were three dwell times for standard billboards greater than 2,000 ms, the difference in average dwell times for CEVMS and standard billboards was not significant.

Using a gaze duration of 2,000 ms away from the road ahead as a criterion indicative of increased risk has been developed principally as it relates to looking inside the vehicle to in-vehicle information systems and other devices (e.g., for texting) where the driver is indeed looking completely away from the road ahead.(14,53,54) The fixations to the standard billboards in the present case showed a long dwell time for a billboard. However, unlike gazing or fixating inside the vehicle, the driver's gaze was within the forward roadway where peripheral vision could be used to monitor for hazards and for vehicle control. Peripheral vision has been shown to be important for lane keeping, visual search orienting, and monitoring of surrounding objects.(55,56)

The results showed that drivers were more likely to gaze at CEVMS on arterials and at standard billboards on freeways. Though every attempt was made to select CEVMS and standard billboard DCZs that were equated on important parameters (e.g., which side of the road the sign was located on, type of road, level of visual clutter), the CEVMS DCZs on freeways had a greater setback from the road (133 ft for both CEVMS) than the standard billboards (10 and 35 ft). Signs with greater setback from the road would in a sense move out of the forward view (road ahead) more quickly than signs that are closer to the road. The CEVMS and standard billboards on the arterials were more closely matched with respect to setback from the road (12 and 43 ft for CEVMS and 20 and 40 ft for standard billboards).

The differences in setback from the road for CEVMS and standard billboards may also account for differences in dwell times to these two types of billboards. However, on arterials where the CEVMS and standard billboards were more closely matched there was only one long dwell time (greater than 2,000 ms) and it was to a standard billboard at night.

RICHMOND

The objectives of the second study were the same as those in the first study, and the design of the Richmond data collection effort was very similar to that employed in Reading. This study was conducted to replicate as closely as possible the design of Reading in a different driving environment. The independent variables included the type of DCZ (CEVMS, standard billboard, or no off-premise advertising), time of day (day or night) and road type (freeway or arterial). As with Reading, the time of day was a between-subjects variable and the other variables were within subjects.

METHOD

Selection of DCZ Limits

Selection of the DCZ limits procedure was the same as that employed in Reading.

Advertising Type

Three DCZ types (similar to those used in Reading) were used in Richmond:

- **CEVMS.** DCZs contained one target CEVMS.
- **Standard billboard.** DCZs contained one target standard billboard.
- **Control conditions.** DCZs did not contain any off-premise advertising.

There were an equal number of CEVMS and standard billboard DCZs on freeways and arterials. Also, there two DCZ that did not contain off-premise advertising with one located on a freeway and the other on an arterial.

Table 7 is an inventory of the target employed in this second study.

Table 7. Inventory of target billboards in Richmond with relevant parameters.

DCZ	*Advertising Type*	*Copy Dimensions (ft)*	*Side of Road*	*Setback from Road (ft)*	*Other Standard Billboards*	*Approach Length (ft)*	*Roadway Type*
5	CONTROL	N/A	N/A	N/A	N/A	710	Arterial
3	CONTROL	N/A	N/A	N/A	N/A	845	Freeway
9	CEVMS	14'0" x 28'0"	L	37	0	696	Arterial
13	CEVMS	14'0" x 28'0"	R	37	0	602	Arterial
2	CEVMS	12'5" x 40'0"	R	91	0	297	Freeway
8	CEVMS	11'0 x 23'0"	L	71	0	321	Freeway
10	Standard	14'0" x 48'0"	L	79	1	857	Arterial
12	Standard	10'6" x 45'3"	R	79	2	651	Arterial
1	Standard	14'0" x 48'0"	L	87	0	997	Freeway
7	Standard	14'0" x 48'0"	R	88	0	816	Freeway

** N/A indicates that there were no off-premise advertising in these areas and these values are undefined.*

Figure 25 through figure 30 below represent various pairings of DCZ type and road type. Target off-premise billboards are indicated by red rectangles.

Figure 25. Example of a CEVMS DCZ on a freeway.

Figure 26. Example of CEVMS DCZ an arterial.

Figure 27. Example of a standard billboard DCZ on a freeway.

Figure 28. Example of a standard billboard DCZ on an arterial.

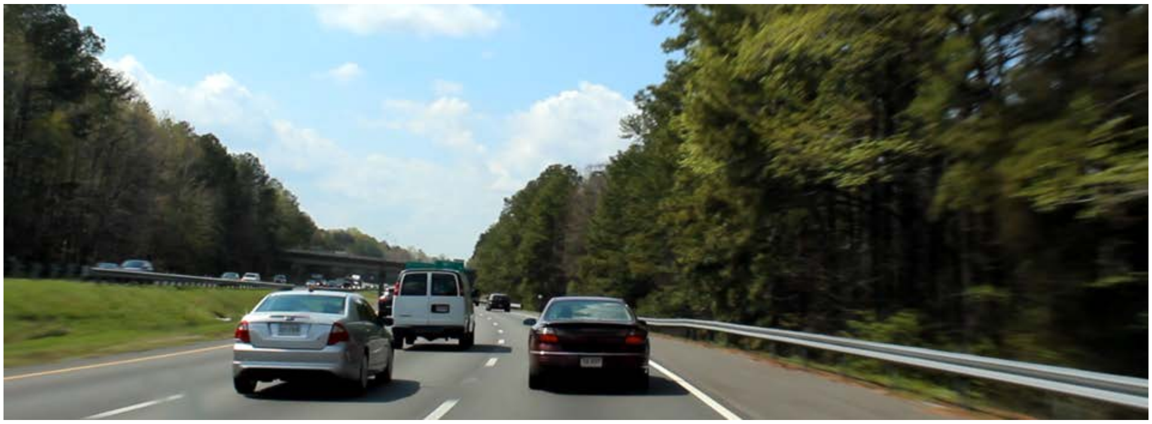


Figure 29. Example of a control DCZ on a freeway.

Figure 30. Example of a control DCZ on an arterial.

Photometric Measurement of Signs

The methods and procedures for the photometric measures were the same as for Reading.

Visual Complexity

The methods and procedures for visual complexity measurement were the same as for Reading.

Participants

A total of 41 participants were recruited for the study. Of these, 6 participants did not complete data collection because of an inability to properly calibrate with the eye tracking system, and 11 were excluded because of equipment failures. A total of 24 participants (13 male, M = 28 years; 11 female, M = 25 years) successfully completed the drive. Fourteen people participated during the day and 10 participated at night.

Procedures

Research participants were recruited locally by means of visits to public libraries, student unions, community centers, etc. A large number of the participants were recruited from a nearby university, resulting in a lower mean participant age than in Reading.

Participant Testing

Two people participated each day. One person participated during the day beginning at approximately 12:45 p.m. The second participated at night beginning at around 7:00 p.m. Data collection ran from November 20, 2009, through April 23, 2010. There were several long gaps in the data collection schedule due to holidays and inclement weather.

Pre-Data Collection Activities

This was the same as in Reading.

Practice Drive

Except for location, this was the same as in Reading.

Data Collection

The procedure was much the same as in Reading. On average, each test route required approximately 30 to 35 minutes to complete. As in Reading, the routes included a variety of freeway and arterial driving segments. One route was 15 miles long and contained two target CEVMS, two target standard billboards, and two DCZs with no off-premise advertising. The second route was 20 miles long and had two target CEVMS and two target standard billboards.

The data collection drives in this second study were longer than those in Reading. The eye tracking system had problems dealing with the large files that resulted. To mitigate this technical difficulty, participants were asked to pull over in a safe location during the middle of each data collection drive so that new data files could be initiated.

Upon completion of the data collection, the participant was instructed to return to the designated meeting location for debriefing.

Debriefing

This was the same as in Reading.

DATA REDUCTION

Eye Tracking Measures

The approach and procedures were the same as used in Reading.

Other Measures

The approach and procedures were the same as used in Reading.

RESULTS

Photometric Measurement of Signs

The photometric measurements were performed using the same equipment and procedures that were employed in Reading with a few minor changes. Photometric measurements were taken during the day and at night. Measurements of the standard billboards were taken at an average distance of 284 ft, with maximum and minimum distances of 570 ft and 43 ft, respectively. The average distance of measurements for the CEVMS was 479 ft, with maximum and minimum distances of 972 ft and 220 ft, respectively. Again, the distances employed were significantly affected by the requirement to find a safe location on the road from which to take the measurements.

Luminance

The mean luminance of CEVMS and standard billboards, during daytime and nighttime are shown below in table 8. The results here are similar to those for Reading.

Contrast

The daytime and nighttime Weber contrast ratios for both types of billboards are shown in table 8. During the day, the contrast ratios of both CEVMS and standard billboards were close to zero (the surroundings were about equal in brightness to the signs). At night, the CEVMS and standard billboards had positive contrast ratios. Similar to Reading, the CEVMS showed a higher contrast ratio than the standard billboards at night.

Table 8. Summary of luminance (cd/m^2) and contrast (Weber ratio) measurements.

	Luminance (cd/m^2)		***Contrast***	
Day	Mean	St. Dev.	Mean	St. Dev.
CEVMS	2134	798.70	-0.20	0.53
Standard Billboard	3063	2730.92	0.03	0.32
Night				
CEVMS	56.44	16.61	69.70	59.18
Standard Billboard	8.00	5.10	6.56	3.99

Visual Complexity

As with Reading, the feature congestion measure was used to estimate the level of visual complexity/clutter in the DCZs. The analysis procedures were the same as for Reading.

Figure 31 shows the mean feature congestion measures for each of the advertising types (standard errors are included in the figure). Unlike the results for Reading, the selected off-premise advertising DCZs for Richmond differed in terms of mean feature congestion; $F(3, 36) = 3.95$, $p = 0.016$. Follow up t-tests with an alpha of 0.05 showed that the CEVMS DCZs on arterials had significantly lower feature congestion than all of the other off-premise advertising conditions. None of the remaining DCZs with off-premise advertising differed from each other. The selection of DCZs for the conditions with off-premise advertising took into account the type of road, the side of the road the target billboard was placed, and the perceived level of visual clutter. Based on the feature congestion measure, these results indicated that the conditions with off-premise advertising were not equated with respect to level of visual clutter.

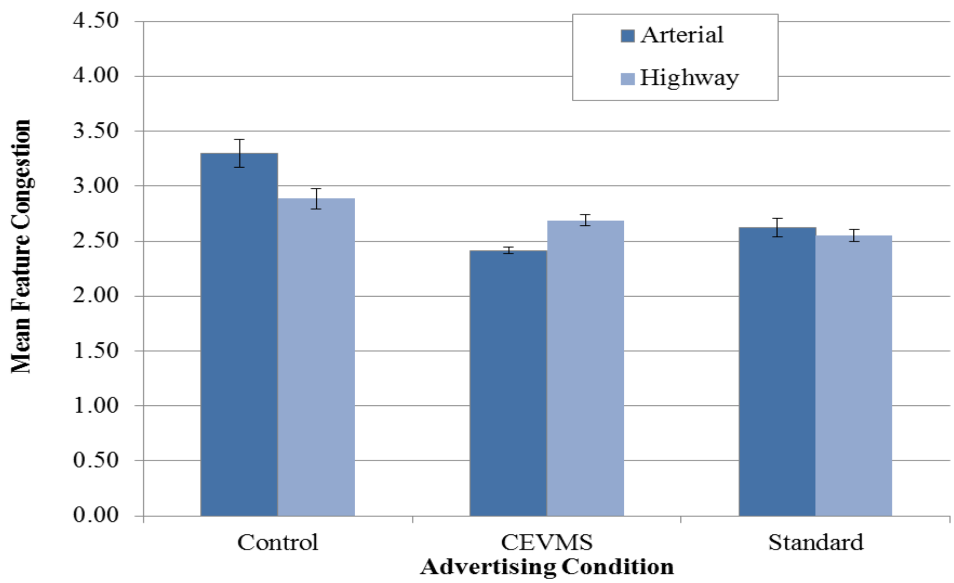


Figure 31. Mean feature congestion as a function of advertising condition and road type.

Effects of Billboards on Gazes to the Road Ahead

As was done for the data from Reading, GEE were used to analyze the probability of a participant gazing at the road ahead. A logistic regression model for repeated measures was generated by using a binomial response distribution and Logit link function. The resultant value was the probability of a participant gazing at the road ahead (as previously defined).

Time of day (day or night), road type (freeway or arterial), advertising type (CEVMS, standard billboard, or control), and all corresponding second-order interactions were explanatory variables in the logistic regression model. The interaction of advertising type by road type was statistically significant, $\chi^2(2) = 14.19$, $p < 0.001$. Table 9 shows the corresponding probability of gazing at the road ahead as a function of advertising condition and road type.

Table 9. The probability of gazing at the road ahead as a function of advertising condition and road type.

Advertising Condition	*Arterial*	*Freeway*
Control	0.78	0.92
CEVMS	0.76	0.82
Standard	0.81	0.85

Follow-up analyses for the interaction used Tukey-Kramer adjustments with an alpha level of 0.05. The freeway control had the greatest probability of gazing at the road ahead (M = 0.92). This probability differed significantly from the remaining five probabilities. On arterials, there were no significant differences among the probabilities of gazing at the road ahead among the three advertising conditions. On freeways, there was no significant difference between the probability associated with CEVMS DCZs and the probability associated with standard billboard DCZs.

Additional descriptive statistics were computed for the three advertising types to determine the probability of gazing at the ROIs that were defined in the panoramic scene. As was done with the data from Reading, some of the ROIs were combined for ease of analysis. Table 10 presents the probability of gazing at the different ROIs.

Table 10. Probability of gazing at ROIs for the three advertising conditions on arterials and freeways.

Road Type	*ROI*	*CEVMS*	*Standard Billboard*	*Control*
Arterial	*CEVMS*	0.06	N/A	N/A
	Left Side of Vehicle	0.03	0.05	0.04
	Road ahead	0.76	0.81	0.78
	Right Side of Vehicle	0.07	0.06	0.09
	Standard Billboard	N/A	0.02	N/A
	Participant Vehicle	0.07	0.06	0.09
Freeway	*CEVMS*	0.05	N/A	N/A
	Left Side of Vehicle	0.03	0.01	0.01
	Road ahead	0.82	0.85	0.92
	Right Side of Vehicle	0.04	0.04	0.03
	Standard Billboard	N/A	0.04	N/A
	Participant Vehicle	0.06	0.06	0.05

The probability of gazing away from the forward roadway ranged from 0.08 to 0.24. In particular, the probability of gazing toward a CEVMS was slightly greater on arterials (M = 0.06) than on freeways (M = 0.05). In contrast, the probability of gazing toward a standard billboard was greater on freeways (M = 0.04) than on arterials (M = 0.02). In both situations, the probability of gazing at the road ahead was greatest on freeways.

Fixations to CEVMS and Standard Billboards

About 2.5 percent of the fixations were to CEVMS. The mean fixation duration to a CEVMS was 371 ms and the maximum fixation duration was 1,335 ms. Figure 32 shows the distribution of fixation durations to CEVMS during the day and at night. In the daytime, the mean fixation duration to a CEVMS was 440 ms and at night it was 333 ms. Approximately 1.5 percent of the fixations were to standard billboards. The mean fixation duration to standard billboards was 318 ms and the maximum fixation duration was 801 ms. Figure 33 shows the distribution of fixation durations for standard billboards. The mean fixation duration to a standard billboard was 313 ms and 325 ms during the day and night, respectively. For comparison purposes, figure 34 shows the distribution of fixation durations to the road ahead during the day and night. In the daytime, the mean fixation duration to the road ahead was 378 ms and at night it was 358 ms.

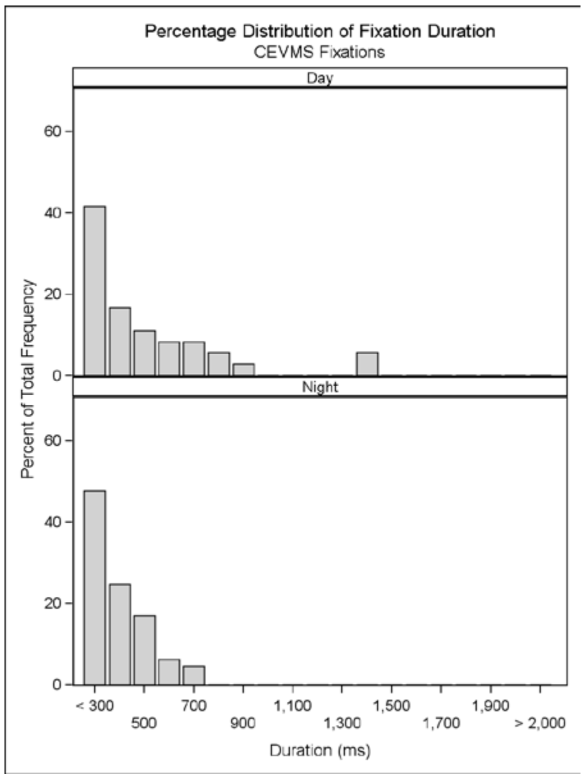


Figure 32. Fixation duration for CEVMS in the day and at night.

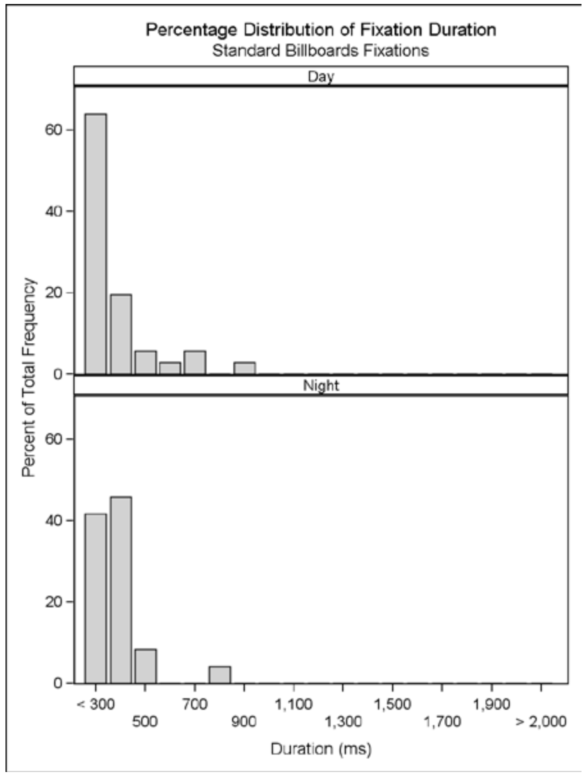


Figure 33. Fixation duration for standard billboards in the day and at night.

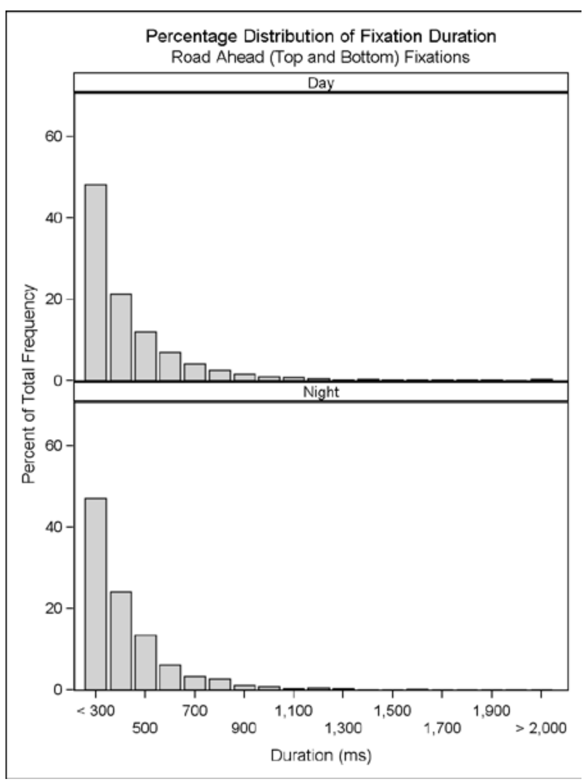


Figure 34. Fixation duration for the road ahead in the day and at night.

As was done with the data for Reading, the record of fixations was examined to determine dwell times to CEVMS and standard billboards. There were a total of 21 separate dwell times to CEVMS with a mean of 2.86 sequential fixations (minimum of 2 fixations and maximum of 6 fixations). The 21 dwell times came from 12 different participants and four different CEVMS. The mean dwell time duration to the CEVMS was 1,039 ms (minimum of 500 ms and maximum of 2,720 ms). There was one dwell time greater than 2,000 ms to CEVMS. To the standard billboards there were 13 separate dwell times with a mean of 2.31 sequential fixations (minimum of 2 fixations and maximum of 3 fixations). The 13 dwell times came from 11 different participants and four different standard billboards. The mean dwell time duration to the standard billboards was 687 ms (minimum of 450 ms and maximum of 1,152 ms). There were no dwell times greater than 2,000 ms to standard billboards.

In some cases several dwell times came from the same participant. To compute a statistic on the difference between dwell times for CEVMS and standard billboards, average dwell times were computed per participant for the CEVMS and standard billboard conditions. These average values were used in a *t*-test assuming unequal variances. The difference in average dwell time between CEVMS (M = 1,096 ms) and standard billboards (M= 674 ms) was statistically significant, $t(14) = 2.23$, $p = .043$.

Figure 35 through figure 37 show heat maps for the dwell-time durations to the CEVMS that were greater than 2,000 ms. The DCZ was on a freeway during the daytime. The CEVMS is located on the left side of the road (indicated by an orange rectangle). There were three fixations to this billboard, and the single fixations were between 651 ms and 1,335 ms. The dwell time for this billboard was 2,270 ms. Figure 35 shows the first fixation toward the CEVMS. There are no vehicles near the participant in his/her respective travel lane or adjacent lanes. In this situation, the billboard is relatively close to the road ahead ROI. Figure 36 shows a heat map later in the DCZ where the driver continues to look at the CEVMS. The heat map does not overlay the CEVMS in the picture since the heat map has integrated over time where the driver was gazing. The CEVMS has moved out of the area because of the vehicle moving down the road. However, visual inspection of the video and eye tracking statistics showed that the driver was fixating on the CEVMS. Figure 37 shows the end of the sequential fixations to the CEVMS. The driver returns to gaze directly in front of the vehicle. Once the CEVMS was out of the forward field of view, the driver quit looking at the billboard.

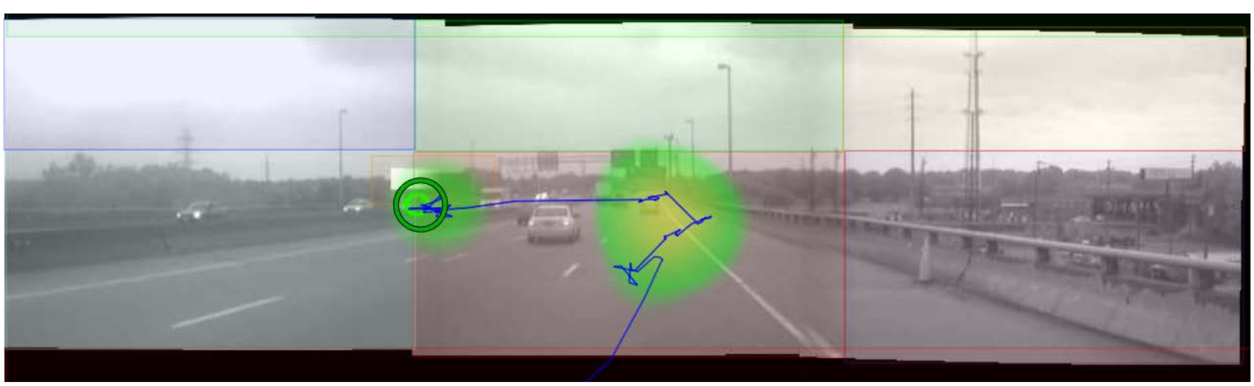


Figure 35. Heat map for first fixation to CEVMS with long dwell time.

Figure 36. Heat map for later fixations to CEVMS with long dwell time.

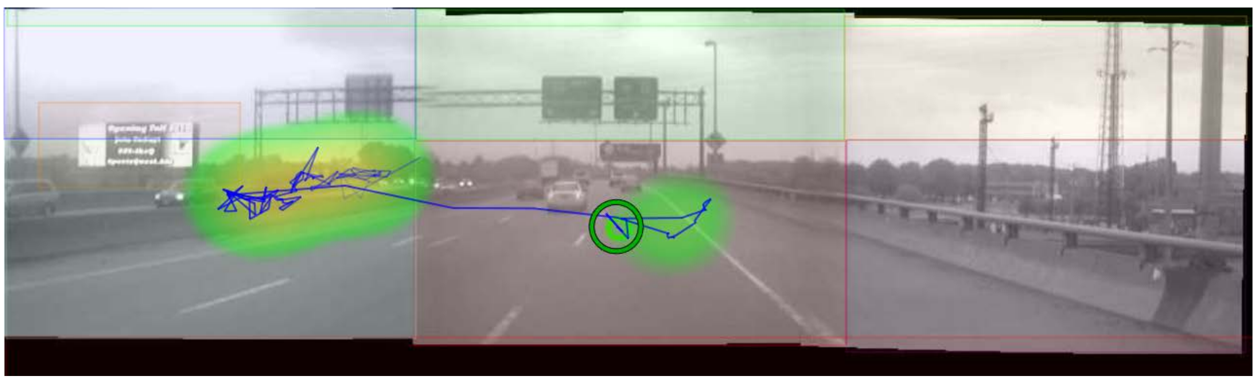


Figure 37. Heat map at end of fixations to CEVMS with long dwell time.

Comparison of Gazes to CEVMS and Standard Billboards

As was done for the data from Reading, GEE were used to analyze whether a participant gazed more toward CEVMS than toward standard billboards, given that the participant was looking at off-premise advertising. Recall that a sample probability greater than 0.5 indicated that participants gazed more toward CEVMS than standard billboards when the participants gazed at off-premise advertising. In contrast, if the sample probability was less than 0.5, participants showed a preference to gaze more toward standard billboards than CEVMS when directing visual attention to off-premise advertising.

Time of day (i.e., day or night), road type (i.e., freeway or arterial), and the corresponding interaction were explanatory variables in the logistic regression model. Time of day had a significant effect on participant gazes toward off-premise advertising, $\chi^2(1) = 4.46$, $p = 0.035$. Participants showed a preference to gaze more toward CEVMS than toward standard billboards during both times of day. During the day the preference was only slight (M = 0.52), but at night the preference was more pronounced (M = 0.71). Road type was also a significant predictor of where participants directed their gazes at off-premise advertising, $\chi^2(1) = 3.96$, $p = 0.047$. Participants gazed more toward CEVMS than toward standard billboards while driving on both types of roadways. However, driving on freeways yielded a slight preference for CEVMS over standard billboards (M = 0.55), but driving on arterials resulted in a larger preference in favor of CEVMS (M = 0.68).

Observation of Driver Behavior

No near misses or driver errors occurred.

Level of Service

Table 11 shows the level of service as a function of advertising type, type of road, and time of day. As expected, there was less congestion during the nighttime runs than in the daytime. In general, there was traffic during the data collection runs; however, the eye tracking data were recorded while the vehicles were in motion.

Table 11. Estimated level of service as a function of advertising condition, road type, and time of day.

	Arterial		Freeway	
	Day	Night	Day	Night
Control	B	A	C	B
CEVMS	B	A	B	A
Standard	C	A	C	C

DISCUSSION OF RICHMOND RESULTS

Overall the probability of looking at the forward roadway was high across all conditions and consistent with the findings from Reading and previous related research.(11,9,12) In this second study the CEVMS and standard billboard conditions did not differ from each other. For the DCZs on arterials there were no significant differences among the control, CEVMS, and standard billboard conditions. On the other hand, while the CEVMS and standard billboard conditions on the freeways did not differ from each other, they were significantly different from their respective control conditions. The control condition on the freeway principally had trees along the sides of the road and the signs that were present were freeway signs located in the road ahead ROI.

Measures such as feature congestion rated the three DCZs on freeways as not being statistically different from each other. These types of measures have been useful in predicting visual search and the effects of visual salience in laboratory tasks.(34) Models of visual salience may predict that, at least during the daytime, trees on the side of the road may be visually salient objects that would attract a driver's attention.(47) However, it appears that in the present study, participants principally kept their eyes on the road ahead.

The mean fixations to CEVMS, standard billboards, and the road ahead were found to be similar in magnitude with no long fixations. Examination of dwell times showed that there was one long dwell time for a CEVMS greater than 2,000 ms and it occurred in the daytime on a sign located on the left side of the road on a freeway DCZ. Furthermore, when averaging among participants the mean dwell time for CEVMS was significantly longer than to standard billboards, but still under 2,000 ms. For the dwell time greater than 2,000 ms, examination of the scene camera video and eye tracking heat maps showed that the driver was initially looking toward the forward roadway and made a first fixation to the sign. Three fixations were made to the sign and then the driver started looking back to the road ahead as the sign moved out of the forward field of view. On the video there were no vehicles near the subject driver's own lane or in adjacent lanes.

Only the central 2 degrees of vision, foveal vision, provide resolution sharp enough for reading or recognizing fine detail.[(57)] However, useful information for reading can be extracted from parafoveal vision, which encompasses the central 10 degrees of vision.[(57)] More recent research on scene gist recognition[3] has shown that peripheral vision (beyond parafoveal vision) is more useful than central vision for recognizing the gist of a scene.[(58)] Scene gist recognition is a critically important early stage of scene perception, and influences more complex cognitive processes such as directing attention within a scene and facilitating object recognition, both of which are important in obtaining information while driving.

The results of this study do show one duration of eyes off the forward roadway greater than 2,000 ms, the duration at which Klauer et al. observed near-crash/crash risk at more than twice those of normal, baseline driving.[(14,53)] When looking at the tails of the fixation distributions, few fixations were greater than 1,000 ms, with the longest fixation being equal to 1,335 ms.[(53,54)] The one long dwell time on a CEVMS that was observed was a rare event in this study, and review of the video and eye tracking data suggests that the driver was effectively managing acquisition of visual information while driving and fixated on the advertising. However, additional work needs to be done to derive criteria for gazing or fixating away from the forward road view where the road scene is still visible in peripheral vision.

The results showed that drivers are more likely to look at CEVMS than standard billboards during the nighttime across the conditions tested (at night the average probability of gazing at CEVMS was M= 0.71). CEVMS do have greater luminance than standard billboards at night and also have higher contrast. The CEVMS have the capability of being lit up so that they would appear as very bright signs to drivers (for example, up to about10,000 cd/m^2 for a white square on the sign.). However, our measurements of these signs showed an average luminance of about 56 cd/m^2. These signs would be conspicuous in a nighttime driving environment but significantly less so than other light sources such as vehicle headlights. Drivers were also more likely to look at CEVMS than standard billboards on both arterials and freeways, with a higher probability of gazes on arterials.

In this second study, CEVMS and standard billboards were more nearly equated with respect to setback from the road. Gazes to the road ahead were not significantly different between CEVMS and standard billboard DCZs across conditions and the proportion of gazes to the road ahead were consistent with previous research. One long dwell time for a CEVMS was observed in this study; however, it occurred in the daytime where the luminance and contrast (affecting the perceived brightness) of these signs are similar to those for standard billboards.

[3] "Scene gist recognition" refers to the element of human cognition that enables us to determine the meaning of a scene and categorize it by type (e.g., a beach, an office) almost immediately upon seeing it.

GENERAL DISCUSSION

This study was conducted to investigate the effect of CEVMS on driver visual behavior in a roadway driving environment. An instrumented vehicle with an eye tracking system was used. Roads containing CEVMS, standard billboards, and control areas with no off-premise advertising were selected. The CEVMS and standard billboards were measured with respect to luminance, location, size, and other relevant variables to characterize these visual stimuli. Unlike previous studies on digital billboards, the present study examined CEVMS as deployed in two United States cities and did not contain dynamic video or other dynamic elements. The CEVMS changed content approximately every 8 to 10 seconds, consistent within the limits provided by FHWA guidance.[2] In addition, the eye tracking system used had nearly a 2-degree level of resolution that provided significantly more accuracy in determining what objects the drivers were gazing or fixating on as compared to some previous field studies examining CEVMS.

CONCLUSIONS

Do CEVMS attract drivers' attention away from the forward roadway and other driving relevant stimuli?

Overall, the probability of looking at the road ahead was high across all conditions. In Reading, the CEVMS condition had a lower proportion of gazes to the road ahead than the standard billboard condition on the freeways. Both of the off-premise advertising conditions had a lower proportion of gazes to the road ahead than the control condition on the freeway. The lower proportion of gazes to the road ahead can be attributed to the overall distribution of gazes away from the road ahead and not just to the CEVMS. On the other hand, for the arterials the CEVMS and standard billboard conditions did not differ from each other, but both had a lower proportion of gazes to the road ahead compared to the control. In Richmond there were no differences among the three advertising conditions on the arterials. However, for the freeways the CEVMS and standard billboard conditions did not differ from each other but had a lower proportion of gazes to the road ahead than the control.

The control conditions differed across studies. In Reading, the control condition on arterials showed 92 percent for gazing at the road ahead while on the freeway it was 86 percent. On the other hand, in Richmond the control condition for arterials was 78 percent and for the freeway it was 92 percent. The control conditions on the freeway differed across the two studies. In Reading there were businesses off to the side of the road; whereas in Richmond the sides of the road were mostly covered with trees. The control conditions on the arterials also differed across cities in that both contained businesses and on-premise advertising; however, in Reading arterials had four lanes and in Richmond arterials had six lanes. The reason for these differences across cities was that these control conditions were selected to match the other conditions (CEVMS and standard billboards) that the drivers would experience in the two respective cities. Also, the selection of DCZs was obviously constrained by what was available on the ground in these cities.

The results for the off-premise advertising conditions are consistent with Lee et al., who observed that 76 percent of drivers' time was spent looking at the road ahead in the CEVMS scenario and 75 percent in the standard billboard scenario.[9] However, it should be kept in mind that drivers did gaze away from the road ahead even when no off-premise advertising was present and that the presence of clutter or salient visual stimuli did not necessarily control where drivers gazed.

Do glances to CEVMS occur that would suggest a decrease in safety?

In DCZs containing CEVMS, about 2.5 percent of the fixations were to CEVMS (about 2.4 percent to standard billboards). The results for fixations are similar to those reported in other field data collection efforts that included advertising signs.[12,11,9,13] Fixations greater than 2,000 ms were not observed for CEVMS or standards billboards.

However, an analysis of dwell times to CEVMS showed a mean dwell time of 994 ms (maximum of 1,467 ms) for Reading and a mean of 1,039 ms (maximum of 2,270 ms) for Richmond. Statistical comparisons of average dwell times between CEVMS and standard billboards were not significant in Reading; however, in Richmond the average dwell times to CEVMS were significantly longer than to standard billboards, though below 2,000 ms. There was one dwell time greater than 2,000 ms to a CEVMS across the two cities. On the other hand, for standard billboards there were three long dwell times in Reading; there were no long dwell times to these billboards in Richmond. Review of the video data for these four long dwell times showed that the signs were not far from the forward view when participants were fixating. Therefore, the drivers still had access to information about what was in front of them through peripheral vision.

As the analyses of gazes to the road ahead showed, drivers distributed their gazes away from the road ahead even when there were no off-premise billboards present. Also, drivers gazed and fixated on off-premise signs even though they were generally irrelevant to the driving task. However, the results did not provide evidence indicating that CEVMS were associated with long glances away from the road that may reflect an increase in risk. When long dwell times occurred to CEVMS or standard billboards, the road ahead was still in the driver’s field of view.

Do drivers look at CEVMS more than at standard billboards?

The drivers were generally more likely to gaze at CEVMS than at standard billboards. However, there was some variability between the two locations and between type of roadway (arterial or freeway). In Reading, the participants looked more often at CEVMS when on arterials, whereas they looked more often at standard billboards when on freeways. In Richmond, the drivers looked at CEVMS more than standard billboards no matter the type of road they were on, but as in Reading the preference for gazing at CEVMS was greater on arterials (68 percent on arterials and 55 percent on freeways). The slower speed on arterials and sign placement may present drivers with more opportunities to gaze at the signs.

In Richmond, the results showed that drivers gazed more at CEVMS than standard billboards at night; however, for Reading no effect for time of day was found. CEVMS do have higher luminance and contrast than standard billboards at night. The results showed mean luminance of about 56 cd/m^2 in the two cities where testing was conducted. These signs would appear clearly visible but not overly bright.

SUMMARY

The results of these studies are consistent with a wealth of research that has been conducted on vision in natural environments.(26,22,21) In the driving environment, gaze allocation is principally controlled by the requirements of the task. Consistent results were shown for the proportion of gazes to the road ahead for off-premise advertising conditions across the two cities. Average fixations were similar to CEVMS and standard billboards with no long single fixations evident for either condition. Across the two cities, four long dwell times were observed: one to a CEVMS on a freeway in the day, two to the same standard billboard on a freeway (once at night and once in the daytime), and one to a standard billboard on an arterial at night. Examination of the scene video and eye tracking data indicated that these long dwell times occurred when the billboards were close to the forward field of view where peripheral vision could still be used to gather visual information on the forward roadway.

The present data suggest that the drivers in this study directed the majority of their visual attention to areas of the roadway that were relevant to the task at hand (i.e., the driving task). Furthermore, it is possible, and likely, that in the time that the drivers looked away from the forward roadway, they may have elected to glance at other objects in the surrounding environment (in the absence of billboards) that were not relevant to the driving task. When billboards were present, the drivers in this study sometimes looked at them, but not such that overall attention to the forward roadway decreased.

LIMITATIONS OF THE RESEARCH

In this study the participants drove a research vehicle with two experimenters on board. The participants were provided with audio turn-by-turn directions and consequently did not have a taxing navigation task to perform. The participants were instructed to drive as they normally would. However, the presence of researchers in the vehicle and the nature of the driving task do limit the degree to which one may generalize the current results to other driving situations. This is a general limitation of instrumented vehicle research.

The two cities employed in the study appeared to follow common practices with respect to the content change frequency (every 8 to 10 seconds) and the brightness of the CEVMS. The current results would not generalize to situations where these guidelines are not being followed.

Participant recruiting was done through libraries, community centers and at a university. This recruiting procedure resulted in a participant demographic distribution that may not be representative of the general driving population.

The study employed a head-free eye tracking device to increase the realism of the driving situation (no head-mounted gear). However, the eye tracker had a sampling rate of 60 Hz, which made determining saccades problematic. The eye tracker and analyses software employed in this effort represents a significant improvement in technology over previous similar efforts in this area.

The study focused on objects that were 1,000 feet or less from the drivers. This was dictated by the accuracy of the eye tracking system and the ability to resolve objects for data reduction. In addition, the geometry of the roadway precluded the consideration of objects at great distances.

The study was performed on actual roadways, and this limited the control of the visual scenes except via the route selection process. In an ideal case, one would have had roadways with CEVMS, standard billboards, and no off-premise advertising and in which the context surrounding digital and standard billboards did not differ. This was not the case in this study, although such an exclusive environment would be inconsistent with the experience of most drivers. This presents issues with the interpretation of the specific contributions made by billboards and the environment to the driver's behavior.

Sign content was not investigated (or controlled) in the present study, but may be an important factor to consider in future studies that investigate the distraction potential of advertising signs. Investigations about the effect of content could potentially be performed in driving simulators where this variable could be systematically controlled and manipulated.

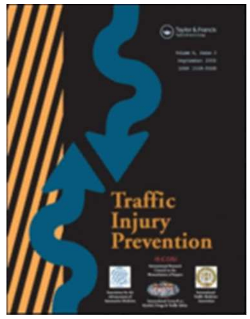
REFERENCES

1. National Highway Traffic Safety Administration. Policy Statement. [Available online at http://www.nhtsa.gov/Driving+Safety/Distracted+Driving/ci.Policy+Statement+and+Compiled+FAQs+on+Distracted+Driving.print.] Accessed 7/27/2012.
2. Shepherd, G. M., 2007: Guidance on Off-Premise Changeable Message Signs. http://www.fhwa.dot.gov/realestate/offprmsgsnguid.htm.
3. Scenic America. Position Paper Regarding the Propriety of Permitting Digital Billboards on Interstate and Federal-Aid Highways under the Highway Beautification Act. 2010.
4. Molino, J. A., J. Wachtel, J. E. Farbry, M. B. Hermosillo, and T. M. Granda. . The Effects of Commercial Electronic Variable Message Signs (Cevms) on Driver Attention and Distraction: An Update., FHWA-HRT-09-018. Federal Highway Administration, 2009.
5. Farbry, J., Wochinger, K., Shafer, T., Owens, N, & Nedzesky, A. Research Review of Potential Safety Effects of Electronic Billboards on Driver Attention and Distraction. Federal Highway Administration. Washington, DC, 2001.
6. Tantala, M. W., and A. M. Tantala. A Study of the Relationship between Digital Billboards and Traffic Safety in Henrico County and Richmond, Virginia. The Foundation for Outdoor Advertising Research and Education (FOARE), 2010.
7. Tantala, M. W., and A. M. Tantala. An Examination of the Relationship between Digital Billboards and Traffic Safety in Reading, Pennsylvania Using Empirical Bayes Analyses. *Moving Toward Zero 2100. ITE Technical Conference and Exhibit*, Buena Vista, FL, Institute of Transportation Engineers, 2011.
8. Elvik, R. The Predictive Validity of Empirical Bayes Estimates of Road Safety. *Accident Analysis & Prevention*, **40**, 2008**,** 1964-1969.
9. Lee, S. E., McElheny, M.J., & Gibbons, R. . Driving Performance and Digital Billboards. Report prepared for Foundation for Outdoor Advertising Research and Education. Virginia Tech Transportation Institute., 2007.
10. Society of Automotive Engineers. Definitions and Experimental Measures Related to the Specification of Driver Visual Behavior Using Video Based Techniques. 2000.
11. Beijer, D., A. Smiley, and M. Eizenman. Observed Driver Glance Behavior at Roadside Advertising Signs. *Transportation Research Record: Journal of the Transportation Research Board,*, ***No. 1899***, 2004**,** 96-103.
12. Smiley, A., T. Smahel, and M. Eizenman. Impact of Video Advertising on Driver Fixation Patters. *Transportation Research Record: Journal of the Transportation Research Board,*, **No. 1899**, 2004**,** 76-83.
13. Kettwich, C., K. Klinger, and U. Lemmer. Do Advertisements at the Roadside Distract the Driver? *Optical Sensors 2008*, San Diego, CA, SPIE, 2008.
14. Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J.D., & Ramsey, D.J. The Impact of Driver Inattention on near-Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data, DOT HS 810 594. National Highway Traffic Safety Administration, 2006.
15. Chattington, M., N. Reed, D. Basacik, A. Flint, and A. Parkes. Investigating Driver Distraction: The Effects of Video and Static Advertising, PPR409. Transport Research Laboratory, 2009.

16. Kettwich, C., K. Klinger, and U. Lemmer, 2008: Do Advertisements at the Roadside Distract the Driver? *Optical Sensors 2008*, F. Berghmans, A. G. Mignani, A. Cutolo, P. P. Moyrueis, and T. P. Pearsall, Eds., SPIE.
17. Cole, B. L., and P. K. Hughes. A Field Trial of Attention and Search Conspicuity. *Human Factors*, **26**, 1984**,** 299-313.
18. Ruz, M., and J. Lupiáñez. A Review of Attentional Capture: On Its Automaticity and Sensitivity to Endogenous Control. *Psicológica*, **23**, 2002**,** 283-309.
19. Wachtel, J. Safety Impacts of the Emerging Digital Display Technology for Outdoor Advertising Signs. The Veridian Group, Inc, 2009.
20. Theeuwes, J., and R. Burger. Attentional Control During Visual Search: The Effect of Irrelevant Singletons. *Journal of Experimental Psychology: Human Perception and Performance*, **24**, 1998**,** 1342-1353.
21. Tatler, B. W., M. M. Hayhoe, M. F. Land, and D. H. Ballard. Eye Guidance in Natural Vision: Reinterpreting Salience. *Journal of Vision*, **11**, 2011**,** 1-23.
22. Land, M. F. Vision, Eye Movements, and Natural Behavior. *Visual Neuroscience*, **26**, 2009**,** 51-62.
23. Eckstein, M. P. Visual Search: A Retrospective. *Journal of Vision*, **11**, 2011**,** 1-36.
24. Henderson, J., G. Malcolm, and C. Schandl. Searching in the Dark: Cognitive Relevance Drives Attention in Real-World Scenes. *Psychonomic Bulletin & Review*, **16**, 2009**,** 850-856.
25. Henderson, J. M., J. R. Brockmole, M. S. Castelhano, and M. Mack, 2007: Visual Saliency Does Not Account for Eye Movements During Visual Search in Real-World Scenes. *Eye Movements: A Window on Mind and Brain*, R. P. G. v. Gompel, M. H. Fischer, W. S. Murray, and R. L. Hill, Eds., Elsevier, 537-562.
26. Land, M. F. Eye Movements and the Control of Actions in Everyday Life. *Progress in Retinal and Eye Research*, **25**, 2006**,** 296-324.
27. Hayhoe, M., and D. Ballard. Eye Movements in Natural Behavior. *Trends in Cognitive Sciences*, **9**, 2005**,** 188-194.
28. Jovancevic-Misic, J., and M. Hayhoe. Adaptive Gaze Control in Natural Environments. *The Journal of Neuroscience*, **29**, 2009**,** 6234-6238.
29. Shinoda, H., M. M. Hayhoe, and A. Shrivastava. What Controls Attention in Natural Environments? *Vision Research*, **41**, 2001**,** 3535-3545.
30. SmartEye. Smarteye. [Available online at http://www.smarteye.se/.] Accessed June 22, 2012.
31. Whittle, P., Ed., 1994: *The Psychophysics of Contrast Brightness*. Lawrence Erlbaum Associates.
32. Regan, M. A., K. L. Young, J. D. Lee, and C. P. Gordon, 2009: Sources of Driver Distraction. *Driver Distraction: Theory, Effects, and Mitigation.*, M. A. Regan, J. D. Lee, and K. L. Young, Eds., CRC Press, Taylor & Francis Group.
33. Horberry, T., & Edquist, J., 2009: Distractions Outside the Vehicle. *Driver Distraction: Theory, Effects, and Mitigation.*, M. A. Regan, Lee, J.D., & Young, K.L., Ed., CRC Press, Taylor & Francis Group.
34. Rosenholtz, R., Y. Li, and L. Nakano. Measuring Visual Clutter. *J Vis*, **7**, 2007**,** 17 11-22.
35. Bravo, M. J., and H. Farid. A Scale Invariant Measure of Clutter. *Journal of Vision*, **8**, 2008**,** 1-9.

36. EyesDx. Multiple-Analysis of Psychophysical and Performance Signals (Mapps) [Available online at http://www.eyesdx.com/.] Accessed June 22, 2012.
37. Recarte, M. A., and L. M. Nunes. Effects of Verbal and Spatial-Imagery Tasks on Eye Fixations While Driving. *Journal of Experimental Psychology: Applied*, **6**, 2000**,** 31-43.
38. Manor, B. R., and E. Gordon. Defining the Temporal Threshold for Ocular Fixation in Free-Viewing Visuocognitive Tasks. *Journal of Neuroscience Methods*, **128**, 2003**,** 85-93.
39. Ahlstrom, C., K. Kircher, and A. Kircher. Considerations When Calculating Percent Road Centre from Eye Movement Data in Driver Distraction Monitoring. *Proceedings of the Fifth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*, 2009**,** 132-139.
40. Agresti, A., 2002: Analyzing Repeated Categorical Response Data. *Categorical Data Analysis, 2nd Edition*, D. J. Balding, Ed., John Wiley & Sons, Inc.
41. Stokes, M. E., C. S. Davis, and G. G. Koch. *Categorical Data Analysis Using the Sas System (2nd Ed.).* SAS Institute, Inc., Cary, NC, 2000.
42. Molenbergs, G., and G. Verbeke. Likelihood Ratio, Score, and Wald Tests in a Constrained Parameter Space. *The American Statistican*, **61**, 2007**,** 22-27.
43. ISO, 2002: Road Vehicles — Measurement of Driver Visual Behaviour with Respect to Transport Information and Control Systems —Part 1: Definitions and Parameters. ISO.
44. ISO, 2001: Road Vehicles — Measurement of Driver Visual Behaviour with Respect to Transport Information and Control Systems — Part 2: Equipment and Procedures. ISO.
45. *Highway Capacity Manual.* Transportation Research Board, Washington, DC, 2000.
46. Itti, L., and C. Koch. A Saliency-Based Search Mechanism for Overt and Covert Shifts of Visual Attention. *Vision Research*, **40**, 2000**,** 1489-1506.
47. Walther, D., and C. Koch. Modeling Attention to Salient Proto-Objects. *Neural Networks*, **19**, 2006**,** 1395-1407.
48. Itti, L., C. Koch, and E. Niebur. A Model of Saliency-Based Visual Attention for Rapid Scene Analysis. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, **20**, 1998**,** 1254-1259.
49. Walther, D. B. Saliency Toolbox. [Available online at http://www.saliencytoolbox.net/index.html.] Accessed 6/27/2012.
50. Land, M. F. Predictable Eye-Head Coordination During Driving. *Nature*, **359**, 1992**,** 318-320.
51. Balas, B., L. Nakano, and R. Rosenholtz. A Summary-Statistic Representation in Peripheral Vision Explains Visual Crowding. *Journal of Vision*, **9**, 2009**,** 1-18.
52. Levi, D. M. Crowding--an Essential Bottleneck for Object Recognition: A Mini-Review. *Vision Research*, **48**, 2008**,** 635-654.
53. Horrey, W. J., and C. D. Wickens. In-Vehicle Glance Duration: Distributions,Tails, and Model of Crash Risk. *Transportation Research Record*, **2018**, 2007**,** 22-28.
54. Wierwille, W. W., 1993: Visual and Manual Demands of in-Car Controls and Displays. *Automotive Ergonomics*, B. Peacock, and W. Karwowsk, Eds., Taylor and Francis, 299-320.
55. Strasburger, H., I. Rentschler, and M. Jüttner. Peripheral Vision and Pattern Recognition: A Review. *Journal of Vision*, **11**, 2011**,** 1-82.

56. Reimer, B. Impact of Cognitive Task Complexity on Drivers' Visual Tunneling. *Transportation Research Record: Journal of the Transportation Research Board*, **No. 2138**, 2009**,** 13–19.
57. Rayner, K., A. W. Inhoff, R. E. Morrison, M. L. Slowiaczek, and J. H. Bertera. Masking of Foveal and Parafoveal Vision During Eye Fixations in Reading. *Journal of Experimental Psychology: Human Perception and Performance*, **7**, 1981**,** 167-179.
58. Larson, A. M., and L. C. Loschky. The Contributions of Central Versus Peripheral Vision to Scene Gist Recognition. *Journal of Vision*, **9**, 2009**,** 1-16.



Effects of electronic billboards on driver distraction

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Effects of electronic billboards on driver distraction

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ABSTRACT

Objective: There is an increase in electronic advertising billboards along major roads which may cause driver distraction due to the highly conspicuous design of the billboards. Yet, only limited research on the impact of billboards on driving performance and driver behaviour is available. The Swedish Transport Administration recently approved the installation of twelve electronic billboards for a trial period along a four-lane motorway with heavy traffic running through central Stockholm, Sweden. The aim of this study was to evaluate the effect of these electronic billboards on visual behaviour and on driving performance.

Method: A total of 41 drivers were recruited to drive an instrumented vehicle passing four of the electronic billboards during day and night conditions. A driver was considered visually distracted when looking at a billboard continuously for more than two seconds, or if the driver looked away from the road for a high percentage of time. Dependent variables were eye-tracking measures and driving performance measures.

Results: The visual behaviour data showed that drivers had a significantly longer dwell time, a greater number of fixations and longer maximum fixation duration when driving past an electronic billboard compared to other signs on the same road stretches. No differences were found for the factors day/night, and no effect was found for the driving behaviour data.

Conclusion: Billboards have an effect on gaze behaviour by attracting more and longer glances than regular traffic signs. Whether the billboards attract attention too much, that is, whether they are a traffic safety hazard, cannot be answered conclusively based on the present data.

KEYWORDS

Visual distraction, electronic billboard, traffic safety, field study, eye tracking.

INTRODUCTION

Electronic billboards are designed to attract attention using static, dynamic or full-motion pictures. The more conspicuous and eye-catching the images are, the more likely they are to attract attention. In Sweden and unlike many other countries, the Swedish Transport Administration has been very restrictive in that roadside billboards and electronic billboards have not been permitted. In 2009, however, the administration gave temporary permission to the installation of twelve roadside electronic billboards, eight of which were installed at the time of the study. The trial period was subject to road traffic safety evaluation where driver distraction was of particular interest.

For 50 years electronic billboards have been allowed in many countries such as USA, Australia, Canada and New Zealand. In order to control and limit the potential negative effect on driver behaviour, different rules and guidelines have been established. The guidelines differ between countries and states, but typically they restrict the placement of the signs (i.e. avoid intersections), the luminance of the signs (i.e. avoid dazzling), the size of the board and the length and font size of the message (Cairney & Gunatillake, 2000; Farbry et al., 2001; Transit, 2008).

Driver distraction in general is believed to be a contributory factor to many accidents (Klauer et al., 2006; NHTSA, 2009; Olson et al., 2009). Modern electronic billboards are able to display dynamic messages either as slideshows or as animations or videos. The intent of these dynamic messages is to trigger bottom-up processes from the visual-sensory channels in order to capture the driver's attention. Most previous works have not been able to attribute increased crash rates to electronic billboards per se (McMonagle, 1952; Tantala & Tantala, 2007; Wallace, 2003), however, Farbry et al. (2001) found an increase in especially sideswipe crashes and rear-end crashes. Results from simulator studies show that the dynamic content as well as the placement of the billboard with respect to its surroundings have an influence on driving performance, i.e. greater variability on lateral lane position or slower speed while passing the billboards (Chattington et al., 2009; Crundall et al., 2006; Hughes & Cole, 1986). Eye-tracking studies confirm the attention grabbing nature of electronic billboards (Beijer et al., 2004; Crundall et al., 2006; Smiley et al., 2005; Young & Mahfoud, 2007; Young et al., 2009). A recent simulator study by Edquist et al. (2011) showed that billboards affected visual scanning, caused increased reaction times to road signs and increased the number of driver errors. Moreover, novice and older drivers were more affected. In another simulator study, Bendak and Al-Saleh (2010) found that road stretches with billboards caused more lane deviations and more occasions of recklessly crossing dangerous intersections.

A two-dimensional framework for attention selection in driving has been proposed by Trick and Enns (2009) where the first dimension accounts for top-down (goal-driven) processing versus bottom-up (stimulus-driven) processing, while the second dimension accounts for automatic processing versus controlled processing. Automatic processes can be *reflex* (bottom-up) or *habit* (top-down). These automatic processes are innate and are triggered by certain stimuli in the driving environment. Controlled processes can be *exploratory* (bottom-up) or *deliberate* (top-down). In the context of electronic billboards, the mechanism that has the greatest influence on the driver is reflexive attention selection (automatic/bottom-up). Reflexive responses cannot be disengaged and at best the negative effects can be minimised by intentional inhibition (Trick & Enns, 2009). Also, if the driver is interested in the advertisement, deliberate attention selection may occur (controlled/top-down).

Driver inattention has been defined as “insufficient, or no attention, to activities critical for safe driving” (Regan et al., 2011). This implies that whether a driver has been distracted or not can only be determined in retrospect, at least if “safe driving” is defined as the absence of crashes or critical situations. Based on Trick and Enns framework, a glance towards a billboard can have different reasons. The driver may employ a routine scanning behaviour to assess the traffic situation continuously. Noticing the billboard, the driver may choose to have a closer look, while having a mental picture of how the traffic situation is likely to develop. Thus, the glance is planned and unlikely to result in a dangerous situation. According to the definition above, such behaviour would not be considered distracted. Only if the driver’s attention is absorbed by the billboard more than originally intended, the driver may become distracted. Additionally, the billboard may also attract the driver’s attention in a reflexive manner, such that the glance can be described as involuntary. This may occur in all kinds of situations, including those in which averting the glance from the traffic scene is likely to lead to insufficient uptake of information. As it is difficult to separate intended from reflexive glances based on eye movement measurements, a more pragmatic definition was employed in the present study, which builds on the duration and frequency of glances directed towards the billboard.

The objective of this study is to evaluate the effect of electronic billboards on drivers’ visual behaviour and driving performance in a realistic field setting.

METHODOLOGY

The data were collected during a field study performed on a motorway in Stockholm, Sweden, in the fall of 2010. The study was approved by the local ethics committee in Linköping (2010-309-31).

Participants

In total, 41 drivers participated in the study. Their mean ± sd age was 42 ± 8 years and they had held their driving licence for 22 ± 9 years. Twenty participants drove between 9 a.m. to 3 p.m. (daylight conditions) and 21 participants drove between 6.30 p.m. to 9.30 p.m. (night-time conditions).These hours were chosen to avoid rush hours. All participants gave their informed consent and the local ethics committee approved the study.

Criteria for the recruitment of participants were that drivers should be between 35 to 55 years old, drive at least 5,000 km/year and drive several times a week. The recruitment process was done in two steps. First, a randomised sample of 200 drivers was acquired from the Swedish vehicle register. Based on this selection twelve drivers agreed to participate in the study. In a second step, the remaining drivers were recruited via an advertisement on the Swedish National Road and Transport Research Institute's website.

Stimuli and Apparatus

Visual behaviour was measured with a head-mounted eye tracker (IView, SMI, Teltow, Germany). An instrumented vehicle, a Volvo V70, was equipped with a data acquisition unit (VBox, RaceLogic, Buckingham, U.K.) to measure vehicle dynamics, and with a camera (MobilEye, Amstelveen, the Netherlands) to record the lateral position and longitudinal headway. All signals were sampled at 50 Hz.

Four electronic advertisement billboards were investigated in the study. The Swedish Transport Administration had constrained how the advertisements were to be displayed, for example, no video messages were allowed. In practice, the billboards changed the message every seven seconds which results in three to four different advertisements while passing the billboard. One of the billboards is illustrated in Figure 1. In addition to the four electronic advertisement billboards, another seven traffic signs were included in the study for comparison. These include three overhead gantries showing navigation information, two guide signs and one bus lane sign. Furthermore, one large static paper billboard sign was included. These signs were all located in the vicinity of the electronic billboards to ensure that the traffic conditions were comparable.

Insert figure 1 about here

There are some distinct differences between the electronic billboards and the other signs in the study: The billboards are lit, while the other signs are retroreflective, which most likely makes the billboards brighter. The message on the billboards is changed every 7^{th} second, which makes them somewhat dynamic, as each driver will see a number of changes on approach. In addition, the billboards are bigger than most regular traffic signs, which also increase their bottom-up attractiveness.

Design and Procedure

Light condition (daylight / night time) was treated as a between-subjects factor whereas type of sign (electronic billboard / conventional sign) and road stretch (stretch 1 – billboard, stretch 2 – before billboard, stretch 3 – after billboard) were treated as within-subjects factors.

The participants were welcomed at the office and started out by filling in an informed consent form. Then, the calibration of the eye tracking system was performed in the vehicle before the drive. The participants got accustomed to the car and to the eye tracker while driving from the office to the motorway where the actual experiment took place. The experimental route was 40 km long and took approximately 40 minutes to complete, depending on the traffic density. The participants received navigational instructions from an experimenter present in the car.

The participants were not informed about the purpose of the experiment until after the drive. Instead, they were told that the aim of the experiment was to investigate whether the eye tracking equipment could be used in real traffic and under different weather conditions.

Analyses

Driving behaviour was analysed in terms of mean speed, standard deviation of lateral position and minimum time headway. Since the traffic environment and the surrounding traffic changed continuously over time, it is important that baseline values were sampled in close proximity of the billboards. Therefore, the performance indicators were calculated based on data from three different road stretches in the proximity of each billboard. The stretch corresponding to the electronic billboard started where the sign became visible (at 750 m, 450 m, 650 m and 700 m for the four signs) and ended at the location of the sign. The other two stretches had the same length as the billboard stretch and were located just before and just after the billboard stretch. The distances indicating when the advert became visible were determined based on the helmet mounted camera on the eye tracker, and may underestimate the true distance since the camera has limited resolution and does not show everything in the visual field. Road stretches with a mean velocity below 50 km/h were excluded from the analysis.

Gaze analyses were carried out in BeGaze 3.0 (SensoMotoric Instruments, Teltow, Germany). In this software the areas of interest, that is the four electronic billboards and the seven other signs, were marked in the recorded video stream of each driver. Gazes and glances towards these highlighted areas were then automatically quantified. In this study, visual behaviour was analysed in terms of four different performance indicators: (i) dwell time, defined as the accumulated total time that the participants looked at a sign; (ii) visual time sharing, the percentage of time that the driver looked at a sign, defined as the dwell time divided by the exposure time; (iii) number of fixations, the total amount of fixations directed towards a sign and (iv) maximum fixation duration, the duration of the longest fixation directed towards a sign. Exposure time is defined as the duration from when the sign became visible until the vehicle passed the sign, excluding the time when the line of sight was obstructed by, for example, surrounding traffic. Fixations were detected based on a dispersion algorithm built into the analysis software, with a minimum fixation length of 80 ms and a maximum dispersion of 100 pixels.

The statistical analyses involved two-factor ANOVAs with interaction terms, using the factors time-of-day (daytime vs. night-time) and sign (billboard vs. control sign). Visual behaviour was analysed in two steps. It has to be noted that not all drivers looked at all signs. In the first analysis step the percentage of drivers who looked at billboards and the percentage of drivers who looked at control signs was determined. Gaze-based performance indicators (PI) could only be computed for those instances in which a driver had looked at a sign. It was decided to calculate one PI value per sign, which equals the mean of all instances in which a participant had looked at this particular sign. The analysis of variance was then conducted based on each sign, which could either be an electronic billboard or a control sign, and which could have been looked at during daytime or during night-time. The factors were treated as "between-subjects", as the glances which each sign attracted stemmed from different participants for the time-of-day factor, and could stem from either the same or different participants for the sign-type factor.

ANOVAs were also conducted for driving behaviour, but with the factors time-of-day and road stretch (stretch 1 – billboard, stretch 2 – before billboard, stretch 3 – after billboard). Separate analyses were performed for the four billboards since the preconditions, for example the speed limit, differed between the billboards. Missing values were present in the driving behaviour data as well, partly due to data acquisition issues but also since a lead vehicle was not always present.

All analyses were carried out in Matlab 7.11 (Mathworks Inc., Natick, MA, USA) and all tests used a significance level of $\alpha = 0.05$.

In the present study, a driver is considered to be visually distracted when looking at a billboard for more than two seconds with a single long glance or if the driver looks away from the road for a high percentage of time. The first criterion is based on the observation that long glances away from the road are detrimental for traffic safety (H.T. Zwahlen, Adams, Jr., et al., 1988). In the second criterion, the threshold for "high percentage" is set as when the dwell time is equal to or exceeds (exposure time +12)/9. This threshold stems from naturalistic driving studies where it has been found that the odds ratio for a crash is larger when the driver looks away for more than two seconds during the past six seconds or, alternatively, for more than three seconds during the past fifteen seconds (Klauer et al., 2010). The threshold, dwell time ≥ (exposure time +12)/9, is simply the linear function that connects the two coordinates <dwell time=2, exposure time=6> and <dwell time=3, exposure time=15>, where dwell time is used as a surrogate for eyes off road and exposure time is used as a surrogate to past 6/15 seconds. The range of the linear equation was limited to the interval of exposure times between 6 – 15 seconds (figure 5). The lower limit is motivated by earlier research which states that eye glances away from the road rarely exceed a duration of two seconds (Tania Dukic et al., 2005; Wikman et al., 1998) and that glances with durations longer than two seconds are considered dangerous (Klauer et al., 2006; Helmut T Zwahlen, Adams, & DeBald, 1988). The upper limit is based on Klauer's (2010) work which only considers time durations up to fifteen seconds.

RESULTS

The percentage of drivers who looked at the various signs is shown in figure 2. When aggregating the different signs into the two groups electronic billboards (S1 – S4) and other signs, it becomes clear that significantly more participants looked at the billboards ($F(1,18) = 13.3$, $p < 0.05$) than to the other signs. However, there is no significant difference between daytime and night-time ($F(1,18) = 0.5$, $p = 0.47$). “No tracking” indicates data loss which may be due to makeup, strong sunshine, reflections in the participants’eyeglasses or any other factor that interferes with the eye tracker.

Insert figure 2 about here

The differences in visual behaviour between the factors time-of-day and sign are presented in table 1. When drivers passed an electronic billboard, as compared to other signs, the dwell times were longer ($F(1,18)=16.4$, $p<0.05$), the number of fixations were greater ($F(1,18)=18.6$, $p<0.05$) and the maximum fixation duration was longer ($F(1,18)=5.7$, $p<0.05$). However, no significant effect on visual time sharing behaviour was found ($F(1,18)=1.8$, $p=0.19$). No significant differences were found in the visual behaviour variables between daytime and night-time, nor were there any significant interactions between the two factors. Boxplots for the different gaze behaviour variables and for all signs are presented in Figure 3 and estimated marginal means, divided by the factors time-of-day and sign, are presented in Figure 4.

Insert table 1 about here

Insert figure 3 about here

Insert figure 4 about here

In total there were 75 fixations to the billboards during daytime and 61 fixations during night-time. Corresponding numbers for the other signs were 23 fixations during daytime and 42 fixations during night-time. There were six fixations on the four electronic billboards that lasted for more than two seconds (range 2.1–3.5 s). These fixations originated from different drivers and were distributed amongst all four billboards except S1. In comparison, such long fixations only occurred once in total for the seven other signs. Figure 5 shows that there were five cases that were classified as visually distracted according to the visual time sharing criteria. Since two of the eleven distraction cases coincided, this adds up to nine distracted drivers. Outside the distraction boundaries, i.e. exposure times below 6 s or above 15 s, there were another ten occurrences of intensive visual time-sharing behaviour. Note that all cases where the visual time sharing intensity exceeds the threshold belong to the electronic advertising billboard group.

Insert figure 5 about here

Driving behaviour based performance indicators for the factors day/night and road stretch are presented in table 2. No consistent effects were found for any of the factors. A significantly lower speed was found during the night, but only for billboard S1, $F(116,1)=11.55$, $p<0.001$, and S2, $F(117,1)=62.75$, $p<0.001$. There was also a significantly longer time headway during the night, but only for billboard S3, $F(56,1)=4.71$, $p=0.03$. For the factor road stretch, significantly different speeds were found for billboard S1, $F(116,2)=12.55$, $p<0.001$, and S4, $F(100,2)=6.08$, $p=0.003$. Significantly different variability in lateral position was also found for billboard S1, $F(85,2)=7.50$, $p=0.001$, and S3, $F(95,2)=8.17$, $p=0.0005$, with . Post hoc analyses with t-tests showed that these differences mainly occurred on road stretches before and after the billboards, with lower speed on stretch 2 for S1 and higher speed on stretch 2 for S4, and with larger variability in lateral position on stretch 1 for S1 and larger variability on stretch 2 for S3.

Insert table 2 about here

Discussion

Overall, the electronic billboards attract more visual attention than the other traffic signs included in the study. Dwell times are longer, the visual time sharing intensity is higher, very long single glances are more frequent, and the number of fixations is greater for the electronic billboards. As the information on the billboards changes with regular intervals, the signs have the potential ability to keep up the drivers' curiosity over an extended period of time.

In short, the billboards are designed to attract attention in a bottom-up fashion, while traffic signs are built to inform when and where necessary, and drivers usually know approximately where to look for them. Earlier research has shown that drivers usually do not recall road signs that were not of direct relevance to the driver (Johansson & Backlund, 1970; Johansson & Rumar, 1966; Sprenger et al., 1997). This is an indication that drivers either ignore the signs already when passing them, as their top-down script tells them that those signs are not relevant at the moment, or that they process their content on a shallow level, without lasting memory traces. This is completely meaningful for traffic signs, both from the drivers' perspective and from the perspective of the road administration who set up the signs. For billboards this is different. Here the obvious wish of the producer is to attract attention and to create lasting memory traces. This means that signs must be visually conspicuous and attract attention long enough and intensively enough for passers-by to store them to memory.

Our data show that the billboards, in fact, attract more glances than the other signs. This comes as no surprise since there is something new to look at every seventh second. This particular cycle length is a compromise between traffic safety demands and requests from the billboard owners and was specified by the Swedish Road Administration based on trial and error followed by further refinements after complaints from the public. A different cycle length would probably have resulted in a slightly different outcome. A longer cycle length makes the billboards more similar to traditional signs whereas a higher message rate will eventually allow full motion video. A further refinement that resulted from official complaints was how the transition between to messages occurred. In the beginning two messages were separated by blanking out the display. This was found to cause distraction since some drivers said that they couldn't help waiting for the next message to appear. The transition was therefore altered so that two commercial messages followed directly after each other.

Our data also show that the billboards attract the glances of more drivers than the other signs do, which speaks for a reflexive component in the glance behaviour, according to the framework by Trick and Enns (2009). The next question is whether this reflexive component is strong enough that it endangers safe driving or not. Is the drivers' gaze inadvertently drawn to the billboards, or can drivers ignore the signs if necessary? As can be deducted from Figure 2 a substantial number of drivers did not look at the billboards at all, which is a strong indication that they actually can be ignored. We cannot know whether drivers actively ignored the signs, willing themselves not to look at them (Hallett, 1978), or whether drivers did not notice the signs at all. If they actively ignored the signs, this could be due to a top-down component of traffic requiring attention, or to the drivers' having learnt the position of the signs during earlier trips, which led to the drivers' making an active decision not to look at the presented advertisements.

For the investigated performance indicators, no differences were found between daytime and night-time driving. Theoretically it should be assumed that the billboards would be more conspicuous at night, as they appear brighter, but still, drivers did not look at the billboards more or for longer periods of time than during daytime. One reason might be an increased top-down pressure to fixate on the road in low visibility conditions. Another reason could be that the drivers chose to ignore the billboards in order to resist glare.

As the drivers' glances do not appear to be drawn to the billboards invariably, it can be assumed that drivers have a choice, at least to a certain extent, whether to look at the billboards or not. If drivers consider it safe to do so, is it still dangerous? Especially during night-time there could be other issues that are not caught by the performance indicators investigated here. As the billboards are rather bright in comparison to standard signs, there can be a concern about glare, due to the high contrast to the surrounding environment. Unfortunately we did not have the opportunity to measure the luminance of the electronic billboards. However, drivers did not avoid looking at the billboards at night-time more than during daytime, indicating that the brightness was not so high as to cause considerable glare.

Figure 4 shows that more glances are directed at the billboards than at the other signs. This could be due to the fact that a driver who looks at the billboard becomes interested in the message. Several glances might follow to decode the message completely, which may lead to insufficient attention to traffic due to a shift of goals. As shown in Figure 5, six out of seven glances exceeding two seconds were actually directed at the electronic billboards, and in four of these six cases high levels of glance diversion were reached with respect to the 2-in-6 to 3-in-15-seconds rule.

No consistent significant changes in driving behaviour with respect to speed, lateral placement of the vehicle or headway could be found between the phases before the billboard was visible, while it was visible and after it was passed. This finding is not completely unexpected, as this type of behaviour is rather automated. While no driving related impairments could be measured, it is still possible that latent decrements were present. It is theoretically possible that performance was reduced somewhat when drivers looked at the billboards intensively, but not enough to lead to conflicts. It is also possible that drivers would have had delayed reaction times and an impaired capability to detect divergent behaviour of other road users, making the long glances a catalyst for traffic conflicts. On the other hand, it might also be the case that performance was not reduced, as the drivers still might have kept enough resources directed at the traffic to perform unaffectedly. How driving behaviour and gaze behaviour would change in more or less complex situations than the one under examination here needs to be investigated in future studies.

The data can be interpreted in the way that those drivers who are understimulated by the traffic situation look around for entertainment, which is provided by the billboards. If this notion can be corroborated, the phenomenon might be used to steer drivers' attention in the desired direction in situations where it can be expected that drivers are likely to get bored, as situational stimulation is low. This could be the case in long tunnels, on motorways or long country roads with low traffic volumes.

The data were collected during real driving, thereby ensuring high external validity. The head mounted system used for eye tracking allowed gaze target detection, which made the glance evaluation reliable. However, the percentage of tracking loss was quite substantial, with losses of around 30% of the participants for some of the signs. Due to time and budget restrictions it could not be investigated whether those losses varied systematically with other variables that might have influenced the drivers' propensity to look at the billboards.

Furthermore, the drivers were not required to stay in a certain lane, as their driving behaviour should be as natural as possible. This means that trucks in adjacent lanes could obstruct the view of the billboards for some drivers, but not for others. This issue is in part taken care of by using the actual exposure time, that is, the time that the driver was physically able to see the sign, as a dimensioning factor for the relevant PI.

The participants in this study received their navigational instructions from the experimenter present in the car, which implies that there was only a limited need for the participants to look at signs with navigation information. Consequentially there should be no or only very little top-down activation to search for navigation signs, while other traffic signs like speed limits or lane restrictions still provide useful information. All drivers were familiar with the road including the billboards, which might have influenced how they reacted to the billboards, but also to the other signs. Top-down processing is likely to have a higher impact on a familiar route, as drivers do not need to look for signs and information the way they would have to on an unfamiliar route. This increases the likelihood that drivers who looked at the billboards extensively actually wanted to do so.

External validity, i.e. how generalizable the results are, was considered through the following measures. A homogeneous group of participants who were very familiar with the road was selected to make shore that the billboards were not novel to the driver. Middle-aged experienced drivers were selected to reduce the spread in the data further. The subject sample selected for this study should be seen as a best case scenario as both novice and older drivers have been found to be more affected by electronic billboards (Edquist et al., 2011). In general, both novice and older drivers have difficulties to manage larger amounts of information (de Waard et al., 1999; Ponds et al., 1988), and elderly drivers have deteriorated physiological abilities and are more prone to suffer from glare (Puell et al., 2004). Limited resources allowed us to include at most 40 participants, and to maintain a critical mass in each subgroup, we were left with the choice of either investigating daytime versus night-time effects or different age groups. In this case we selected to study the effects of different light conditions while leaving the equally important question about age to future studies.

As the billboards had already been in place when the study was commissioned, it was not possible to run a baseline-treatment comparison in the exact location of the billboards. This was only considered a minor problem in the analyses of driving behaviour; road stretches in immediate vicinity to the billboards were very similar to those where the billboards were placed, both in terms of geographical factors, traffic density, weather and lighting conditions. Therefore, these stretches could be used as viable baselines.

CONCLUSIONS

To conclude, billboards appear to have an effect on gaze behaviour as that they attract more and longer glances than regular traffic signs. This clearly indicates that they do what they are built for. Whether they attract attention too much, that is, whether they are a traffic safety hazard, cannot be answered conclusively based on the present data. This has to be investigated on the one hand in more controlled studies, where traffic situations of varying complexity can be staged and the environment can be controlled in a better way, and on the other hand in on-road studies that do not only consider gaze behaviour, speed and lateral position data, but also tactical manoeuvring and conflicts.

The present study constitutes one part of a larger investigation (T. Dukic et al., 2011), where analyses of speed at a macro level and accident statistics from 2003 to March 15, 2011, were included (no significant differences were found that could be attributed to the billboards when comparing before and after their installation). The Swedish Road Administration also administered a larger questionnaire study (unpublished) which showed that glare and visual clutter was seen as a problem. Based on the results reported here, along with results from the other studies, the Swedish authorities decided not to extend the test period and to remove the billboards under investigation.

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References

Beijer, D, Smiley, A, & Eizenman, M. Observed Driver Glance Behavior at Roadside Advertising Signs. *Transp Res Rec.* 2004, 1899, 96-103.

Bendak, S, & Al-Saleh, K. The role of roadside advertising signs in distracting drivers. *Int J Ind Ergon.* 2010, 40, 233-236.

Cairney, P, & Gunatillake, T. Roadside advertising signs - A review of the literature and recommendations for policy. 2000. ARRB Transp Res. Contract Report for RACV (Royal Automobile Club of Victoria).

Chattington, M, Reed, N, Basacik, D, Flint, A, & Parkes, A. Investigating driver distraction: The effects of video and static advertising (No. CPR208). 2009. Crowthorne, UK: Transport Research Laboratory.

Crundall, D, Van Loon, E, & Underwood, G. Attraction and distraction of attention with roadside advertisements. *Accid Anal Prev.* 2006, 38, 671-677.

de Waard, D, van der Hulst, M, & Brookhuis, KA. Elderly and young driver's reaction to an in-car enforcement and tutoring system. *Appl Ergon.* 1999, 30(2), 147-157.

Dukic, T, Ahlström, C, Björketun, U, Kettwich, C, Yahya, M-R, Patten, C, Tapani, A, & Vadeby, A. Effects of billboards on traffic safety – A study on the motorway E4 in Stockholm (No. 725). 2011. Linköping, Sweden.

Dukic, T, Hanson, L, Holmqvist, K, & Wartenberg, C. Effect of button location on driver's visual behaviour and safety perception. *Ergonomics.* 2005, 48(4), 399-410.

Edquist, J, Horberry, T, Hosking, S, & Johnston, I. Effects of advertising billboards on simulated driving. *Appl Ergon.* 2011, 42(4), 619-626.

Farbry, J, Wochinger, K, Shafer, T, Owens, N, & Nedzesky, A. Research review of potential safety effects of electronic billboards on driver attention and distraction. 2001. Washington, DC.

Hallett, P. Primary and secondary saccades to goals defined by instructions. *Vision Res.* 1978, 18, 1279-1296.

Hughes, PK, & Cole, BL. What Attracts Attention When Driving? *Ergon.* 1986, 29(6), 377-391.

Johansson, G, & Backlund, F. Drivers and road signs. *Ergon.* 1970, 13, 749-759.

Johansson, G, & Rumar, K. Drivers and road signs: A preliminary investigation of the capacity of car drivers to get information from road signs. *Ergon.* 1966, 9, 57-62.

Klauer, SG, Dingus, TA, Neale, VL, Sudweeks, J, & Ramsey, D. The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data (No. DOT HS 810 594). 2006. Washington DC: NHTSA.

Klauer, SG, Guo, F, Sudweeks, J, & Dingus, TA. An Analysis of Driver Inattention Using a Case-Crossover Approach 100-Car Data: Final Report (No. DOT HS 811 334). 2010. Washington, DC.

McMonagle, A. Traffic accidents and roadside features. *Highway Res Board Bulletin.* 1952, 55, 38-48.

NHTSA. Traffic safety facts – Research note: An examination of driver distraction as recorded in NHTSA databases (No. DOT HS 811 216). 2009.

Olson, RL, Hanowski, RJ, Hickman, JS, & Bocanegra, J. Driver distraction in commercial vehicle operations (No. FMCSA-RRR-09-042). 2009. Washington, D.C.

Ponds, RW, Brouwer, WH, & van Wolffelaar, PC. Age differences in divided attention in a simulated driving task. *J Gerontol.* 1988, 43(6), P151-156.

Puell, MC, Palomo, C, Sanchez-Ramos, C, & Villena, C. Mesopic contrast sensitivity in the presence or absence of glare in a large driver population. *Graefes Arch Clin Exp Ophthalmol.* 2004, 242(9), 755-761.

Regan, MA, Hallett, C, & Gordon, CP. Driver distraction and driver inattention: Definition, relationship and taxonomy. *Accid Anal Prev.* 2011, 43(5), 1771-1781.

Smiley, A, Persaud, B, Bahar, G, Mollett, C, Lyon, C, Smahel, T, & Kelman, WL. Traffic safety evaluation of video advertising signs. *Transp Res Record.* 2005, 1937, 105-112.

Sprenger, A, Scheider, W, & Derkum, H. (1997). *Traffic signs, visibility and recognition.* Paper presented at the 7th Int Conf Vision in Vehicles, Marseilles.

Tantala, AM, & Tantala, MW. A study of the relation between digital billboards and traffic safety in Cuyahoga county, Ohio. 2007. Philadelphia, PA: Tantala Associates.

Transit. Can I put an advertising sign alongside a state highway? 2008. Retrieved 2012/04/19, from http://www.nzta.govt.nz/resources/advertising-sign-alongside-sh/

Trick, LM, & Enns, JT. (2009). A two-dimensional framework for understanding the role of attention selection in driving. In C. Castro (Ed.), *Human Factors of Visual and Cognitive Performance in Driving* Boca Raton, Florida: CRC Press.

Wallace, B. Driver distraction by advertising: genuine risk or urban myth? *Munic Eng.* 2003, 156, 185-190.

Wikman, A-S, Nieminen, T, & Summala, H. Driving experience and time-sharing during in-car tasks on roads of different width. *Ergonomics.* 1998, 41(3), 358-372.

Young, MS, & Mahfoud, JM. Driven to Distraction: Determining the effects of Roadside Advertising on Driver Attention. 2007. Uxbridge, UK: Brunel University.

Young, MS, Mahfoud, JM, Stanton, NA, Salmon, PM, Jenkins, DP, & Walker, GH. Conflicts of interest: The implications of roadside advertising for driver attention. *Transp Res Part F.* 2009, 12, 381-388.

Zwahlen, HT, Adams, CC, & DeBald, DP. (1988). *Safety aspects of CRT touch panel controls in automobiles.* Paper presented at the Vision in Vehicles II, Nottingham, England.

Zwahlen, HT, Adams, CC, Jr., & Debald, DP. (1988). Safety aspects of CRT touch panel controls in automobiles. In A. G. Gale, M. H. Freeman, C. M. Haslegrave, P. A. Smith & S. P. Taylor (Eds.), *Vision in Vehicle II* (Vol. 2, pp. 335-344). North Holland: Elsevier Science B.V.

Table 1: Mean and standard deviation of the different gaze behaviour variables grouped by the factors day/night and electronic billboard versus other types of signs.

	Day		Night	
	Billboard	Other signs	Billboard	Other signs
Dwell time (s)	2.23 ± 2.26	0.87 ± 0.73	2.09 ± 2.21	1.16 ± 0.74
Visual Time Sharing (%)	15.29 ± 13.21	9.20 ± 5.84	11.33 ± 11.84	10.80 ± 5.87
Number of fixations (#)	2.68 ± 1.93	1.26 ± 0.45	2.10 ± 1.37	1.50 ± 0.88
Maximum fixation duration (s)	0.95 ± 0.78	0.62 ± 0.55	1.00 ± 0.73	0.70 ± 0.43

Table 2: Mean and standard deviation of the different driving performance variables in groups of the factors day/night and road stretch (at the billboard, before the billboard and after the billboard).

		Day			Night		
		Billboard	Before	After	Billboard	Before	After
Mean velocity (km/h)	S1	86.41 ± 5.53	81.94 ± 5.19	88.03 ± 5.88	83.30 ± 6.93	78.09 ± 5.93	84.28 ± 5.14
	S2	105.43 ± 4.32	105.26 ± 5.33	106.32 ± 4.16	99.04 ± 4.82	98.94 ± 4.86	98.05 ± 5.66
	S3	88.48 ± 8.04	90.85 ± 5.41	90.53 ± 4.30	89.97 ± 5.95	90.31 ± 6.06	89.79 ± 6.63
	S4	82.82 ± 6.17	85.65 ± 4.38	80.42 ± 5.98	82.45 ± 6.66	86.67 ± 5.37	82.64 ± 6.03
Standard deviation of lateral position (cm)	S1	16.76 ± 3.84	16.02 ± 5.70	14.53 ± 5.85	24.20 ± 12.95	14.16 ± 6.60	12.67 ± 3.95
	S2	12.85 ± 3.11	15.62 ± 4.49	14.15 ± 9.83	18.15 ± 11.52	17.16 ± 5.83	14.02 ± 7.41
	S3	14.18 ± 5.07	26.45 ± 20.41	16.65 ± 5.23	12.66 ± 3.88	18.50 ± 7.85	15.94 ± 7.73
	S4	16.31 ± 5.36	17.74 ± 4.60	14.48 ± 5.13	15.66 ± 5.15	19.72 ± 7.36	16.01 ± 7.34
Minimum time headway (s)	S1	1.70 ± 0.73	2.02 ± 1.02	1.90 ± 0.90	1.79 ± 0.82	1.64 ± 0.91	2.32 ± 1.14
	S2	1.86 ± 0.85	1.81 ± 0.84	1.91 ± 0.88	2.14 ± 0.81	2.32 ± 0.87	2.03 ± 0.82
	S3	1.85 ± 0.48	2.25 ± 1.33	1.63 ± 0.34	2.89 ± 1.29	2.56 ± 1.54	2.22 ± 0.98
	S4	1.53 ± 0.60	1.63 ± 0.63	1.65 ± 0.46	1.91 ± 0.84	1.67 ± 0.88	1.60 ± 0.86

Figure 1: Example showing one of the electronic advertising billboards.

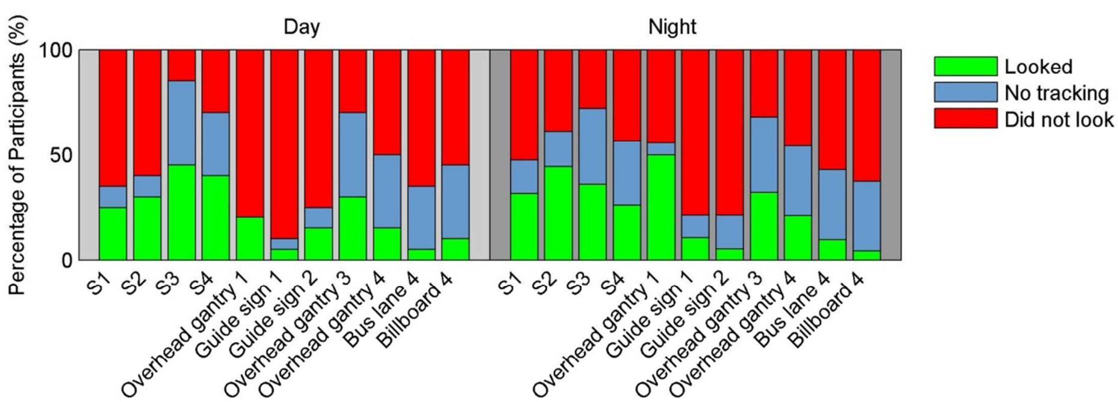

Figure 2: The percentage of participants that looked (green) or did not look (red) at the different signs. Light grey background indicates daytime driving and dark grey background illustrates night-time driving. The number after the signs indicates the location from where the data originates. For example, overhead gantry 1 and guide sign 1 were located in the vicinity of the electronic billboard S1.

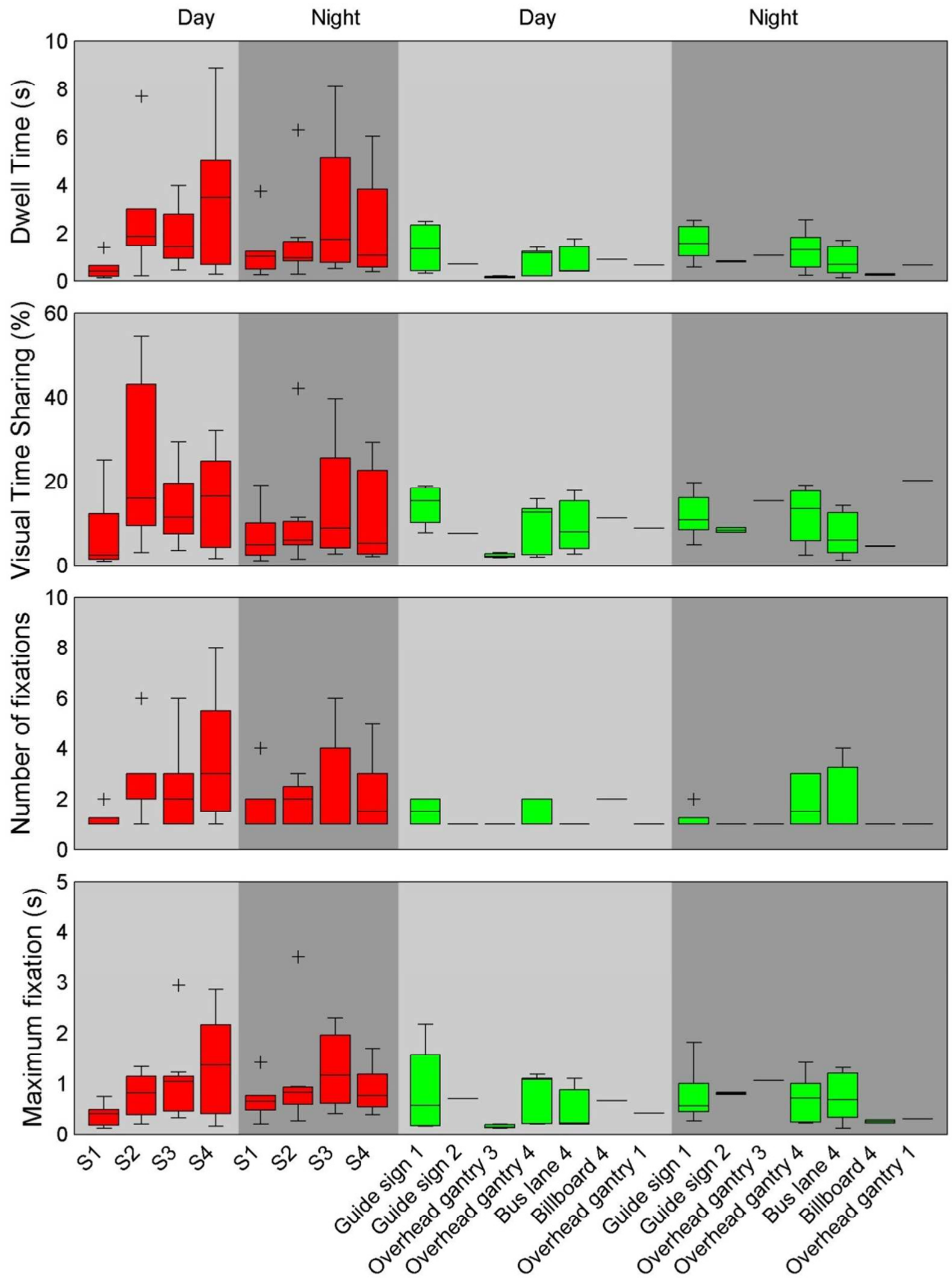

Figure 3: Boxplots of dwell time, visual time sharing, number of fixations and the longest fixations for each sign. Red boxes are electronic billboards, green boxes are other signs. Light grey background indicates daytime driving and dark grey background illustrates night-time driving. On each box, the central mark is the median, the edges of the box are the first and third quartiles, the whiskers extend to the most extreme data points within 1.5 times the interquartile range and outliers are plotted individually.

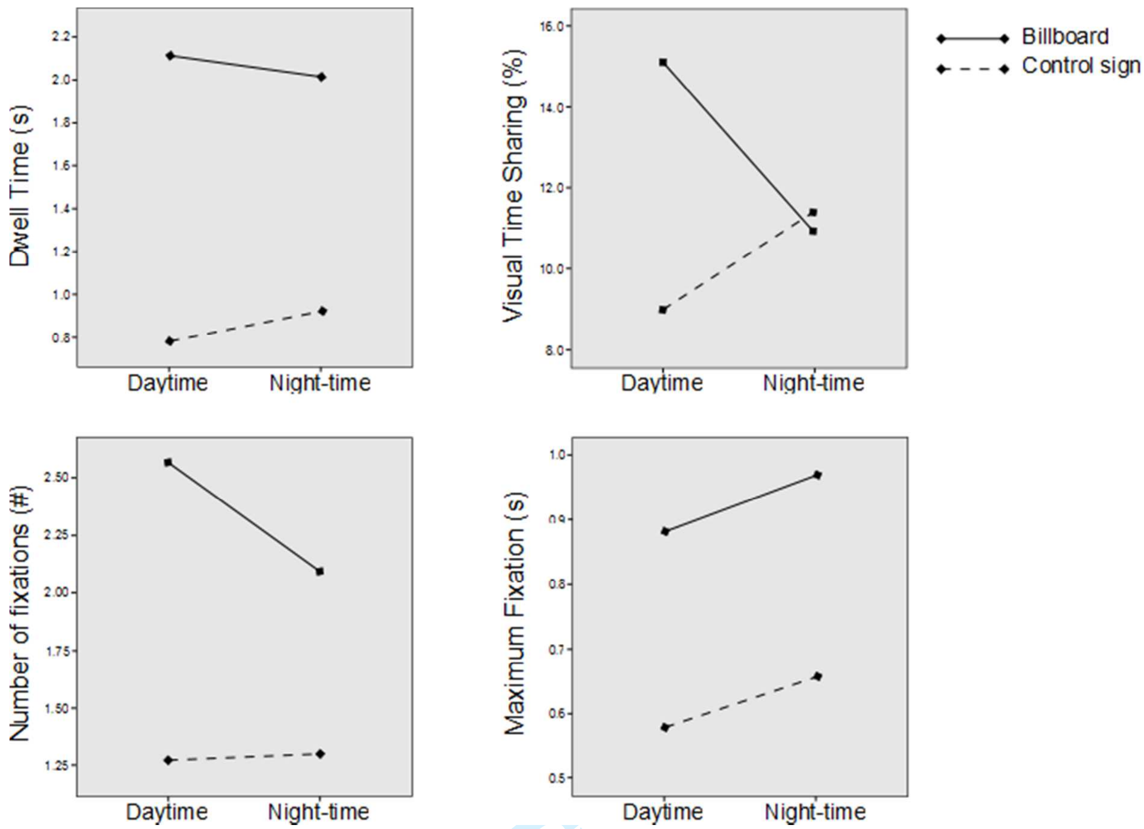

Figure 4: Mean values across participants and signs for dwell time, visual time sharing, number of fixations and the longest fixations for the factors time-of-day and sign-type.

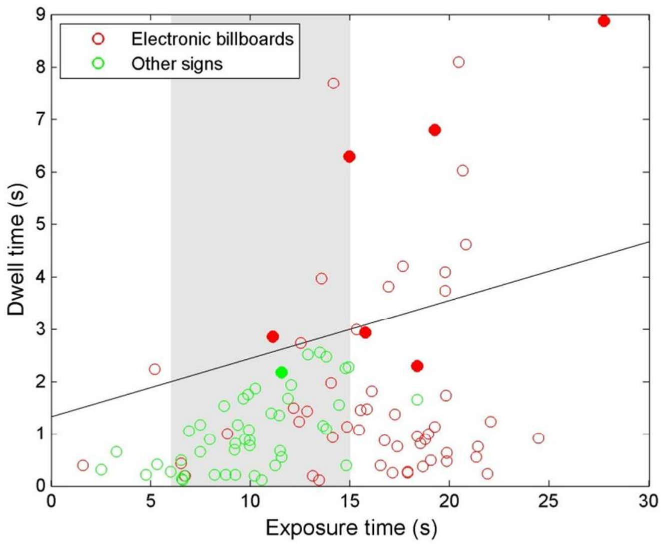

Figure 5: Scatter plot of dwell time as a function of exposure time. Red circles indicate glances at electronic advertising billboards and green circles represent glances at other types of signs. Filled circles represent cases with a single glance longer than two seconds. The line represents a threshold based on the 2-in-6 and the 3-in-15 rules, where all cases above the line are considered as occurrences of visual distraction. The shaded area determines where these rules are considered as valid.

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The Impact of Driver Inattention On Near-Crash/Crash Risk:

An Analysis Using the 100-Car Naturalistic Driving Study Data

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16. Abstract

The purpose of this report was to conduct in-depth analyses of driver inattention using the driving data collected in the 100-Car Naturalistic Driving Study. An additional database of baseline epochs was reduced from the raw data and used in conjunction with the crash and near-crash data identified as part of the original 100-Car Study to account for exposure and establish near-crash/crash risk. The analyses presented in this report are able to establish direct relationships between driving behavior and crash and near-crash involvement. Risk was calculated (odds ratios) using both crash and near-crash data as well as normal baseline driving data for various sources of inattention. The corresponding population attributable risk percentages were also calculated to estimate the percentage of crashes and near-crashes occurring in the population resulting from inattention. Additional analyses involved: driver willingness to engage in distracting tasks or driving while drowsy; analyses with survey and test battery responses; and the impact of driver's eyes being off of the forward roadway.

The results indicated that driving while drowsy results in a four- to six-times higher near-crash/crash risk relative to alert drivers. Drivers engaging in visually and/or manually complex tasks have a three-times higher near-crash/crash risk than drivers who are attentive. There are specific environmental conditions in which engaging in secondary tasks or driving while drowsy is more dangerous, including intersections, wet roadways, and areas of high traffic density. Short, brief glances away from the forward roadway for the purpose of scanning the driving environment are safe and actually decrease near-crash/crash risk. Even in the cases of secondary task engagement, if the task is simple and requires a single short glance the risk is elevated only slightly, if at all. However, glances totaling more than 2 seconds for any purpose increase near-crash/crash risk by at least two times that of normal, baseline driving.

17. Key Words 100-Car, Naturalistic, Intelligent Vehicle Initiative, Driver Behavior, Human Factors, Inattention, Distraction, Eyes Off Forward Roadway, Driver Drowsiness		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, VA 22161	
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EXECUTIVE SUMMARY

INTRODUCTION

The purpose of this report was to conduct in-depth analyses of driver inattention using the driving data collected in the 100-Car Naturalistic Driving Study. These data provide unique opportunities for transportation researchers as data were collected over an 18-month period and represent normal, daily driving with all the stress and pressures that occur in a metropolitan environment.

This analysis also demonstrates one of the primary strengths of large-scale naturalistic driving data in that analytical methods from epidemiology, empirical research, and qualitative research can all be employed to answer research questions. Figure ES.1 shows the relationship of naturalistic data to empirical and epidemiological data. Naturalistic data can help complete gaps in the transportation research between epidemiology and empirical methods by collecting enough data to conduct epidemiological analyses while still collecting detailed driver behavior and driving performance data.

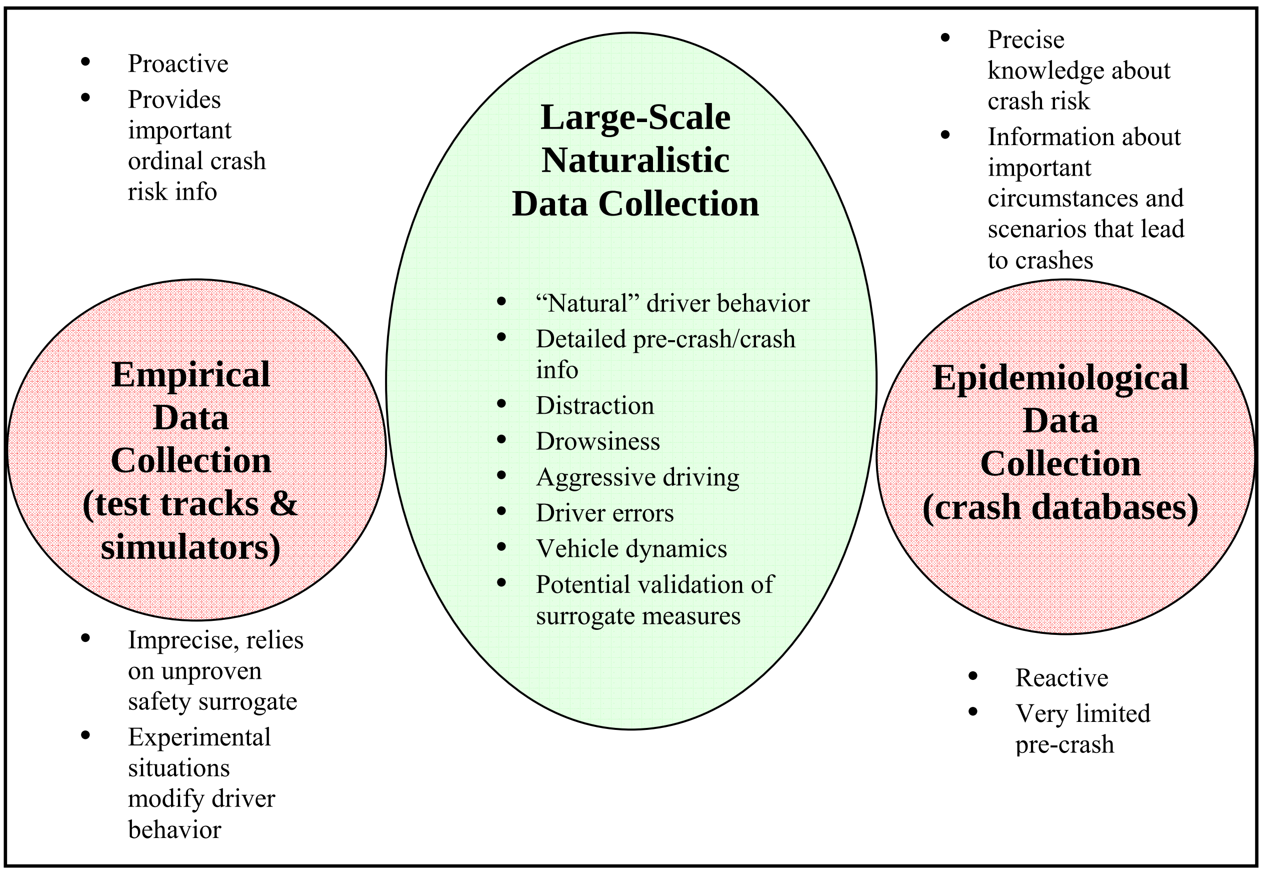

Figure ES.1. The relationship between empirical, naturalistic, and epidemiological methods in driving safety research.

The following analyses are able to establish direct relationships between driving inattention and crash and near-crash involvement because of the extensive real-world observations of drivers' behavior. Relative near-crash/crash risk was calculated (odds ratios) using both crash and near-crash data compared to normal, baseline driving data for various sources of inattention. Crashes and near-crashes were used because it was found that the kinematic signatures of both are similar and using both increased statistical power. The corresponding population attributable risk percentage calculations were used to determine what percentage of crashes and near-crashes occurring in the population are attributable to inattention. The relative near-crash/crash risk and population attributable risk percentage calculations provide useful counterpoint assessments of the crash-risk problem. The odds ratio provides the increased risk of each source of inattention per individual whereas the population attributable risk percentage provides an assessment of how this individual risk translates to a percentage of crashes and near-crashes in the population at-large.

METHOD

For these analyses, two reduced databases were used: the 100-Car Study *event database* that consists of the reduced crashes, near-crashes, and incidents; and the *baseline database*. The *baseline database* was created specifically for this analysis by stratifying the entire dataset based upon the number of crashes, near-crashes, and incidents each vehicle was involved in and then randomly selecting 20,000 6-second segments from the 6.3 terabytes of driving data. For example, a vehicle involved in over 3 percent of all the total crashes, near-crashes, and incidents would also represent 3 percent of the baselines. Vehicles that were not involved in any crashes, near-crashes, or incidents were not represented in the baseline database. This stratification of the baseline epochs was performed to create a *case-control* data set where there are multiple baseline epochs per each crash or near-crash event to allow for more accurate calculation of odds ratios.

The variables that were recorded for the 20,000 baseline epochs included the vehicle, environmental, and most drivers' state variables. In addition, eyeglance analyses were performed for 5,000 of these baseline epochs. The event variables were not recorded for the baseline epochs as these variables (e.g., precipitating factor, evasive maneuver) were not present when an incident, near-crash, or crash did not occur. Table ES.1 shows the breakdown of the type of data that currently exists as part of the original 100-Car Study event database and the baseline database.

Table ES.1. Description of the Databases Created for the Distraction Analysis

	100-Car Study Event Database	**Baseline Database (epochs)**
1.	Vehicle variables	Vehicle variables
2.	Event variables	N/A
3.	Environmental Variables	Environmental Variables
4.	Driver's State Variables	Driver's State Variables
	Eyeglance data (crashes, near-crashes, and incidents)	Eyeglance data on 5,000 randomly selected baseline distraction events.
	Observer Rating of Drowsiness (ORD) for crashes and near-crashes	Drowsiness was marked yes/no with "yes" = ORD of 60 or above.
5.	Driver/Vehicle 2	N/A
10.	Narrative	N/A

The questionnaire data collected during the 100-Car Study was also used in these analyses. Table ES.2 presents a list of all the surveys and test batteries that were administered to the primary drivers.

Table ES.2. Description of questionnaire and computer-based tests used for the 100-Car Study.

	Name of Testing Procedure	Type of Test	Time test was administered	Brief description
1.	Driver demographic information	Paper/pencil	In-processing	General information on driver age, gender, etc.
2.	Driving History	Paper/pencil	In-processing	General information on recent traffic violations and recent collisions.
3.	Health assessment questionnaire	Paper/pencil	In-processing	List of variety of illnesses/medical conditions/or any prescriptions that may affect driving performance.
4.	Dula Dangerous Driving Index	Paper/pencil	In-processing	One score that describes driver's tendencies toward aggressive driving.
5.	Sleep Hygiene	Paper/pencil	In-processing	List of questions that provide information about driver's general sleep habits/substance use/sleep disorders.
6.	Driver Stress Inventory	Paper/Pencil	In-processing	One score that describes the perceived stress levels drivers experience during their daily commutes.
7.	Life Stress Inventory	Paper/pencil	In-processing/Out-processing	One score that describes drivers stress levels based upon the occurrence of major life events.
8.	Useful Field-of-View	Computer-based test	In-processing	Assessment of driver's central vision and processing speed, divided and selective attention.
9.	Waypoint	Computer-based test	In-processing	Assessment of the speed of information processing and vigilance.
10.	NEO-FFI	Paper/pencil	In-processing	Personality test.
11.	General debrief questionnaire	Paper/pencil	Out-processing	List of questions ranging from seatbelt use, driving under the influence, and administration of experiment.

MAJOR CONCLUSIONS

The analyses reported in this document are derived from direct measurements of driver inattention immediately prior to a crash or near-crash. The analytical methods that were used in this report were borrowed from epidemiology, empirical research, and qualitative research. The application of these analytical methods demonstrates the power of naturalistic driving data and its importance in relating driving behavior to crash and near-crash involvement.

Driver inattention was defined for this report as one of the following:

1) Driver engagement in secondary tasks (those tasks not necessary to the primary task of driving)
2) Driver drowsiness
3) Driving-related inattention to the forward roadway
4) Non-specific eyeglance away from the forward roadway

These four types of inattention, singly or in combination, were used to answer the research questions addressed in this report. Some of the important findings are presented below:

- This study allowed for the calculation of relative near-crash/crash risk of engaging in various types of inattention-related activities. Some of the primary results were that driving while drowsy increases an individual's near-crash/crash risk by four to six times, engaging in complex secondary tasks increases risk by three times, and engaging in moderate secondary tasks increases risk by two times that of normal, baseline driving. *Driving-related inattention to the forward roadway* was actually shown to be safer than normal, baseline driving (odds ratio of 0.45). This was not surprising as drivers who are checking their rear-view mirrors are generally alert and engaging in environmental scanning behavior.

- This study also allowed for the calculation of population attributable risk percentages. This calculation produces an estimate of the percentage of crashes and near-crashes in the population where the specific inattention-related activity was a contributing factor. The results of this analysis indicated that driving while drowsy was a contributing factor for 22 to 24 percent of the crashes and near-crashes and secondary-task distraction contributed to over 22 percent of all crashes and near-crashes. This is a useful metric since odds ratios estimate risk on a per-task (or drowsiness episode) basis while the population attributable risk percentage accounts for the frequency of occurrence. Thus, some inattention-related activities that indicated high relative near-crash/crash risk had corresponding population attributable risk percentages indicating low total percentages. This was due to lower frequency of occurrence. Conversely, other more frequently performed inattention activities, while obtaining lower relative near-crash/crash risks, obtained higher population attributable risk percentages.

- The prevalence of driving inattention was analyzed by using normal, baseline driving (i.e., no event crash, near-crash, or incident present) as established by the baseline distraction database. The four types of inattention were recorded alone and in combination with the other types of inattention. The percent of the total baseline epochs in which drivers were engaged in each type of inattention is as follows:

  secondary tasks – 54 percent of baseline epochs
  driving-related inattention – 44 percent of baseline epochs
  drowsiness – 4 percent of baseline epochs
  non-specific eyeglance – 2 percent of baseline epochs

  Note that the total is higher than 100 percent since drivers engaged in multiple types of inattention activities at one time. *Non-specific eyeglance* was most frequently recorded as associated with the other types of inattention but accounts for only 2 percent of the baseline epochs, singularly. Given that the baseline epochs most closely represent "normal, baseline driving," these results suggest that drivers frequently engage in inattention-related tasks.

- The analysis of eyeglance behavior indicates that total eyes-off-road durations of greater than 2 seconds significantly increased individual near-crash/crash risk whereas eyeglance durations less than 2 seconds did not significantly increase risk relative to normal, baseline driving. The purpose behind an eyeglance away from the roadway is important to consider. An eyeglance directed at a rear-view mirror is a safety-enhancing activity in the larger context of driving while eyeglances at objects inside the vehicle are not safety-enhancing. It is important to remember that scanning the driving environment is an activity that enhances safety as long as it is systematic and the drivers' eyes return to the forward view in under 2 seconds.

- The results for the analysis investigating the impact of driver drowsiness on environmental conditions resulted in many interesting results. First, driver drowsiness may vary depending on time of day or ambient lighting conditions. Drowsiness was also seen to slightly increase in the absence of high roadway or traffic demand. A higher percentage of drowsiness-related baseline epochs were found during free-flow traffic densities on divided roadways and areas free of roadway junctions.

- The results of the analysis investigating the impact of complex or moderate secondary task engagement on various environmental conditions were more varied. Each of the eight environmental conditions resulted in odds ratios greater than 1.0 when engaging in complex secondary tasks. Engaging in moderate secondary tasks rarely resulted in odds ratios significantly greater than 1.0 which indicates that these behaviors are not as risky as driving while engaging in complex secondary tasks.

- The most frequent type of secondary task engagement, hand-held device use, also obtained odds ratios greater than 1.0 for both *dialing hand-held device* (OR = 2.8; CL = 1.6 – 4.9) and *talking/listening to a hand-held device* (OR = 1.3; CL = 0.9 – 1.8). *Talking/listening to a hand-held device* was not significantly different than 1.0, indicating that this task was not as risky as *dialing a hand-held device*. Despite the differences in these odds ratios, the *hand-held-device-related* secondary tasks had nearly identical population attributable risk percentages (each contributing to 3.6 percent of crashes and near-crashes). This is because drivers were talking/listening to hand-held devices a much larger percentage of time than they were dialing hand-held devices. Thus, the percentage of crashes and near-crashes that were attributable to these two actions was similar due to the fact that dialing was more dangerous but was performed less frequently whereas talking/listening was less dangerous but performed more frequently.

- The results from the survey and test battery response analyses indicated that drivers with high involvement in inattention-related crashes and near-crashes were significantly younger and possessed less driving experience than the drivers who were involved in fewer inattention-related crashes and near-crashes. The high-involvement drivers also self-reported significantly more traffic violations and being involved in more accidents prior to the beginning of the study. Other test scores demonstrated that the high-involvement drivers were more often drowsy and scored significantly lower on selected personality inventories than did the drivers that were involved in fewer inattention-related crashes and near-crashes.

- A clear relationship between involvement in inattention-related crashes and near-crashes and engaging in inattention-related activities during baseline driving was observed. A correlation of 0.72 was obtained suggesting that those drivers who are frequently involved in inattention-related crashes and near-crashes are not simply getting "caught" at inopportune moments. These drivers engage in inattention-related activities frequently. Those drivers who are not frequently engaging in inattention-related tasks are therefore not involved in as many inattention-related crashes and near-crashes.

GLOSSARY OF TERMS

ANOVA – Analysis of variance.

Additional driver – Family or friends of the primary driver who drove the subject's vehicle and were not involved with the in-processing.

Associative Factors – Any environmental or vehicular factor where direct causation to crashes, near-crashes, or incidents is not possible to attain but correlation may be determined.

Backing crash – A crash that occurs while the driver's vehicle is in reverse gear.

Chase vehicle – Vehicle designated for locating (through GPS or other means) and downloading data from subject vehicles.

Contributing factors – Any circumstance that leads up to or has an impact on the outcome of the event. This term encompasses driver proficiency, willful behavior, roadway infrastructure, distraction, vehicle contributing factors and visual obstructions.

Crash – Any contact with an object, either moving or fixed, at any speed in which kinetic energy is measurably transferred or dissipated. Includes other vehicles, roadside barriers, objects on or off the roadway, pedestrians, cyclists, or animals.

Crash-Relevant Event – A subjective judgment of any circumstance that requires, but is not limited to, a crash avoidance response on the part of the subject-vehicle driver, any other vehicle, pedestrian, cyclist, or animal that is less severe than a rapid evasive maneuver (as defined in near-crash event), but greater in severity than a "normal maneuver" to avoid a crash. A crash avoidance response can include braking, steering, accelerating, or any combination of control inputs. A "normal maneuver" for the subject vehicle is defined as a control input that falls outside of the 95 percent confidence limit for control input as measured for the same subject.

Conflict Type – All crashes, near-crashes, crash-relevant conflicts and proximity conflicts were categorized based on the initial conflict that lead to the crash that occurred or would have occurred in the case of near-crashes and incidents. There were 20 types of conflicts used which are as follows: conflict with lead vehicle, following vehicle, oncoming traffic, vehicle in adjacent lane, merging vehicle, vehicle turning across subject-vehicle path (same direction), vehicle turning across subject-vehicle path (opposite direction), vehicle turning into subject vehicle path (same direction), vehicle turning into subject-vehicle path (opposite direction), vehicle moving across subject-vehicle path (through intersection), parked vehicle, pedestrian, cyclist, animal, obstacle/object in roadway, single-vehicle conflict, other, no known conflict, unknown conflict. This list was primarily from National Automotive Sampling System (NASS) General Estimates System (GES) Accident Types.

DAS – Data Acquisition System.

Data Reduction – Process by which trained Virginia Tech Transportation Institute (VTTI) employees reviewed segments of driving video and recorded a taxonomy of variables that provide information regarding the sequence of events leading up to the crash, near-crash, incident, as well as environmental variables, roadway variables, and driver-behavior variables.

Driver distraction - When a driver has chosen to engage in a secondary task that is not necessary to perform the primary driving task.

Driver Impairment – The driver's behavior, judgment, or driving ability is altered or hindered. This includes drowsiness, use of drugs or alcohol, illness, lack of or incorrect use of medication, or disability.

Driver Proficiency – Whether the individual's driving skills, abilities, or knowledge are inadequate. This specifically refers to whether the driver appeared to be aware of specific traffic laws (i.e., no U-turn), whether the driver was incompetent to safely perform a driving maneuver (i.e., check for traffic before pulling out on a roadway), unaware of the vehicle's turning radius, or performs driving maneuvers under the incorrect assumption that it is safe, (i.e., drives over a concrete median).

Driver-Related Inattention to the Forward Roadway – Inattention due to a necessary and acceptable driving task where the subject is required to shift attention away from the forward roadway. (e.g., checking blind spots, center mirror, instrument panel).

Driver Reaction – The evasive maneuver performed in response to the precipitating event.

Driver Seat Belt Use – Variable indicating if the subject is wearing a seat belt during an event.

Drowsiness – Refers to a driver who is either moderately to severely drowsy, as defined by Wierwille and Ellsworth (1994). A driver who is moderately drowsy will exhibit slack musculature in the facial muscles and limited overall body movement as well as a noticeable reduction in eye scanning behaviors. A severely drowsy driver will exhibit all the above behaviors as well as extended eye lid closures and will have difficulties keeping his/her head in a lifted position.

EDR – Electronic data recorder.

Epoch – Typically, a 6-second period of time that was selected randomly to allow for the observation of normal, baseline driving.

Event – A term referring to all crashes, near-crashes, and incidents. The "event" begins at the onset of the precipitating factor and ends after the evasive maneuver.

Event Nature – Classification of the type of conflict occurring in the event (e.g., conflict with lead vehicle, conflict with vehicle in adjacent lane).

Event Severity – Classification of the level of harm or damage resulting from an event. The five levels were crash, near-crash, crash-relevant, proximity, and non-conflict.

FARS – Fatality Analysis Reporting System.

FOV – Field of view.

FV – Following vehicle**.**

GPS – Global Positioning System **–** used by data reductionists to locate participant vehicle for information on an event.

Inattention – Any event or epoch where drowsiness, driver-related inattention to the forward roadway, driver secondary tasks, or non-specific eyeglance away from the forward roadway were identified as a contributing factors to the event.

Incident – Encompasses the event severities of crash-relevant conflicts and proximity conflicts.

IVI – Intelligent Vehicle Initiative**.**

IR LEDs – Infrared light-emitting diode.

Invalid Trigger – Any instance where a prespecified signature in the driving performance data stream is observed but no safety-relevant event is present. See Appendix C for a more complete definition of triggers.

LV – Lead vehicle.

MVMT – Million vehicle miles traveled.

NHTSA – National Highway Traffic Safety Administration.

Naturalistic – Unobtrusive observation. Observation of behavior taking place in its natural setting.

Near-crash – A subjective judgment of any circumstance that requires, but is not limited to, a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal to avoid a crash. A rapid, evasive maneuver is defined as a steering, braking, accelerating, or any combination of control inputs that approaches the limits of the vehicle capabilities.

Non-Conflict – Any incident that increases the level of risk associated with driving, but does not result in a crash, near-crash, or incident as defined. Examples include driver-control error without proximal hazards being present, driver-judgment error such as unsafe tailgating or excessive speed, or cases in which drivers are visually distracted to an unsafe level.

Non-Subject Conflict – Any incident, crash-relevant conflict, near-crash, or crash that is captured on video but does not involve the subject driver. Labeled as a non-subject conflict but data reduction was not completed.

Onset of Conflict - Sync number designated to identify the beginning of a conflict; also known as the beginning of the precipitating factor.

ORD – Observer Rating of Drowsiness; measured on a scale from 0 to 100 in increasing severity of drowsiness. Based on Wierwille and Ellsworth (1994), who developed this procedure where observable behaviors were identified to allow data reductionists to reliably and consistently rate the drowsiness of drivers using post-hoc video data reduction.

Precipitating factor – The driver behavior or state of the environment that initiates the crash, near-crash, or incident, and the subsequent sequence of actions that result in an incident, near-crash, or crash.

Primary Driver – The recruited participant designated as the main driver of his or her own vehicle or a leased vehicle

Proximity Event – Any circumstance resulting in extraordinarily close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the driver(s), pedestrians, cyclists, or animals, there is no avoidance maneuver or response attempted. Extraordinarily close proximity is defined as a clear case where the absence of an avoidance maneuver or response is inappropriate for the driving circumstances (including speed, sight distance, etc.).

Pre-Incident Maneuver – The maneuver that the driver was performing immediately prior to the event. The importance of this is to record what the driver was doing before the precipitating event occurred.

Precipitating Factor – The action of a driver that begins the chain of events leading up to the crash, near-crash, or incident. For example, for a rear-end striking collision, the precipitating factor most likely would be lead vehicle begins braking (or lead vehicle brake lights illuminate).

Secondary Task – Task, unrelated to driving, which requires subjects to divert attention resources from the driving task, e.g., talking on the hand-held device, talking to passenger, eating, etc.

Rear-end striking – Refers to the subject vehicle striking a lead vehicle.

Rear-end struck - Refers to the subject vehicle being struck by a following vehicle.

Sideswipe – Refers to either a vehicle in the adjacent lane changing lanes into the subject vehicle lane or the subject vehicle changing lanes into an already occupied adjacent lane.

SV – Subject vehicle.

Time-to-Collision (TTC) – A calculation that estimates the moment of impact. This calculation uses radar data (either forward or rear) to obtain measures of range and range-rate.

Trigger/Trigger Criteria – A signature in the data stream that, when exceeded, 90 seconds of video data (60 seconds prior and 30 seconds after the data excedence) and the corresponding driving performance data are copied and saved to a database. Trained data reductionists assessed these segments of video and driving performance data to determine whether this segment of data contained a safety-relevant conflict (i.e., crash, near-crash, or incident) or not. Examples of triggers include a driver braking at 0.76 *g* longitudinal deceleration or swerving around an obstacle, obtaining a 0.8 *g* lateral acceleration. For a more complete description of triggers, see Appendix C.

US DOT – United States Department of Transportation.

Valid Event or Valid Trigger – Those events where a specific signature in the data stream was identified and viewed by a data reductionist and deemed to contain a safety-relevant scenario. Data reductionists recorded all relevant variables and stored this data in the 100-Car Study database.

Vehicle Run-Off-Road – Describes a situation when the subject vehicle departed the roadway.

VDOT – Virginia Department of Transportation.

Virginia Tech Motor Pool – An extension of the Virginia Tech Office of Transportation.

VTTI – Virginia Tech Transportation Institute.

Visual Obstruction – This variable refers to glare, weather, or an object obstructing the view of the driver that impacts the event in any way.

Willful Behavior – The driver knowingly and purposefully drives in an unsafe or inappropriate manner. Includes aggressive driving, purposeful violation of traffic laws, use of vehicle for improper purposes (i.e., intimidation).

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CHAPTER 1: INTRODUCTION AND METHOD

BACKGROUND

Transportation researchers have long been aware of the negative effects of driver distraction and inattention on driving performance. Researchers have devised clever experimental designs on test tracks and simulators to gain greater understanding of the effects of various sources of driver inattention on reaction time, lateral deviations, time-to-collision (TTC), etc., in both normal and unexpected driving environments. While this research is important and useful to understanding whether these behaviors impact driving performance, it is largely unknown whether driver inattention actually decreases safety and relative crash risk on roadways (Hancock, Lesch, and Simmons, 2003; Dingus, 1995).

Crash database research has found that driver inattention is a contributing factor in approximately 25 to 30 percent of all actual crashes on roadways (Wang, Knipling, and Goodman, 1996). Unfortunately, this statistic is based upon police accident reports that were completed at the scene of crashes. The investigating police officer would only mark distraction or inattention if the driver admitted guilt or an eyewitness observed that the driver was inattentive. Given the source of this information and the potential for inaccurate information to be recorded, most transportation researchers believe that the actual percentage is much higher. Regardless of beliefs, the true effects of driving inattention on crash rates are unknown.

While both empirical and epidemiological research are useful to understanding aspects of the problem of driving inattention, there are significant questions that still need to be addressed. The 100-Car Naturalistic Driving Study (Dingus et al., 2005) provides the type of pre-crash driver behavior data that is necessary to take initial steps at calculating measures such as:

- The increased relative near-crash/crash risk for various types of driver inattention
- The frequency and prevalence of driver inattention in a normal roadway environment
- The types of environmental conditions in which drivers choose to engage in driving inattention
- The impact of eyeglance behavior on near-crash/crash risk

Also, using questionnaire data from the participating drivers, initial attempts to characterize those drivers who are involved in inattention-related crashes versus those drivers who are not involved in inattention-related crashes can also be performed.

The purpose of this report was to conduct in-depth analyses of driver inattention using the driving data collected in the 100-Car Study. These data provide unique opportunities for transportation researchers, as data were collected in 109 cars for a period of 12 to 13 months per car. The data represent normal, baseline driving with all the natural stress and pressures that occur in an urban environment.

For the analyses conducted in this report, two reduced databases were used: the 100-Car Study *event database* and the *baseline database*.

For the original 100-Car Study analyses, the *event database* consisted of crashes, near-crashes, and incidents, which were defined as follows:

- Crash: Any physical contact between the subject vehicle and another vehicle, fixed object, pedestrian, cyclist, animal, etc., as assessed by either the lateral or longitudinal accelerometers.
- Near-crash**:** A conflict situation requiring a rapid, severe, evasive maneuver to avoid a crash.
- Incident**:** A conflict requiring an evasive maneuver, but of lesser magnitude than a near-crash.

The *baseline database* was created specifically for this analysis by randomly selecting a stratified sample of 20,000 6-second segments, referred to as *baseline epochs*. The method used to randomly stratify this sample will be discussed in detail below.

This report will use the *event database*, the *baseline database*, and the questionnaire data to answer the following six research objectives:

Objective 1. What are the prevalence as well as the types of driver inattention in which drivers engage during their daily driving? What is the relative risk of a crash or near-crash while engaging in an inattentive task? Does the relative risk differ for different types of secondary tasks?

Objective 2. What are the environmental conditions associated with a drivers' choice of engaging in secondary tasks or driving while drowsy? What are the relative risks of a crash or near-crash while engaging in driving inattention while encountering these environmental conditions (e.g., time of day, road type, weather conditions, passengers in the vehicle, etc.)?

Objective 3. Determine the differences in demographic data, test battery results, and performance-based measures between inattentive and attentive drivers? How might that knowledge be used to mitigate the potential negative consequences of inattentive driving behaviors? Could this information be used to improve driver education courses or traffic schools?

Objective 4. What is the relationship between measures obtained from pretest batteries (e.g., a life stress test) and the frequency of engagement in distracting behaviors while driving? Does there appear to be any correlation between willingness to engage in distracting behaviors and life stress scores, personality characteristics, or ability to focus attention?

Objective 5. Are there differences in driving performance for drivers who are engaging in an inattentive task versus those drivers who are attending solely to the forward roadway?

Objective 6. Are there differences in driving performance for drivers who are engaging in a distraction task versus those drivers who are attending to driving? Are some of the safety surrogate measures more sensitive to driving performance differences when driving while distracted versus other safety surrogate measures?

Each of these six research objectives will be presented in a separate chapter with results from the data analysis and conclusions. The last chapter of the report will summarize all key results and conclusions from this analysis and outline future directions for this research.

For a complete description of the 100-Car Study method, instrumentation, and data collection procedure, refer to Dingus et al. (2005). In order to provide an abbreviated description, the following description is provided from the Neale, Klauer, Dingus, and Goodman (2005) report.

METHOD

Instrumentation

The 100-Car Study instrumentation package was engineered by the Virginia Tech Transportation Institute (VTTI) to be rugged, durable, expandable, and unobtrusive. It constituted the seventh generation of hardware and software developed over a 15-year period that has been deployed for a variety of purposes. The system consisted of a Pentium-based computer that receives and stores data from a network of sensors distributed around the vehicle. Data storage was achieved via the system's hard drive, which was large enough to store data for several weeks of driving before requiring data downloading.

Each of the sensing subsystems in the car was independent so any failures that occurred were constrained to a single sensor type. Sensors included: a vehicle network box that interacted with the vehicle network, an accelerometer box that obtained longitudinal and lateral kinematic information, a headway detection system to provide information on leading or following vehicles, side obstacle detection to detect lateral conflicts, an incident box to allow drivers to flag incidents for the research team, a video-based lane-tracking system to measure lane-keeping behavior, and video to validate any sensor-based findings. The video subsystem was particularly important as it provided a continuous window into the happenings in and around the vehicle. This subsystem included five camera views monitoring the driver's face and driver side of the vehicle, the forward view, the rear view, the passenger side of the vehicle, and an over-the-shoulder view for the driver's hands and surrounding areas. An important feature of the video system is that it was digital with software-controllable video compression capability. This allowed synchronization, simultaneous display, and efficient archiving and retrieval of 100-Car Study data. A frame of compressed 100-Car Study video data is shown in Figure 1.1.

The modular aspect of the data collection system allowed for integration of instrumentation that was not essential for data collection, but provided the research team with additional and important information. These subsystems included: automatic collision notification that informed the research team of the possibility of a collision; cellular communications that were used by the research team to communicate with vehicles on the road to determine system status and position; system initialization equipment that automatically controlled system status; and a Global Positioning System (GPS) subsystem that collected information on vehicle position. The GPS subsystem and the cellular communications were often used in concert to allow for vehicle localization and tracking.

Figure 1.1. A compressed video image from the 100-Car Study data. The driver's face (upper left quadrant) is distorted to protect the driver's identity. The lower right quadrant is split with the left-side (top) and the rear (bottom) views.

The system included several major components and subsystems that were installed on each vehicle. These included the main data acquisition system (DAS) unit that was mounted under the package shelf for the sedans (Figure 1.2) and behind the rear seat in the SUVs.

Doppler radar antennas were mounted behind special plastic license plates on the front and rear of the vehicle (Figure 1.3). The location behind the plates allowed the vehicle instrumentation to remain inconspicuous to other drivers.

Figure 1.2. The main DAS unit mounted under the "package shelf" of the trunk.

Figure 1.3. Doppler radar antenna mounted on the front of a vehicle, covered by a mock-up of one of the plastic license plates used for the study.

The final major components in the 100-Car Study hardware installation were mounted above and in front of the center rear-view mirror. These components included an "incident" pushbutton box which housed a momentary pushbutton that the subject could press whenever an unusual event happened in the driving environment. Pressing the incident button would open an audio channel which recorded the driver's voice explaining the nature of the incident. Also contained in the housing was an unobtrusive miniature camera that provided the driver face view. The camera was invisible to the driver since it was mounted behind a “smoked” Plexiglas cover.

Mounted behind the center mirror were the forward-view camera and the glare sensor (Figure 1.4). This location was selected to be as unobtrusive as possible and did not occlude the driver’s normal field of view.

Figure 1.4. The incident pushbutton box mounted above the rear-view mirror. The portion on the right contains the driver-face/left-vehicle side camera hidden by a smoked plexiglass cover.

Subjects

One-hundred drivers who commuted into or out of the Northern Virginia/Washington, DC, metropolitan area were initially recruited as primary drivers to have their vehicles instrumented or to receive a leased vehicle for this study. Drivers were recruited by placing flyers on vehicles as well as by placing announcements in the classified section of local newspapers. Drivers who had their private vehicles instrumented (78) received $125 per month and a bonus at the end of the study for completing necessary paperwork. Drivers who received a leased vehicle (22) received free use of the vehicle, including standard maintenance, and the same bonus at the end of the study for completing necessary paperwork. Drivers of leased vehicles were insured under the Commonwealth of Virginia policy.

As some drivers had to be replaced for various reasons (for example, a move from the study area or repeated crashes in leased vehicles), 109 primary drivers were included in the study. Since other family members and friends would occasionally drive the instrumented vehicles, data were collected on 132 additional drivers.

A goal of this study was to maximize the potential to record crash and near-crash events through the selection of subjects with higher than average crash or near-crash risk exposure. Exposure was manipulated through the selection of a larger sample of drivers below the age of 25, and by the selection of a sample of drivers who drove more than the average number of miles. The age by gender distribution of the primary drivers is shown in Table 1.1. The distribution of miles driven by the subjects during the study appears as Table 1.2. As presented, the data are somewhat biased compared to the national averages in each case, based on TransStats, 2001. Nevertheless, the distribution was generally representative of national averages when viewed across the distribution of mileages within the TransStats data.

One demographic issue with the 100-Car Study data sample that needs to be understood is that the data were collected in only one region (i.e., Northern Virginia/Washington, DC, metropolitan area). This area represents primarily urban and suburban driving conditions, often in moderate to heavy traffic. Thus, rural driving, as well as differing demographics within the United States, are not well represented.

Table 1.1. Driver age and gender distributions.

	Gender		
Age	**Female** N Percent	**Male** N Percent	**Grand Total**
18-20	9 8.3%	7 6.4%	16 14.7%
21-24	11 10.1%	10 9.2%	21 19.3%
25-34	7 6.4%	12 11.0%	19 17.4%
35-44	4 3.7%	16 14.7%	20 18.3%
45-54	7 6.4%	13 11.9%	20 18.3%
55+	5 4.6%	8 7.3%	13 11.9%
Total N Total %	43 39.4%	66 60.6%	109 100.0%

Table 1.2. Actual miles driven during the study.

Actual miles driven	Number of Drivers	Percent of Drivers
0-9,000	29	26.6%
9,001-12,000	22	20.2%
12,001-15,000	26	23.9%
15,001-18,000	11	10.1%
18,001-21,000	8	7.3%
More than 21,000	13	11.9%

A goal of the recruitment process was to attempt to avoid extreme drivers in either direction (i.e., very safe or very unsafe). Self-reported historical data indicate that a reasonably diverse distribution of drivers was obtained.

Vehicles

Since over 100 vehicles had to be instrumented with a number of sensors and data collection hardware and the complexity of the hardware required a number of custom mounting brackets to be manufactured, the number of vehicle types had to be limited for this study. Six vehicle models were selected based upon their prevalence in the Northern Virginia area. These included five sedan models (Chevrolet Malibu and Cavalier, Toyota Camry and Corolla, and Ford Taurus) and one SUV model (Ford Explorer). The model years were limited to those with common body types and accessible vehicle networks (generally 1995 to 2003). The distribution of these vehicle types was:

- Toyota Camry – 17 percent
- Toyota Corolla – 18 percent
- Chevy Cavalier – 17 percent
- Chevy Malibu – 21 percent
- Ford Taurus – 12 percent
- Ford Explorer – 15 percent

PROCEDURE FOR DATA REDUCTION: 100-CAR STUDY EVENT DATABASE

Data reduction for the 100-Car Naturalistic Driving Study as well as for these current analyses refers to a process of recording specific variables based upon review of the video. This data reduction process will be discussed in detail in the following sections.

Sensitivity Analysis

As stated in Dingus et al. (2005), data were collected continuously on board the instrumented vehicles. As project resources did not allow for the review of all the data, a sensitivity analysis was conducted to establish post-hoc “triggers.” A post-hoc trigger uses either a single signature (e.g., any lateral acceleration value greater than ±0.6 *g*) or multiple signatures (e.g., forward TTC value > 3 seconds plus a longitudinal deceleration value > -0.5 *g*) in the driving performance data stream to identify those points in time when it was likely that a driver was involved in an incident, near-crash, or crash.

Figure 1.5 shows the data reduction plan in a flow chart format. Raw data from each vehicle was saved on the network attached storage (NAS) unit at VTTI until approximately 10 percent of the data was collected. At that time, a sensitivity analysis was performed to establish post-hoc trigger criteria.

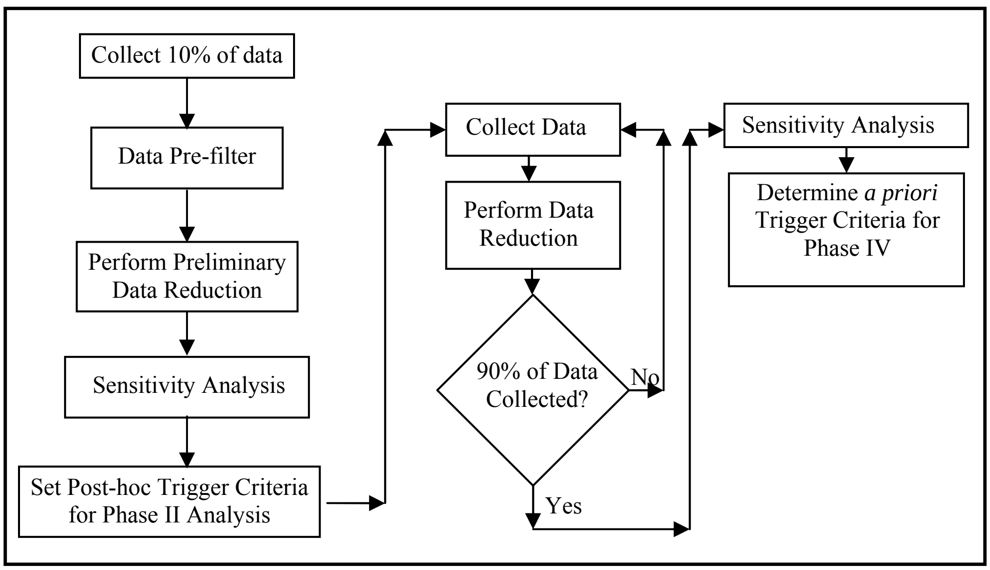

Figure 1.5. Flow chart of the data reduction process.

The sensitivity analysis was performed by setting the trigger criteria to a very liberal level, ensuring that the chance of a missed valid event was minimal while allowing a high number of invalid events (false alarms) to be identified (see Figure 1.6). Data reductionists then viewed all of the events produced from the liberal trigger criteria and classified each event as valid or invalid. The numbers of valid events and invalid events that resulted from this baseline setting were recorded.

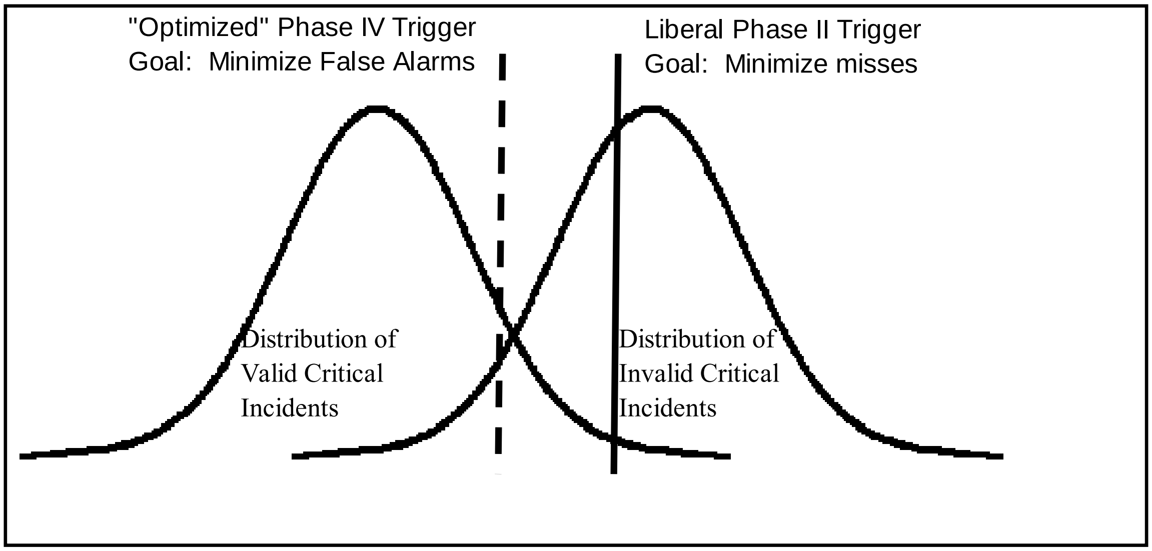

Figure 1.6. Graphical depiction of trigger criteria settings for Phase II and Phase IV using the distribution of valid events. Note that this distribution and criterion placement is unique for each trigger type.

The trigger criteria for each dependent variable was then set to a slightly more conservative level and the resulting number of valid and invalid events was counted and compared to the first frequency count. The trigger criteria were made more and more conservative and the number of valid and invalid triggers counted and compared until an optimum trigger criteria value was determined (a level which resulted in a minimal amount of valid events lost and a reasonable amount of invalid events identified). The goal in this sensitivity analysis was to obtain a miss rate of less than 10 percent and a false-alarm rate of less than 30 percent. Therefore, the data reductionists would be presented with nearly all valid events but would have to reject less than 30 percent of the events that they reviewed. The list of dependent variables ultimately used as triggers used to identify crashes, near-crashes, and incidents is presented in Table 1.3.

Table 1.3. Dependent variables used as event triggers.

TRIGGER TYPE	DESCRIPTION
1. Lateral acceleration	• Lateral motion equal to or greater than 0.7 *g*.
2. Longitudinal acceleration	• Acceleration or deceleration equal to or greater than 0.6 *g*. • Acceleration or deceleration equal to or greater than 0.5 *g* coupled with a forward TTC of 4 seconds or less. • All longitudinal decelerations between 0.4 *g* and 0.5 *g* coupled with a forward TTC value of ≤ 4 seconds and that the corresponding forward range value at the minimum TTC is not greater than 100 ft.
3. Event button	• Activated by the driver by pressing a button located on the dashboard when an event occurred that he/she deemed critical.
4. Forward time-to-collision	• Acceleration or deceleration equal to or greater than 0.5 *g* coupled with a forward TTC of 4 seconds or less. • All longitudinal decelerations between 0.4 *g* and 0.5 *g* coupled with a forward TTC value of ≤ 4 seconds and that the corresponding forward range value at the minimum TTC is not greater than 100 ft.
5. Rear time-to-collision	• Any rear TTC trigger value of 2 seconds or less that also has a corresponding rear range distance of ≤ 50 feet and any rear TTC trigger value in which the absolute acceleration of the following vehicle is greater than 0.3 *g*.
6. Yaw rate	• Any value greater than or equal to a plus and minus 4-degree change in heading (i.e., vehicle must return to the same general direction of travel) within a 3-second window of time.

Based on data from past VTTI studies, it was originally hypothesized that as many as 26 crashes, 520 near-crashes, and over 25,000 incidents (crash-relevant conflicts and proximity conflicts) would be collected. However many of these early estimates were based on long-haul-truck-driving data. It was soon discovered, after the sensitivity analysis process began that the variability in light-vehicle drivers' braking, acceleration, and steering behavior is much larger than with truck drivers. These differences in variability are primarily due to the differences in vehicle dynamics and the more uniform driving skill of commercial truck drivers. While greater variability was expected for light-vehicle drivers, the high degree of variability that was observed was a very interesting result.

Given the variability in light-vehicle driving performance, the sensitivity analysis proved to be challenging. VTTI researchers determined that the best option was to accept a very low miss rate while accepting a fairly high false alarm rate to ensure that few valid events were missed. This resulted in viewing over 110,000 triggers in order to validate 9,125 events. The distribution of the total number of reduced events by severity is shown in Table 1.4.

Table 1.4. The total number of events reduced for each severity level.

Event Severity	Total Number
Crash	69 (plus 13 without complete data)
Near-crash	761
Incidents (Crash-relevant Conflicts and Proximity Conflicts)	8,295

Once the trigger criteria were set, data reductionists watched 90-second epochs for each event (60 seconds prior to and 30 seconds after), reduced and recorded information concerning the nature of the event, driving behavior prior to the event, the state of the driver, the surrounding environment, etc. The specific variables recorded in the data reduction process are described in detail in the data reduction software framework section of this chapter.

Recruiting and Training Data Reductionists

Based upon past experience, it was estimated that reductionists would be able to complete an average of four events per hour. Fourteen data reductionists were recruited by posting flyers and sending notices to various graduate student listservs on the Virginia Tech campus. The data reduction manager interviewed, hired, and trained the data reductionists on how to access the data from the server and operate the data reduction software. Training was also provided on all relevant operational and administrative procedures (approximately 4 hours). The manager gave each data reductionist a data reduction manual to guide him or her in learning the software and reduction procedures. All analyst trainees practiced data reduction procedures with another trained analyst prior to reducing data independently. After each trainee felt comfortable with the process, the trainee worked alone under the supervision of the data reduction manager. Once the trainee and manager felt confident of the analyst's abilities, the analyst began working independently with "spot check" monitoring from the project leader and other reductionists. The data reductionists were responsible for analyzing a minimum number of events per week and were required to attend weekly data reduction meetings to discuss issues that arose during the data reduction process.

The data reductionists performed two general tasks while creating the *event database*. On the first 10 to 15 percent of the data, they performed a preliminary data-reduction task in which they viewed events to determine whether the event was valid or invalid. If invalid, they then determined the severity of the event. After the trigger criteria was set using the results from the sensitivity analysis, the data reductionists validated the data, determined severity, and performed a full data reduction. For the full data-reduction process, they recorded all of the required variables (discussed below) for the event type.

Event Database Reduction Software Framework

The data reduction framework for the *event database* was developed to identify various driving behavior and environmental characteristics for four levels of event severity: crashes, near-crashes, crash-relevant conflicts, and proximity conflicts. The operational definitions for these severity levels are presented in Table 1.5. The variables recorded were selected based upon past instrumented-vehicle studies (Hanowski et al., 2000; Dingus et al., 2002), national crash databases (General Estimates System [GES] and Fatality Analysis Reporting System [FARS]), and questions on Virginia State Police accident reports. Using this technique, the reduced database can be used to directly compare crash data from GES and FARS to those crashes, near-crashes, and incidents (crash-relevant conflicts and proximity conflicts) identified in this dataset.

Table 1.5. Operational Definitions for All Event Severity Levels

Severity Level	Operational Definition
Crash	Any contact with an object, either moving or fixed, at any speed in which kinetic energy is measurably transferred or dissipated. Includes other vehicles, roadside barriers, objects on or off of the roadway, pedestrians, cyclists, animals, etc.
Near-Crash	Any circumstance that requires a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal to avoid a crash. A rapid, evasive maneuver is defined as a steering, braking, accelerating, or any combination of control inputs that approaches the limits of the vehicle capabilities.
Crash-Relevant Conflict	Any circumstance that requires a crash-avoidance response on the part of the subject vehicle, any other vehicle, pedestrian, cyclist, or animal that is less severe than a rapid evasive maneuver (as defined above), but greater in severity than a "normal maneuver" to avoid a crash. A crash avoidance response can include braking, steering, accelerating, or any combination of control inputs. A "normal maneuver" for the subject vehicle is defined as a control input that falls outside of the 95 percent confidence limit for control input as measured for the same subject.
Proximity Conflict	Any circumstance resulting in extraordinarily close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the driver, pedestrians, cyclists, or animals, there is no avoidance maneuver or response. Extraordinarily close proximity is defined as a clear case where the absence of an avoidance maneuver or response is inappropriate for the driving circumstances (including speed, sight distance, etc.).

The general method for data reduction was to have trained data reductionists view the video data and record the battery of variables for all valid events. The data reduction manager and project manager performed all data reduction on the near-crashes and crashes. Varying levels of detail were recorded for each type of event. Crash-relevant conflicts and proximity conflicts have the least amount of information recorded and near-crashes and crashes have the most information recorded. A total of four areas of data reduction were recorded for each event type. These four areas include: vehicle variables, event variables, environmental variables, and driver state variables. Table 1.6 defines each area of data reduction, provides examples, and describes additional features of the data reduction. The complete list of all variables reduced during data reduction is shown in Appendix C.

Table 1.6. Areas of data reduction, definition of the area, and examples.

Area of Data Reduction	Definition	Example
Vehicle Variables	All of the descriptive variables including the vehicle identification number, vehicle type, ownership, and those variables collected specifically for that vehicle, such as vehicle miles traveled (VMT).	Vehicle ID, Vehicle type, Driver type (leased or private), and VMT.
Event Variables	Description of the sequence of actions involved in each event, list of contributing factors, and safety or legality of these actions.	Nature of Event/ Crash type, Pre-event maneuver, Precipitating Factors, Corrective action/Evasive maneuver, Contributing Factors, Types of Inattention, Driver impairment, etc.
Environmental Variables	General description of the immediate environment, roadway, and any other vehicle at the moment of the incident, near-crash, or crash. Any of these variables may or may not have contributed to the event, near-crash or crash.	Weather, ambient lighting, road type, traffic density, relation to junction, surface condition, traffic flow, etc.
Driver's State	Description of the instrumented-vehicle driver's physical state.	Hands on wheel, seat belt usage, fault assignment, eyeglance, PERCLOS, etc.
Driver/Vehicle 2	Description of the vehicle(s) in the general vicinity of the instrumented vehicle and the vehicle's action.	Vehicle 2 body style, maneuver, corrective action attempted, etc.
Narrative	Written description of the entire event.	
Dynamic reconstruction	Creation of an animated depiction of the event.	

Baseline Database Framework

The *baseline database* was comprised of approximately 20,000 6-second segments where the vehicle maintained a velocity greater than 5 mph (referred to as an *epoch*). Kinematic triggers on driving performance data were not used to select these baseline epochs. The epochs were selected at random throughout the 12- to 13-month data collection period per vehicle. A 6-second segment of time was used as this was the time frame used by data reductionists to ascertain whether a particular secondary task was a contributing factor for each crash, near-crash, and incident. For example, a driver had to take a bite of a sandwich 5 seconds prior to or 1 second after the onset of the conflict for the activity to be considered a contributing factor to the crash, near-crash, or incident.

Each *baseline epoch* was randomly selected from the 12-13 months of data collected on each vehicle. However, the number of baseline epochs selected per vehicle was stratified as a proportional sample based upon vehicle involvement in crashes, near-crashes, and incidents. This stratification, based on frequency of crash, near-crash, and incident involvement was conducted to create a case-control dataset in which multiple baseline epochs are present to compare to each crash and near-crash. Case-control designs are optimal for calculating odds ratios (also referred to as relative near-crash/crash risk) due to the increased power that a case-control data set possesses. Greenberg et al. (2001) argue that using a case-control design allows for an efficient means to study rare events, such as automobile crashes, even though smaller sample sizes are used. Given that relative near-crash/crash risk calculations were an objective of the following analyses, the creation of a case-control data set was deemed important.

Considering that the number of baseline epochs was dependent upon the number of crashes, near-crashes, and incidents of vehicle involvement, not driver involvement, an analysis was conducted to determine the percentage of events and baseline epochs that were attributable to the primary driver and secondary driver. The results indicated that 89.6 percent of all events and 88.2 percent of all baseline epochs were primary drivers. Therefore, even though the baselines were selected based upon vehicle involvement, the vast majority of crashes and near-crashes as well as baseline epochs were primary drivers.

Four vehicles did not have any crashes, near-crashes, or incidents and were therefore eliminated from the baseline database. The reasons that these four vehicles did not contain a single crash, near-crash, or incident included very low mileage due to driver attrition (2 vehicles), frequent mechanical malfunctions (1 vehicle), and excellent driver performance (1 vehicle).

Figure 1.7 shows the number of events that each vehicle was involved (y-axis) and the corresponding number of baseline epochs that were identified for that vehicle (x-axis). Note that the vehicles that were involved in multiple crashes, near-crashes, and incidents also had a larger number of baseline epochs.

There are two data points on the far right side of the figure. These two data points represent two female drivers, 18 and 41 years of age, respectively. The 18-year-old female was involved in 3 crashes, 53 near-crashes, and 401 incidents. The 41-year-old female was involved in 4 crashes, 56 near-crashes, and 449 incidents. Both drivers were over-represented in their crash, near-crash and incident involvement.

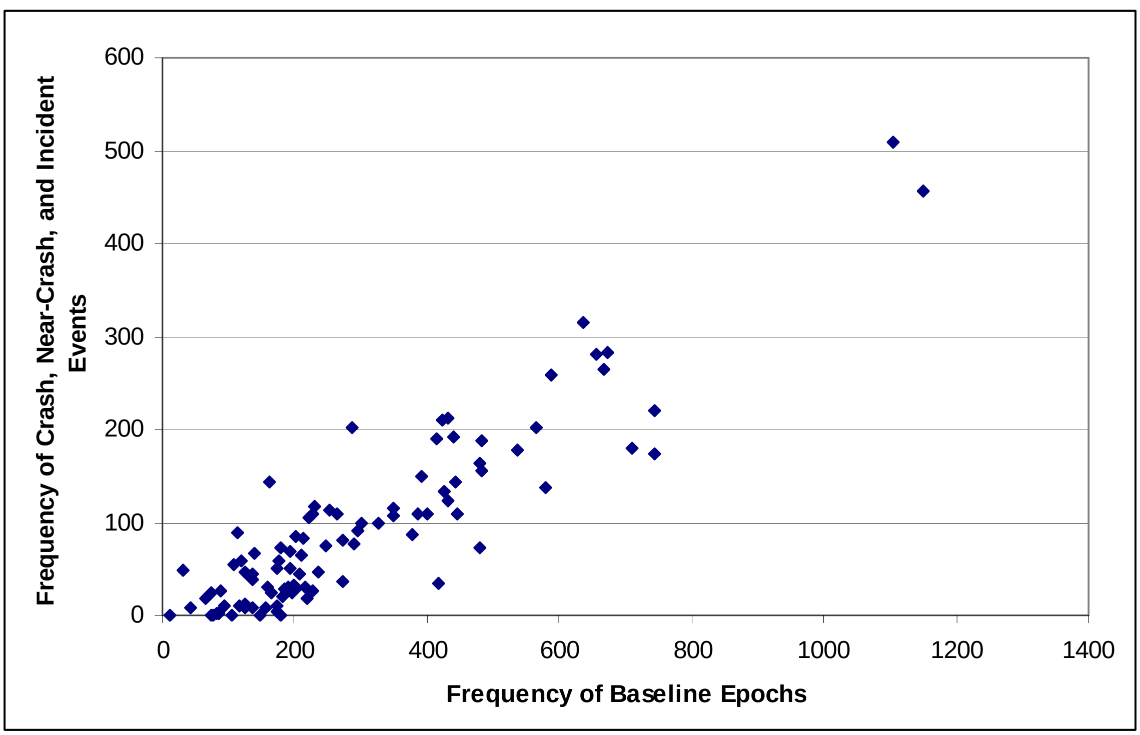

Figure 1.7. The frequency of each vehicle's involvement in crash, near-crash, and incident events versus the number of baseline epochs selected for each vehicle.

The *baseline database* will be used in the assessment of the prevalence of various types of inattentive driving. This will determine the relative near-crash/crash risk for each of these types of inattention as well as the percentage of crashes and near-crashes in the population that are attributable to these types of inattention. While the reader should keep in mind that the baseline epochs were stratified, this does not reduce the generalizability of the data analysis for the following reasons:

1) 99 of 103 vehicles are represented in the 20,000 baseline epochs;
2) 101 out of 109 primary drivers are represented in the baseline epochs;
3) multiple drivers drove each vehicle; and
4) no environmental or driver behavior data was used in the stratification.

The variables that were recorded for the 20,000 *baseline epochs* included vehicle, environmental, and most driver-state variables. In addition, eyeglance analyses were performed for 5,000 randomly selected baseline epochs from the 20,000 baseline epochs. These 5,000 baseline epochs also represent data from all 99 vehicles and 101 primary drivers.

The event variables (number 2 in Table 1.7) were not recorded for the baseline epochs as these variables (e.g., precipitating factor, evasive maneuver) were not present when an incident, near-crash, or crash did not occur. Table 1.7 shows the breakdown of the type of data that currently exists as part of the original 100-Car Study *event database* and the *baseline database*.

Table 1.7. Description of the databases created for the inattention analysis.

	100-Car Study Event Database	**Baseline Database (epochs)**
1.	Vehicle variables	Vehicle variables
2.	Event variables	N/A
3.	Environmental Variables	Environmental Variables
4.	Driver-state Variables	Driver-state Variables
	Eyeglance data (crashes, near-crashes, and incidents)	Eyeglance data on 5,000 randomly selected baseline inattention events.
	Observer Rating of Drowsiness (ORD) for Crashes and Near-crashes	Drowsiness was marked yes/no with "yes" = ORD of 60 or above.
5.	Driver/Vehicle 2	N/A
10.	Narrative	N/A

Data Reduction Inter- and Intra-Rater Reliability for the 100-Car Study Event Database

Training procedures were implemented to improve both inter- and intra-rater reliability given that data reductionists were asked to perform subjective judgments on the video and driving data. Reliability testing was then conducted to measure the resulting inter- and intra-rater reliability.

First, data-reductionist managers performed spot checks of the reductionists' work, monitoring both event validity judgments as well as recording all database variables. Reductionists also performed 30 min of spot-checks of their own or other reductionists' work every week. This was done to ensure accuracy but also to allow reductionists the opportunity to view other reductionists' work. It was anticipated that this would encourage each reductionist to modify his or her own work and to improve consistency in decision-making techniques across all reductionists. Mandatory weekly meetings were held to discuss issues concerning data reduction techniques. Issues were usually identified by the spot-checking activities of the reductionist managers and the reductionists, or specific difficult events that the reductionists had encountered. These meetings provided iterative and ongoing reduction training throughout the entire data reduction process.

To determine how successful these techniques were, an inter- and intra-rater reliability test was conducted during the last 3 months of data reduction. Three reliability tests were developed (each containing 20 events) for which the reductionist was required to make validity judgments. Three of the 20 events were also completely reduced in that the reductionist recorded information for all reduction variables (i.e., event variables, driver-state variables, and environmental variables as opposed to simply marking severity of event). Three of the test events on Test 1 were repeated on Test 2 and three other events were duplicated between Tests 2 and 3 to obtain a measure of intra-rater reliability.

Using the expert reductionists' evaluations of each epoch as a "gold" standard, the percent correct was calculated for each rater's test. The measures for each rater for each testing period, along with a composite measure, can be found in Table 1.8.

Table 1.8. Percentage agreement with expert reductionists.

Rater	**Test 1 Percent**	**Test 2 Percent**	**Test 3 Percent**
1	78.3	87.5	91.3
2	65.2	70.8	78.3
3	100	91.7	95.7
4	100	91.7	87.0
5	100	83.3	87.0
6	95.7	87.5	91.3
7	91.3	87.5	91.3
8	91.3	91.7	91.3
9	95.7	70.8	91.3
10	95.7	91.7	87.0
11	95.7	87.5	100
12	78.3	87.5	87.0
13	87.0	83.3	96.0
14	78.3	83.3	91.3
	Average (across all tests)	88.4	

The Kappa statistic was also used to calculate inter-rater reliability. Although there is controversy surrounding the usefulness of the Kappa statistic, it is viewed by many researchers as the standard for rater assessment (e.g., Cicchetti and Feinstein, 1990). The Kappa coefficient ($K = 0.65$, $p < 0.0001$) indicated that the association among raters is significant. While the coefficient value is somewhat low, given the highly subjective nature of the task, the number of raters involved, and the conservative nature of this statistic, the Kappa calculation probably errs on the low side.

A tetrachoric correlation coefficient is a statistical calculation of inter-rater reliability based on the assumption that the latent trait underlying the rating scale is continuous and normally distributed. Based on this assumption, the tetrachoric correlation coefficient can be interpreted in the same manner as a correlation coefficient calculated on a continuous scale. The average of the pair-wise correlation coefficients for the inter-rater analysis is 0.86. The coefficients for the intra-rater analysis were extremely high with nine raters achieving a correlation of 1.0 among the three reliability tests and five raters achieving a correlation of 0.99.

Given these three methods of calculating inter-rater reliability, it appears that the data reduction training coupled with spot-checking and weekly meetings proved to be an effective method for achieving high inter- and intra-rater reliability.

Baseline Database

Inter-rater reliability tests were also conducted for the baseline events. All trained data reductionists were given a random sample of 25 baseline epochs to view and record the secondary tasks, driving-related inattention behaviors, and moderate to severe drowsiness. The reductionists' responses were then compared to an expert data reductionist's responses. The results indicated an average of 88 percent accuracy among all the data reductionists. Given that the Kappa coefficient and the tetrachoric correlation coefficient did not provide additional information, these tests were not conducted on the baseline inter-rater reliability test.

SURVEYS, QUESTIONNAIRES AND PERFORMANCE-BASED TESTS

As part of the 100-Car Study, the primary drivers were administered questionnaires and performance-based tests either prior to data collection or post data collection (dependent upon the type of test). Table 1.9 provides a list and description of each type of questionnaire and performance-based test that was completed. A copy of all questionnaires and surveys is located in Appendix B.

Table 1.9. Description of questionnaire and computer-based tests used for the 100-Car Study.

	Name of Testing Procedure	Type of Test	Time test was administered	Brief description
1.	Driver demographic information	Paper/pencil	In-processing	General information on drivers age, gender, etc.
2.	Driving History	Paper/pencil	In-processing	General information on recent traffic violations and recent collisions.
3.	Health assessment questionnaire	Paper/pencil	In-processing	List of variety of illnesses/medical conditions/or any prescriptions that may affect driving performance.
4.	Dula Dangerous Driving Index	Paper/pencil	In-processing	One score that describes driver's tendencies toward aggressive driving.
5.	Sleep Hygiene	Paper/pencil	In-processing	List of questions that provide information about driver's general sleep habits/substance use/sleep disorders.
6.	Driver Stress Inventory	Paper/Pencil	In-processing	One score that describes the perceived stress levels drivers experience during their daily commutes.
7.	Life Stress Inventory	Paper/pencil	In-processing/Out-processing	One score that describes drivers stress levels based upon the occurrence of major life events.
8.	Useful Field-of-View	Computer-based test	In-processing	Assessment of driver's central vision and processing speed, divided and selective attention.
9.	Waypoint	Computer-based test	In-processing	Assessment of the speed of information processing and vigilance.
10.	NEO-FFI	Paper/pencil	In-processing	Personality test.
11.	General debrief questionnaire	Paper/pencil	Out-processing	List of questions ranging from seatbelt use, driving under the influence, and administration of experiment.

CHAPTER 2: *OBJECTIVE 1,* WHAT IS THE PREVALENCE AS WELL AS THE TYPES OF DRIVER INATTENTION IN WHICH DRIVERS ENGAGE DURING THEIR DAILY DRIVING? WHAT IS THE RELATIVE NEAR-CRASH/CRASH RISK OF DRIVING WHILE ENGAGING IN AN INATTENTIVE TASK? IS THE RELATIVE NEAR-CRASH/CRASH RISK DIFFERENT FOR DIFFERENT TYPES OF SECONDARY TASKS?

During data reduction it became apparent that there were many rear-end and run-off-road collisions that occurred primarily because the driver looked away from the forward roadway at a critical point. In order to conduct defined analyses on these events, separate categories of driver inattention were developed. Throughout this document, driver inattention is broadly defined as any point in time that a driver engages in a secondary task, exhibits symptoms of moderate to severe drowsiness, or looks away from the forward roadway. These categories of driver inattention are operationally defined as follows.

- *Secondary task distraction* – driver behavior that diverts the driver's attention away from the driving task. This may include talking/listening to hand-held device, eating, talking to a passenger, etc. A complete list of all secondary task distractions is provided in Appendix A.
- *Driving-related inattention to the forward roadway* – driver behavior that is directly related to the driving task but diverts driver's attention away from the forward field of view. This includes reductionists observing drivers checking the speedometer, checking blind spots, observing adjacent traffic prior to or during a lane change, looking for a parking spot, and checking mirrors.
- *Drowsiness* – driver behavior that includes eye closures, minimal body/eye movement, repeated yawning, and/or other behaviors based upon those defined by Wierwille and Ellsworth (1994).
- *Non-specific eyeglance away from the forward roadway* – driver behavior that includes moments when the driver glances, usually momentarily, away from the roadway, but at no discernable object, person, or unknown location. Eyeglance reduction and analysis of these events was done for crashes, near-crashes, incidents, and 5,000 of the baseline events.

The terms *driver inattention* and *driver distraction* have been used throughout the transportation literature separately at times and interchangeably at other times, referring to different types of driver inattention. In this report, the term *driver inattention* will refer to a broader scope of behaviors as defined above. The term *driver distraction,* when used, will refer only to secondary-task engagement.

The frequency of occurrence, the *relative near-crash/crash risk*, and *population attributable risk percentage* for each of these associated types of inattention will be determined in this chapter.

Driver Data Included in the Analysis

For the analyses in this chapter, crashes and near-crashes only will be used (incidents will be excluded from the analyses). In Chapter 6, *Objective 2* of the 100-Car Study Final Report, the analyses indicated that the kinematic signatures of both crashes and near-crashes were nearly identical; whereas the kinematic signature of incidents was more variable. Given this result and the need to increase statistical power, the data from both crashes and near-crashes will be used in the calculation of relative risk.

Please note that secondary tasks, driving-related inattention to the forward roadway, and drowsiness were all recorded for crash and near-crash events as well as baseline epochs. Eyeglance data, on the other hand, was recorded for all events and 5,000 of the baseline epochs (25 percent of the baseline epochs). Therefore, all analyses that are conducted requiring eyeglance data will use only the 5,000 *baseline* epochs. All other analyses utilize the entire baseline database. Please note that the 5,000 baseline epochs that contain eyeglance data also represent 99 vehicles and 101 primary drivers which is identical to the number of vehicles and primary drivers represented in all 20,000 baseline epochs.

Recall from Chapter 1 that the *baseline database* consisted of a stratified random sample of epochs. This stratification was performed to provide a case-control data set which possesses greater statistical power for the calculation of relative near-crash/crash risk.

QUESTION 1. WHAT IS THE RELATIVE FREQUENCY OF A DRIVER BEING LABELED INATTENTIVE VERSUS ATTENTIVE?

To determine the relative frequency of inattention, the baseline epochs were analyzed to assess the frequency in which drivers were engaging in inattention-related tasks during normal, baseline driving. While task duration was not recorded, the fact that 73 percent of all 6-second segments contained at least one form of driving inattention indicates that drivers are engaging in secondary tasks, driving while drowsy, or looking away from the forward roadway very frequently.

QUESTION 2. WHAT IS THE RELATIVE FREQUENCY OF EACH TYPE OF DRIVER INATTENTION BEING LABELED AS A CONTRIBUTING FACTOR FOR CRASHES, NEAR-CRASHES, AND/OR PRESENT IN BASELINE EPOCHS?

Two comparisons were performed on different subsets of data. First, a comparison was conducted of the four types of inattention for the crashes and near-crashes versus the **5,000** *baseline epochs*. Second, a separate comparison of three types of inattention, *secondary task, drowsiness,* and *driving-related inattention to the forward roadway*, for all **20,000** *baseline epochs* and crashes and near-crashes was conducted to assess the frequency analysis for the entire dataset.

Figure 2.1 shows the percentage of the total number of crashes, near-crashes, and baseline epochs that were inattention-related. Please note that 78 percent of all crashes, 65 percent of all near-crashes, and 73 percent of all 20,000 baseline epochs contained at least one of the four types of inattention. Therefore, the sum of all of the bars representing crashes is equal to 78.

Each event and epoch is presented in the figure by type of inattention and/or combination of inattention because many of the events and epochs contained multiple types of driving inattention. Please note that s*econdary task, driving-related inattention*, and *driver drowsiness* were the most frequent contributing factors for the crashes and near-crashes. Also note that *secondary task* and *combinations thereof* were the most frequent types of inattention observed for baseline epochs. Drowsiness occurred far less frequently for the baseline epochs than for the crashes and near-crashes. The *non-specific eyeglance* category occurred most frequently in conjunction with *secondary tasks* and *driving-related inattention*, and only accounted for an additional 2 percent of the baseline epochs by itself.

Figure 2.1 shows that *non-specific eyeglance* most commonly occurred in conjunction with other sources of driver inattention for the baseline epochs. For crashes and near-crashes, there were higher percentages of events where *non-specific eyeglance*, by itself, was a contributing factor. This result will be more fully analyzed later in this chapter.

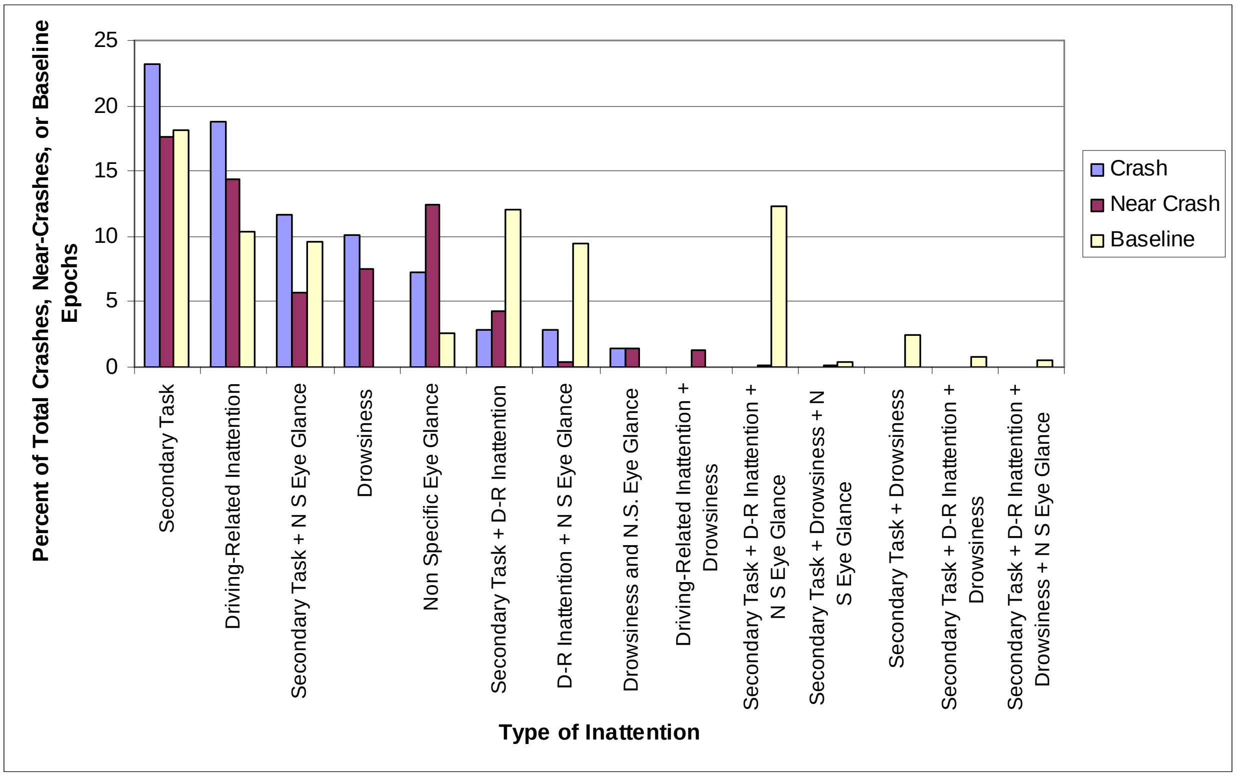

Figure 2.1. The percentage of the total number of crashes and near-crashes identified in the 100-Car Study and the percentage of the total number of baseline epochs in which these four types of inattention were identified as a contributing factor (N = 69 crashes, 761 near-crashes, and 4,977 baseline epochs).

Comparisons were then conducted without the *non-specific eyeglance* inattention category for crashes, near-crashes, and baseline epochs to obtain a complete picture of the frequency of inattention categories for all 20,000 baseline epochs. Without *non-specific eyeglance*, the combinations of inattention-type are fewer. For example, the *secondary task plus non-specific eyeglance* category in Figure 2.1 is now included with the *secondary task* category in Figure 2.2. *Secondary tasks* are still the most frequent type of inattention for crashes and near-crashes, followed by *driving-related inattention to the forward roadway* and *drowsiness*.

Note that the baseline epochs are similar to crashes and near-crashes in that secondary tasks are again the most frequent; followed by *driving-related inattention to the forward roadway* and combinations of these two types of inattention. Drowsiness, however, was observed in less than 2.2 percent of all baseline epochs. This is a very interesting finding when comparing *drowsiness's* low baseline-epoch percentage to the much higher percentage in crashes and near-crashes. This may indicate that driver drowsiness may significantly increase near-crash/crash risk. Also of interest is the high frequency of *driving-related inattention to the forward roadway* for the baseline epochs. This category is present in 27 percent (summed across categories) of the baseline epochs but only 14 percent of the crashes and near-crashes. In this case, relative near-crash/crash risk due to *driving-related inattention to the forward roadway* may be very low. Odds ratios will be presented for all types of inattention in the next section.

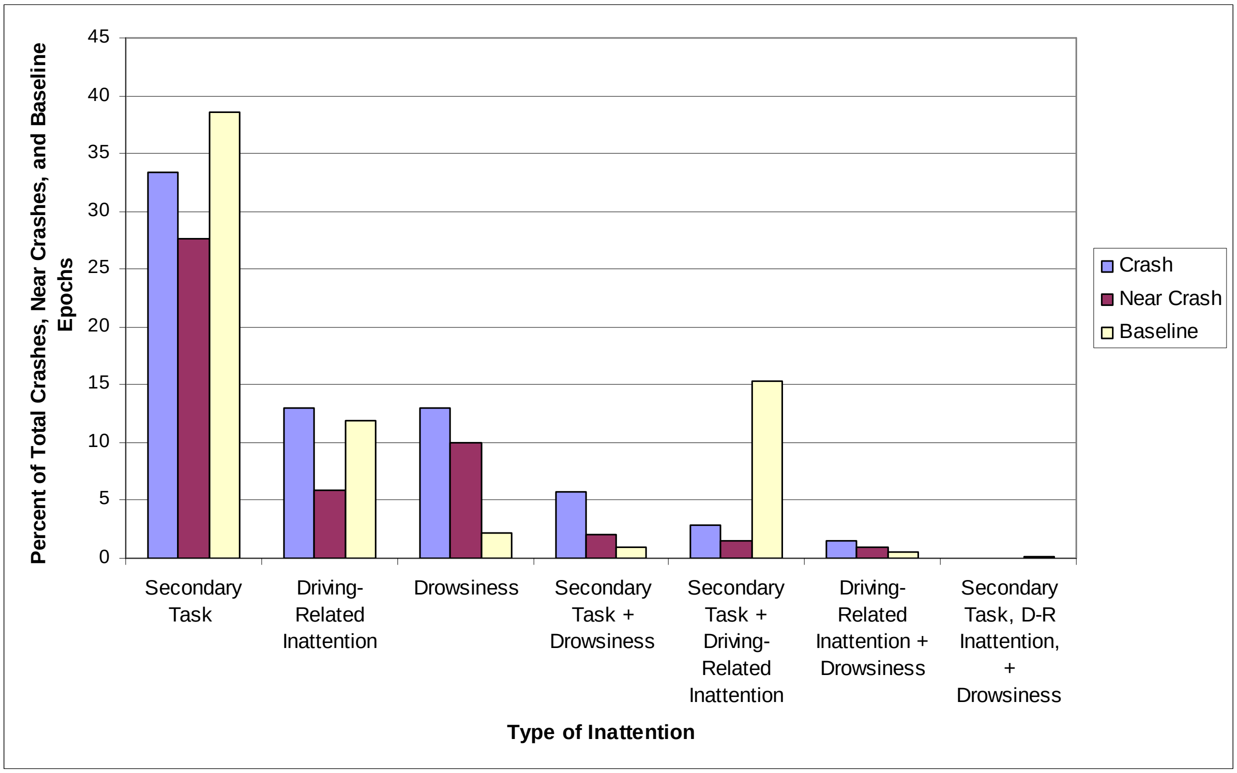

Figure 2.2. The percentage of crashes and near-crashes in which three types of inattention were identified as a contributing factor (N = 69 crashes, 761 near-crashes, and 19,827 baseline epochs).

QUESTION 3. DETERMINE THE RELATIVE NEAR-CRASH/CRASH RISK AND THE POPULATION ATTRIBUTABLE RISK PERCENTAGE FOR EACH TYPE OF INATTENTION. WHAT IS THE RELATIVE RISK FOR DIFFERENT TYPES OF SECONDARY TASKS?

Using the baseline data as a measure of non-event exposure, odds ratios were calculated to obtain an estimate of relative near-crash/crash risk for each of the four types of inattention. In addition, population attributable risk percentages were calculated to determine the percentage of crashes and near-crashes that occur in the general driving population when inattention was a contributing factor.

Both statistics are used because of the complementary information that both provide. While the odds ratio, or relative risk calculation for a crash or near-crash, provides information regarding individual near-crash/crash risk when engaging in a particular behavior, the population attributable risk percentage calculation provides an estimate of the percentage of crashes and near-crashes in the study population that can be attributed to each type of behavior. Therefore, while an individual's near-crash/crash risk may increase while performing a particular task, drivers may not engage in this behavior very often or the behavior requires a brief duration therefore very few crashes in the population are in fact caused by this behavior. On the other hand, if a specific type of behavior does not increase individual near-crash/crash risk greatly in isolation, this behavior may in fact occur frequently and/or for long durations while driving and therefore does account for many crashes in the population.

The following odds ratios are calculated for three levels of *secondary tasks*, two levels of *driving-related inattention*, two levels of *non-specific eyeglances*, and only one level of *drowsiness*. The three levels of secondary tasks are *complex secondary tasks*, *moderate secondary tasks*, and *simple secondary tasks*. The *complex secondary tasks* are defined as a task that requires either multiple steps, multiple eyeglances away from the forward roadway, and/or multiple button presses (Dingus, Antin, Hulse, and Wierwille, 1989). *Moderate secondary tasks* are those that require, at most, two glances away from the roadway and/or at most two button presses. *Simple secondary tasks* are those that require none or one button press and/or one glance away from the forward roadway. Table 2.1 presents the task types that were assigned to each level of complexity. For operational definitions and examples for each of these tasks, please refer to Appendix C.

Table 2.1. Assignment of secondary tasks into three levels of manual/visual complexity.

Simple Secondary Tasks	Moderate Secondary Tasks	Complex Secondary Tasks
1. Adjusting radio	1. Talking/listening to hand-held device	1. Dialing a hand-held device
2. Adjusting other devices integral to the vehicle	2. Hand-held device-other	2. Locating/reaching/ answering hand-held device
3. Talking to passenger in adjacent seat	3. Inserting/retrieving CD	3. Operating a PDA
4. Talking/Singing: No passenger present	4. Inserting/retrieving cassette	4. Viewing a PDA
5. Drinking	5. Reaching for object (not hand-held device)	5. Reading
6. Smoking	6. Combing or fixing hair	6. Animal/object in vehicle
7. Lost in Thought	7. Other personal hygiene	7. Reaching for a moving object
8. Other	8. Eating	8. Insect in vehicle
	9. Looking at external object	9. Applying makeup

There is considerable automotive research indicating that drivers generally do not look away from the forward roadway greater than 1.0 to 1.5 seconds per glance (Wierwille, 1993). Tasks that require longer and more frequent glances decrease safe driving performance. Therefore, the *driving-related inattention to the forward roadway* category, which is operationally defined as eyeglances to one of the rear-view mirrors or windows, was separated into two categories: *total time eyes off the forward roadway: greater than 2 seconds and less than 2 seconds.* The same distinction was used for *non-specific eyeglances away from the forward roadway*. These two inattention categories were separated in this manner to differentiate those short, quick glances that are characteristic of an alert driver scanning his or her environment compared to those drivers who are looking away from the forward roadway longer than a short-duration glance.

This separation of the general categories of inattention was performed since there are many factors present within these categories and an odds-ratio calculation for the entire category of *secondary task*, all durations of *driving-related inattention to the forward roadway*, or all durations of *non-specific eyeglance* would provide misleading information and would not be as useful.

The baseline data was categorized in the same manner, using three levels of *secondary task*, two levels of *driving-related inattention*, and two levels of *non-specific eyeglance* data. Due to the importance of glance length, eyeglance data was required for the separation of *driving-related inattention to the forward roadway* and *non-specific eyeglance*. Therefore, only the 5,000 baseline epochs that contained eyeglance data were used to calculate these odds ratios.

When the frequency counts were conducted for the baseline data, 76 combinations emerged from these eight levels of inattention. These combinations emerged because drivers were eating chips (*moderate secondary task*) and would check their left rear-view mirrors for 0.5 seconds (*driving-related inattention less than 2 seconds*), for example. Very few combinations emerged for the crash and near-crash events. Odds ratios were not calculated for each combination of inattention type as the frequency counts were very low in most instances (resulting in wide confidence limits). Odds ratios were calculated for *drowsiness* as well as *drowsiness* combined with other types of inattention as the correlations between *drowsiness* and other types of inattentive behavior are less compelling than the correlations between *secondary task engagement, driving-related inattention to the forward roadway,* and *non-specific eyeglance*.

Definition of an Odds Ratio Calculation. A commonly used measure of the likelihood of event occurrence is termed as the *odds*. The odds measure the frequency of event occurrence (i.e., presence of inattention type) to the frequency of event non-occurrence (i.e., absence of inattention type). That is, the odds of event occurrence are defined as the probability of event occurrence divided by the probability of non-occurrence. The 2x2 contingency table in Table 2.2 will be used to illustrate this and related measures.

Table 2.2. An example of a 2x2 contingency table that would be used to calculate inattention-related odds ratios.

	Inattention Present	No Inattention Present	
Reduced Event	n_{11}	n_{12}	$n_{1.}$
Baseline Event	n_{21}	n_{22}	$n_{2.}$
	$n_{.1}$	$n_{.2}$	$n_{..}$

If the probability of success (inattention present) for the first row of the table is denoted by $\pi_1 = n_{11}/n_{1.}$ and the probability of failure (no inattention present) is defined as $(1 - \pi_1) = n_{12}/n_{1.}$, then the odds of success is defined as $\pi_1/(1-\pi_1) = n_{11}/n_{12}$. The odds of success for the second row are defined similarly with the corresponding success probability, π_2.

The ratio of the odds is a commonly employed measure of association between the presence of cases (crash and near-crash events) and the controls (baseline driving epochs). Odds ratios are used as an approximation of relative near-crash/crash risk in case control designs. This approximation is necessary due to the separate sampling employed for the events and baselines and is valid for evaluations of rare events. (Greenberg et al., 2001). Referring to Table 2.2, the odds ratio would be defined as:

$$\theta = \frac{\pi_1 / (1-\pi_1)}{\pi_2 / (1-\pi_2)} = \frac{n_{11}/n_{12}}{n_{21}/n_{22}} = \frac{n_{11} n_{22}}{n_{12} n_{21}}$$ *Equation 2.1*

and is a comparison of the odds of success in row 1 versus the odds of success in row 2 of the table.

Algebraically, this equation can be rewritten as shown below. Basic odds ratios are calculated as shown in Equation 2.2.

Odds Ratio = (A x D)/(B x C) *Equation 2.2*

Where:

A = the number of at-fault* events where <inattention type> was present without any other type of inattention
B = the number of at-fault* events where drivers were attentive
C = the number of baseline epochs where <inattention type> was present without any other type of inattention
D = the number of baseline epochs where drivers were attentive

*At-fault was assessed by the data reductionists to indicate whether the driver's actions were primarily the cause of the crash or near-crash or whether the driver was simply reacting to another vehicles poor driving performance. Only those crashes and near-crashes that the reductionists deemed to be the fault of the driver of the instrumented vehicle were included in these analyses.

To interpret odds ratios, a value of 1.0 indicates no significant danger above normal, baseline driving. An odds ratio less than 1.0 indicates that this activity is safer than normal, baseline driving or creates a protective effect. An odds ratio greater than 1.0 indicates that this activity increases one's relative risk of a crash or near-crash by the value of the odds ratio. For example, if *reading while driving* obtained an odds ratio of 3.0, then this indicates that a driver is three times more likely to be involved in a crash or near-crash while reading and driving than if he or she was just driving normally.

Results of Odds Ratio Calculations. The odds ratio calculations were initially conducted for driving-related inattention to determine whether this behavior increases near-crash/crash risk or is a typical behavior of an alert driver (i.e., does not impact near-crash/crash risk). The odds ratios for *driving-related inattention to the forward roadway less than 2 seconds and greater than 2 seconds* are presented in Table 2.3. Note that both odds ratios are significantly less than 1.0 suggesting that this behavior is actually *protective* in that drivers who are engaging in this behavior are safer than those drivers who are simply driving (i.e., not engaging in any extra type of behavior). Given this result, *driving-related inattention to the forward roadway* will *no longer be included in the operational definition of driving inattention for the remainder of this report.*

Table 2.3. Odds ratio point estimates and 95-percent confidence limit intervals to assess likelihood of at-fault-crash (N = 49) or near-crash (N = 439) involvement in driving-related inattention to the forward roadway.

Type of Inattention	Odds Ratio	Lower CL	Upper CL
Driving-Related Inattention to the Forward Roadway – Greater than 2 seconds	0.45	0.24	0.83
Driving-Related Inattention to the Forward Roadway – Less than 2 seconds	0.23	0.15	0.34

Table 2.4 shows the odds ratio calculations as well as the upper and lower confidence levels for the remaining three types of inattention: *drowsiness*, *secondary task*, and *non-specific eyeglance*. *Drowsiness*, *drowsiness (all combinations)*, *moderate secondary tasks,* and *complex secondary tasks* obtained odds ratios of 6.2, 4.2, 2.1, and 3.1 respectively. This result suggests that drivers who drive while severely drowsy are between 4.5 and 8.5 times as likely to be involved in a crash or near-crash as alert drivers. Drivers who are engaging in *moderate secondary task*s are between 1.6 and 2.7 times as likely to be involved in a crash or near-crash, and drivers engaging in *complex secondary tasks* are between 1.7 and 5.5 times as likely. The odds ratio for *simple secondary task*s was also greater than 1.0, however, the lower confidence limit was less than 1.0, indicating these tasks do not significantly alter the likelihood of crash or near-crash involvement over that of normal, baseline driving. The odds ratios for *non-specific eyeglance - greater than 2 seconds and less than 2 seconds* obtained an odds ratios less than 1 (OR = 0.9 and 0.4) but were also not significantly different than 1.0 (as indicated by the upper and lower confidence limit containing 1.0). This result indicates that these types of eyeglance behaviors are probably just as safe as normal, baseline driving. While they may be just as safe, these eyeglance behaviors do not reduce the likelihood of being involved in a crash or near-crash as do eyeglances to mirrors or checking traffic through windows. Note that all odds ratios that are significantly different than 1.0 are in bold font.

Table 2.4. Odds ratio point estimates and 95% confidence intervals to assess likelihood of at-fault crash (N = 49) or near-crash (N = 439) involvement when engaging in driving inattention.

Type of Inattention	Odds Ratio	Lower CL	Upper CL
Complex Secondary Task	**3.10**	**1.72**	**5.47**
Moderate Secondary Task	**2.10**	**1.62**	**2.72**
Simple Secondary Task	1.18	0.88	1.57
Moderate to Severe Drowsiness (in isolation from other types of inattention)	**6.23**	**4.59**	**8.46**
Moderate to Severe Drowsiness (all occurrences)	**4.24**	**3.27**	**5.50**
Non-specific Eye Glance Away from the Forward Roadway-Greater than 2 seconds	0.85	0.20	3.65
Non-specific Eye Glance Away from the Forward Roadway-Less than 2 seconds	0.43	0.17	1.06

Note: These calculations included frequency of events/epochs that included the type of inattention by itself and not in combination with other types of inattention. Only moderate to severe drowsiness (combination) took into account all events in which drowsiness was a contributing factor regardless of whether another type of inattention was present. Five thousand baseline epochs were used along with all crashes and near-crashes where the driver was at fault.

Table 2.5 provides the odds ratios for each type of secondary task separately. Given that these odds ratios are not dependent upon glance length, all 20,000 baseline epochs were used for these calculations. Also, frequencies were counted when each type of secondary task was present, either alone or in combination with other types of inattention. This modification was conducted due to low statistical power associated with breaking data into smaller subsets. While there were over 40 secondary tasks that were identified by the data reductionists, only those secondary tasks that were observed for crashes and near-crashes as well as baseline epochs will be presented in the table. In other words, some secondary tasks were not observed for either the events or baseline epochs, therefore it was not possible to calculate an odds ratio. Those odds ratios that are significantly different than 1.0 are shown in bold font.

As can be viewed from this table, half of the secondary tasks have odds ratios greater than 1.0. *Reaching for a moving object* was shown to have the highest odds ratio followed by *external distraction, reading, applying makeup,* and *dialing a hand-held device*. Please note that *handling a CD, talking or listening to a hand-held device, an insect in the vehicle*, and *reaching for an object (not moving)* also had odds ratios greater than 1.0 but their lower confidence limits went below 1.0, indicating that these secondary tasks may not actually increase the likelihood of crash or near-crash involvement.

The odds ratio for passenger in adjacent seat was also significantly different from 1.0; however, it was significantly lower than 1.0 indicating that it is actually safer to have a passenger in the vehicle than to drive alone. This may be because passengers are often also scanning the environment for hazards and may alert the driver to a hazard that he or she may have missed.

Table 2.5. Odds ratios point estimates and 95 percent conflict confidence intervals to assess the likelihood of crash (N= 49) or near-crash (N = 439) involvement when engaging in secondary tasks.

Type of Secondary Task	Odds Ratio	Lower CL	Upper CL
Reaching for a moving object	**8.82**	**2.50**	**31.16**
Insect in Vehicle	6.37	0.76	53.13
Looking at external object	**3.70**	**1.13**	**12.18**
Reading	**3.38**	**1.74**	**6.54**
Applying makeup	**3.13**	**1.25**	**7.87**
Dialing hand-held device	**2.79**	**1.60**	**4.87**
Inserting/retrieving CD	2.25	0.30	16.97
Eating	1.57	0.92	2.67
Reaching for non-moving object	1.38	0.75	2.56
Talking/listening to a hand-held device	1.29	0.93	1.80
Drinking from open container	1.03	0.33	3.28
Other personal hygiene	0.70	0.33	1.50
Adjusting radio	0.55	0.13	2.22
Passenger in adjacent seat	**0.50**	**0.35**	**0.70**
Passenger in rear seat	0.39	0.10	1.60
Combing hair	0.37	0.05	2.65
Child in rear seat	0.33	0.04	2.40

Note: Calculation included frequency of events/epochs that included the type of inattention by itself or in combination with other types of inattention. Twenty thousand baseline epochs were used along with all crashes and near-crashes where the driver was at fault.

All drivers in the present study were over the age of 18; however, there were 16 drivers between 18 and 20 years old. A second odds ratio was calculated to assess whether the presence of passengers were not protective for this younger age group. These odds ratios are presented in Table 2.6. The results suggest that the odds ratios for the 18- to 20-year-olds is nearly the same as it is for the drivers who are 20 years of age and older. This result is consistent with research findings by Williams (2003) where 16- to 17-year-old drivers' near-crash/crash risk increased with the number of passengers in the vehicle up to six times that of normal, baseline driving, 18- to 19-year-old drivers showed a very slight increase in near-crash/crash risk, and older drivers demonstrated a protective effect for the presence of passengers.

Table 2.6. Odds ratio calculations and 95 percent confidence intervals for "Passenger Present" for drivers who are younger and older than 20 years of age.

Age Group	Odds Ratio for Passenger Present	Lower CL	Upper CL
18 to 20 Years of Age	0.53	0.33	0.83
Older than 20 Years	0.58	0.39	0.87

Definition of Population Attributable Risk. For those types of inattention with an odds ratio greater than 1.0, population attributable risk percentages (PAR%) were also calculated. This calculation provides an assessment of the percentage of crashes and near-crashes that are occurring in the population at-large that are directly attributable to the specific behavior measured. This is an excellent counterpart to the odds ratio calculation in that the odds ratio is measured at the *individual* level whereas the population attributable risk percentage is measured at the *population* level or for all drivers in the population. Please note that data was collected in only a metropolitan area, thus, some degree of caution should be exercised in the interpretation of these results to the population at large.

Population attributable risk percentage is calculated as follows:

$$PAR\% = [(P_e\,(OR - 1))/(1 + P_e\,(OR - 1))] * 100 \qquad \textit{Equation 2.3}$$

Where P_e = population exposure estimate
OR = odds ratio or relative risk estimate for a crash or near-crash

For example, to assess a population attributable risk percentage for complex secondary tasks, the population exposure estimate was calculated by counting the number of baseline epochs where a complex secondary task was present and counting the total number of baseline epochs in equation (# of baseline epochs with complex secondary tasks present + # of baseline epochs where no type of inattention was present), for example:

$$P_e = 49 \text{ baseline epochs with complex secondary tasks}/2{,}273 \text{ total baseline epochs} = 0.02$$

The relative risk or odds ratio of a crash or near-crash, as shown in Table 2.4, indicated that the relative risk for complex secondary tasks was 3.10. Thus, the PAR percent was calculated as follows:

$$PAR\% = [(0.02)\,(3.10 - 1.00)/1.00 + (0.02)\,(3.10 - 1.00))]*100 = 4.3$$

For a more complete discussion of the population attributable risk percentage calculations, see Sahai and Khurshid (1996), *Statistics in Epidemiology*.

Results of Population Attributable Risk Percentage Calculations. The population attributable risk percentage calculations are presented in Table 2.7 for all of those types of inattention and secondary tasks with an odds ratio greater than 1.0. A population attributable risk percentage calculation is not applicable to those sources of inattention with an odds ratio of less than 1.0.

The results indicate that *moderate to severe drowsiness* accounts for between 22 and 24 percent of all crashes and near-crashes, and c*omplex, moderate, and simple secondary tasks* account for 23 percent of all crashes and near-crashes. *Dialing a hand-held device, talking on a hand-held device*, and *reading* all contributed to 3.6 percent, 3.6 percent, and 2.9 percent to all crashes and near-crashes, respectively. Interestingly, *dialing a hand-held device* had an odds ratio of 2.8 whereas *talking/listening to hand-held device* had an odds ratio of 1.3 and was not significantly different than 1.0. These two secondary tasks had nearly the identical population attributable risk percentages. One hypothesis for this is that drivers were talking/listening to hand-held devices a much larger percentage of time than they were dialing hand-held devices. Thus, the percent of crashes and near-crashes that were attributable to these two actions was similar due to the fact that dialing was more dangerous but was performed less frequently whereas talking/listening was less dangerous but done more frequently. The rest of the secondary tasks each accounted for less than 3 percent of all crashes and near-crashes. *In total, drowsiness and secondary task engagement are contributing factors in over 45 percent of all crashes and near-crashes.*

Table 2.7. Population attributable risk percentage point estimates and 95 percent confidence intervals for types of inattention and the specific secondary tasks.

Type of Inattention	Population Attributable Risk Percentage (PAR%)	Lower CL	Upper CL
Complex Secondary Task	4.26	3.95	4.57
Moderate Secondary Task	15.23	14.63	15.83
Simple Secondary Task	3.32	2.72	3.92
Moderate to Severe Drowsiness (in isolation from other types of inattention)	22.16	21.65	22.68
Moderate to Severe Drowsiness (all occurrences)	24.67	21.12	25.23
Reaching for moving object in vehicle	1.11	0.97	1.25
Insect in vehicle	0.35	0.27	0.44
Reading	2.85	2.60	3.10
Dialing hand-held device	3.58	3.29	3.87
Applying Makeup	1.41	1.23	1.59
Looking at external object	0.91	0.77	1.05
Inserting/retrieving CD	0.23	0.15	0.32
Eating	2.15	1.85	2.46
Reaching for non-moving object	1.23	0.96	1.50
Talking/listening to hand-held Device	3.56	3.10	4.10
Drinking from open container	0.04	-0.10	0.18

Please note that the population attributable risk percentages of the individual secondary tasks do not sum to the higher level secondary-task categories. Recall that there are other types of secondary tasks that are being calculated for each general level of secondary task. For example, the sum of the population attributable risk percentages for the individual types of secondary tasks will not add up to the population attributable risk percentage for the complex secondary task type.

CONCLUSIONS

The results from these analyses demonstrate the power of large-scale naturalistic driving studies in that the prevalence of driving inattention, the frequency of occurrence, as well as the relative near-crash/crash risk for various types of driver inattention can finally be assessed using pre-crash driving behavior data. While relative risk calculations for a crash or near-crash have been obtained using survey data and/or police accident reports, this study directly observed drivers prior to crashes and near-crashes and compare this behavior to their driving behaviors during normal, routine driving.

To calculate the prevalence and frequency of driver inattention, the baseline driving database was used. This analysis indicated that drivers engaged in one of four types of inattention in over 70 percent of the 20,000 baseline epochs. Interestingly, *secondary task engagement* accounted for 54 percent, *driving-related inattention to the forward roadway* accounted for 27 percent, and *drowsiness* only accounted for 4 percent of the baseline epochs.

The results of the relative near-crash/crash risk calculations indicated that urban drivers are between four and six times as likely to be involved in a crash or near-crash when driving while severely drowsy than if they were attentive. The odds ratios for complex and moderate secondary task type also indicated that drivers were at increased risk when engaging in these types of tasks while driving. Drivers are two times as likely to be involved in a crash or near-crash when engaging in a moderate secondary task and three times as likely when engaging in a highly complex secondary task.

The results of these analyses indicated that all odds ratios for each of the secondary task types indicated that *reaching for a moving object, looking at an external object (i.e., long glance), reading, applying makeup, dialing a hand-held device,* and *eating* all had odds ratios greater than 1.0. This suggests a higher individual near-crash/crash risk when a driver engages in these activities. Interestingly, *driving with a passenger*, *singing to the radio*, and even some engagement with the radio and the heating/air conditioner unit all resulted in odds ratios less than 1.0. These results most likely suggest that these activities are indicative of a relatively alert driver. For drivers over the age of 18, having a passenger in the vehicle is associated with less likelihood of crash or near-crash involvement than if there was no passenger in the vehicle. A possible interpretation of this result is that the passenger is also scanning the environment and can warn a driver of an impending dangerous situation. Please note that there is a substantial body of research on drivers *under* the age of 18 indicating that passengers in the vehicle actually *increase* near-crash/crash risk. The results from this study should not be interpreted as conflicting with results from the teen-driving research. There were no 16- or 17-year-old drivers in this study and therefore, the data can not be applied to the teenage driving population.

Even though the odds ratios for *reaching for a moving object, external distraction, reading, applying makeup,* and *eating* presented greater individual near-crash/crash risk, these factors did not account for a large percentage of actual crashes and near-crashes in an urban population as shown by the population attributable risk percentage calculations. Drowsiness, on the other hand, attributed to between 22 and 24 percent of the crashes and near-crashes in the population, which is much higher than most crash database research has shown (Campbell, Smith, and Najm, 2003). All complexity levels of secondary tasks attributed to 22 percent of the crashes and near-crashes in an urban environment. In total, inattention contributes to over 45 percent of all crashes and near-crashes that occur in an urban environment.

Also of interest was that *dialing a hand-held device* had an odds ratio of approximately 3.0 whereas *talking/listening to hand-held device* had an odds ratio of slightly over 1.0 and was not significantly different than 1.0. These two secondary tasks had nearly the identical population attributable risk percentages (each attributing to 3.6 percent of crashes and near-crashes). One hypothesis for this is that drivers were talking/listening to hand-held devices a much larger percentage of time than they were dialing hand-held devices. Thus, the percent of crashes and near-crashes that were attributable to these two actions was similar due to the fact that dialing was more dangerous but was performed less frequently whereas talking/listening was less dangerous but performed more frequently.

CHAPTER 3: *OBJECTIVE 2,* WHAT ARE THE ENVIRONMENTAL CONDITIONS ASSOCIATED WITH DRIVER CHOICE OF ENGAGEMENT IN SECONDARY TASKS OR DRIVING WHILE DROWSY? WHAT ARE THE RELATIVE RISKS OF A CRASH OR NEAR-CRASH WHEN ENGAGING IN DRIVING INATTENTION WHILE ENCOUNTERING THESE ENVIRONMENTAL CONDITIONS?

This research objective used large-scale naturalistic driving data to determine the environmental conditions in which drivers choose to engage in secondary tasks or to drive while drowsy. The associated relative near-crash/crash risks of either engaging in complex or moderate secondary tasks or driving drowsy during poor environmental conditions was also assessed. Several types of environmental variables were recorded during the data reduction process for both the 100-Car Study event database and the baseline database. A list of these variables, the respective levels of each, and a definition of each variable is presented in Table 3.1. Please note that all of these variables were recorded based solely upon the video observed at the time of the event or epoch. For lighting levels, the corresponding time stamp was also used to distinguish between dawn and dusk.

Table 3.1. A detailed list of the environmental variable names, levels of each, and operational definition.

Variable Name	Levels of Variable	Definition of Variable
Lighting	Daylight Darkness, lighted Darkness, non lighted Dawn Dusk	Ambient lighting levels to denote the time of day.
Weather	Clear Raining Sleeting Snowing Foggy Misty Other	Description of the presence of ambient precipitation and type of precipitation occurring.
Road Type	Divided Not divided One-way Traffic No lanes	Description of the type of roadway and how traffic is separated.
Road Alignment/Road Profile	Straight, level Straight, grade Curve, level Curve, grade	Description of the road profile at the onset of the conflict.
Traffic Density	Free flow Stable flow, speed restricted Unstable flow, temporary restrictions Unstable flow, temporary stoppages Restricted Flow Forced flow with low speeds and traffic volumes	Level of service definitions (NHTSA) to define six levels of traffic density ranging from free flow to stop-and-go traffic.
Surface Condition	Dry Wet Snowy Icy Other	Description of the resulting condition of the roadway in the presence of precipitation.
Traffic Control Device	Traffic signal Stop sign Yield sign Slow, warning sign Traffic lanes marked Officer/watchman Other Unknown None	Denotes the presence of a traffic signal near the onset of the conflict.
Relation to Junction	Intersection Intersection-related Interchange area Entrance/exit ramp Driveway/alley access Parking lot Non-junction Other	Description of the road and whether a junction was present.

DATA INCLUDED IN THESE ANALYSES

Two databases were used for this analysis. The first was the *event database*, which consisted of all the crashes, near-crashes, and incidents identified and reduced as part of the 100-Car Study. Only the crashes and near-crashes were used in these analyses (for a discussion of the reasons for this, please refer to Chapter 2, *Objective 1*). Recall that this data is referred to as *event* data for this report. The second was the *baseline database*, which consisted of 20,000 randomly selected 6-second segments of video that were viewed by trained data reductionists. The random sample was stratified to produce a case-control data set which increased power for odds ratio calculations. For a complete description of the variables that were recorded for the baseline database, please refer to Chapter 1: Introduction and Method.

For the following analyses, the term *inattention-related event* refers only to complex- and moderate-secondary-task engagement. *Simple secondary task engagement* and *driving-related inattention to the forward roadway* were not used in these analysis; as shown in the previous chapter, these two types of inattention were either not significantly different than normal, baseline driving or provided a protective effect. Also, *non-specific eyeglance* was not considered, since its inclusion would have reduced the number of baseline epochs available for analysis, and because it was found to be a relatively redundant source of inattention for the baseline epochs (as shown in the previous chapter).

As the effect of risk factors were to be compared across levels of environmental variables, a different analysis method was used. The odds ratio estimates in the chapter were obtained using maximum likelihood estimates obtained from logistic regression models. The stratified analysis or logistic regression allows for comparable evaluation of risk factors across the levels or strata of an environmental variable of interest. To ascertain whether it is more risky to engage in complex tasks on a dark roadway or to drive while alert on a dark roadway, the interaction of both complex-secondary-task engagement (*inattentive* or *attentive* driver) and ambient light levels (*daylight*, *dusk*, *dawn*, *darkness-lighted*, *darkness-not-lighted*) must be assessed. Logistic regression models provide a point estimate for the odds of a crash or near-crash based upon the driver engaging in a secondary task (or driving attentively) and driving environment.

Three independent odds ratio calculations were conducted to assess the relative near-crash/crash risk in various weather, roadway, and traffic environments. These three odds ratio calculations assess the following:

1) Is driving drowsy during <*environmental variable level*> riskier than driving alert in <*environmental level*>?
2) Is engaging in complex secondary tasks during < *environmental variable level*> riskier than driving alert in <*environment level* >?
3) Is engaging in moderate secondary tasks during < *environmental variable level*> riskier than driving alert in <*environment level*>?

Only *drowsiness*, *complex*, and *moderate secondary tasks* were used in the following odds ratio calculations. Recall from the previous chapter that complex and moderate secondary task engagements were operationally defined based upon the frequency of eyeglances away from the forward roadway and/or button presses that were necessary to complete the task. Complex secondary tasks required more than three button presses and/or eyeglances away from the forward roadway to complete the task, while moderate secondary tasks required two eyeglances or button presses. It was also demonstrated in the previous chapter that these two types of *secondary tasks*, as well as *drowsiness*, had higher relative near-crash/crash risks than normal, baseline driving, whereas simple secondary tasks were found to not be significantly riskier than normal, baseline driving. Therefore, only *drowsiness*, *complex*, and *moderate secondary tasks* were used in these calculations.

AMBIENT LIGHT/WEATHER CONDITIONS

Lighting Level

To record light levels for this analysis, data reductionists used the video footage and the time stamp corresponding to the epochs or events to make determinations of the ambient lighting levels. Table 3.2 presents the number of *drowsiness*- and *secondary-task*-related crashes, near-crashes, and baseline epochs observed for each of these lighting levels.

Table 3.2 The frequency of drowsiness- and secondary-task-related events and epochs that were recorded for each type of lighting level.

Lighting Level	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary-Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task-Related Baseline Epochs
Darkness- Lighted	27	42	2	13
Darkness- Not Lighted	18	17	279	3021
Dawn	2	5	51	205
Daylight	52	143	240	571
Dusk	13	20	183	305
Total	308	277	755	4115

Using only the baseline data, the percent of inattention-related epochs and the percent of the total number of baseline epochs were used to determine: (1) the percentage of baseline epochs that drivers engaged in secondary tasks or drove while drowsy during each of these lighting conditions, and (2) whether these percentages differed from the total number of baseline epochs that drivers encountered or were exposed to for each of these lighting conditions. These percentages were calculated by dividing the number of baseline epochs where drivers were engaging in a secondary task at a particular lighting level by the total number of epochs where the drivers engaged in a secondary task. For example, the number of baseline epochs where the driver was engaging in a complex or moderate secondary task during daylight was divided by the total number of baseline epochs where the driver was engaging in a complex or moderate secondary task.

Figure 3.1 presents the baseline data percentages for secondary-task-related epochs (N = 4,115), drowsiness-related epochs (N = 755), and total number of epochs (N = 19,467) for each level of lighting. The majority of complex- and moderate-secondary-task-related events and total baseline epochs occurred during daylight hours; this replicates findings from many previous instrumented-vehicle studies (e.g., Lee, Olsen, and Wierwille, 2003; Dingus et al., 2001). The percentages are very similar for the secondary-task-related epochs and the total number of epochs, suggesting that drivers are not selecting to engage in secondary tasks differently based on ambient lighting conditions. Drivers are experiencing drowsiness differently across the ambient lighting conditions, which is to be expected as ambient lighting levels are associated with time of day and daily wake/sleep cycles. Lower percentages of *drowsiness* were observed during the day, whereas higher percentages of *drowsiness* were observed at night compared to the total baseline epochs.

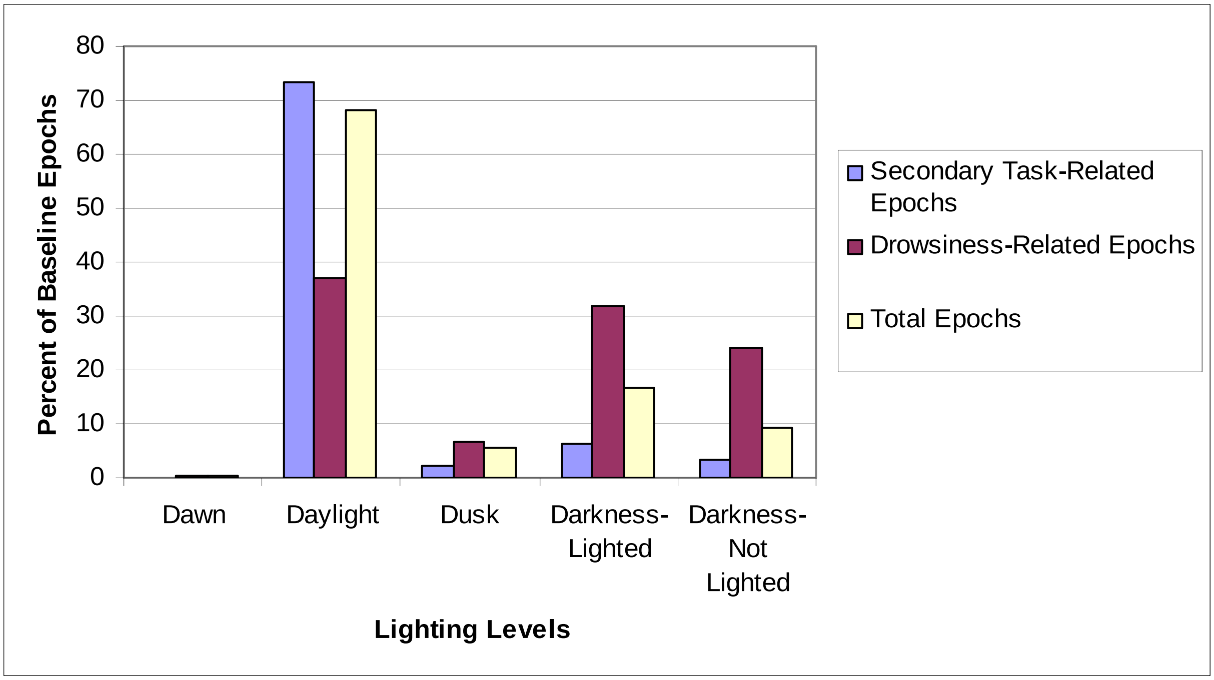

Figure 3.1. Percentage of secondary-task-related, drowsiness-related, and total baseline epochs for the different lighting levels observed.

As shown in Table 3.3, driving drowsy in any of the ambient lighting levels is riskier than driving while alert during similar lighting levels. However, it appears that driving drowsy during the *daylight* may be slightly riskier than driving drowsy in the *dark*. While it is commonly thought that most drowsiness-related crashes occur at night, a majority of the drowsiness-related crashes in this study occurred during the daytime in heavy traffic (during morning and evening commutes). Thus, the risks of driving drowsy during the day may be slightly higher than at night due to higher traffic density.

Table 3.3. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness by type of lighting.

Type of Lighting	Odds Ratio	Lower CL	Upper CL
Dawn	2.43	0.96	6.17
Daylight	5.27	3.55	7.82
Dusk	6.99	3.82	12.80
Darkness-Lighted	3.24	1.92	5.47
Darkness-Not Lighted	3.26	1.82	5.86

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Relative near-crash/crash risks for the complex- and moderate-secondary-task engagement showed that engaging in complex tasks for all levels of ambient lighting were significantly more risky than driving alert at the same lighting levels (Tables 3.4 and 3.5). This was especially true for engaging in complex tasks at night, as these relative near-crash/crash risks were higher than during *dawn*, *dusk*, or *daylight*. The relative near-crash/crash risks for engaging in moderate secondary tasks were all near 1.0, but not significantly different than 1.0, which suggests that engaging in these tasks is not nearly as risky as engaging in complex tasks or driving while drowsy.

Table 3.4. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks by type of lighting.

Type of Lighting	Odds Ratio	Lower CL	Upper CL
Dawn	N/A	N/A	N/A
Daylight	**3.06**	**1.84**	**5.06**
Dusk	**8.91**	**4.41**	**18.03**
Darkness-Lighted	**4.58**	**2.46**	**8.52**
Darkness-Not Lighted	**24.43**	**12.40**	**48.10**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.5. Odds ratio point estimates and 95 percent confidence intervals for the interaction of moderate secondary tasks by type of lighting.

Type of Lighting	Odds Ratio	Lower CL	Upper CL
Dawn	0.71	0.21	2.39
Daylight	0.80	0.59	1.08
Dusk	1.55	0.87	2.76
Darkness-Lighted	0.98	0.61	1.56
Darkness-Not Lighted	0.98	0.61	1.56

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Weather

Reductionists used the video to assess the weather conditions outside the vehicle. Table 3.6 presents the frequency counts of the number of drowsiness- and secondary-task-related events and baseline epochs that occurred during the different weather conditions. A majority of events and epochs occurred during clear weather.

Table 3.6. The frequency of drowsiness-related and secondary-task-related events and epochs that were recorded for each type of weather.

	Type of Weather	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary-Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task-Related Baseline Epochs
1.	**Clear**	92	181	669	3,624
3.	**Rain**	20	45	79	462
4.	**Sleet**	0	0	1	4
5.	**Snow**	0	0	3	12
6.	**Fog**	0	0	2	6
7.	**Mist**	0	0	1	5
8.	**Other**	0	0	0	2
	Total	112	226	755	4,115

Figure 3.2 presents the percent of drowsiness-related, secondary-task-related, and total baseline epochs for each weather type. Nearly all of the epochs occurred during *clear weather*, with 11 percent occurring during *rainy weather*. The percentages are nearly identical for secondary-task-related, drowsiness-related, and total baseline epochs for all weather conditions, indicating that drivers were not engaging in secondary tasks or driving drowsy substantially more often during any particular type of weather. The total number of events and epochs that occurred during *sleet*, *snow*, *fog, mist*, and *other* weather conditions was very small (the sample size was perhaps not large enough to adequately address the issue of secondary-task engagement during these types of weather).

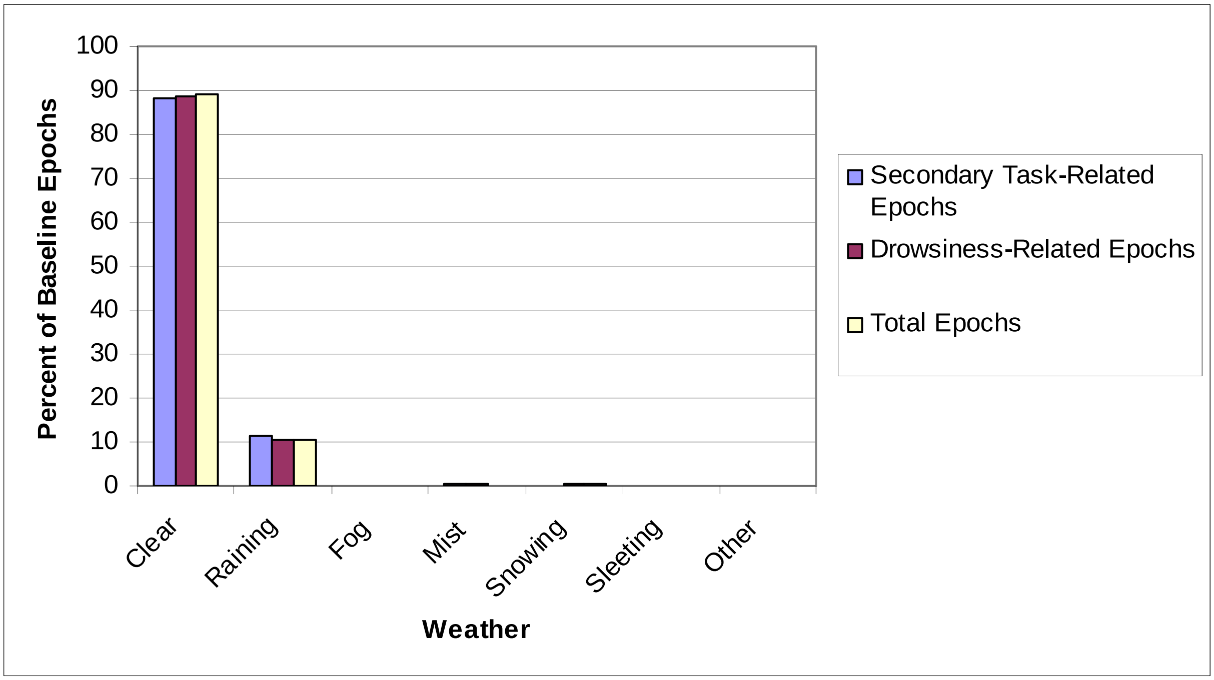

Figure 3.2. Percentage of secondary-task-related, drowsiness-related, and total baseline epochs for each type of weather.

Table 3.7 presents the odds ratio calculations for the different types of weather. Driving while drowsy during both *rainy* and *clear* weather is significantly more risky than driving alert during the same conditions. Interestingly, the elevated near-crash/crash risk is the same for both, suggesting that driving drowsy is very dangerous, regardless of roadway conditions. Unfortunately, the other weather conditions could not be assessed due to low statistical power.

Table 3.7. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness by type of weather.

Type of Weather	Odds Ratio	Lower CL	Upper CL
Clear	**4.34**	**3.22**	**5.86**
Rain	**4.41**	**2.41**	**8.08**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

The relative risk calculations for a crash or near-crash for complex secondary tasks also suggest that engaging in complex secondary tasks is significantly more risky than driving alert in similar conditions (Table 3.8). The relative near-crash/crash risk estimate is higher for rain, suggesting that it may be riskier to engage in complex secondary tasks during the rain than in clear weather. Some caution is urged in this interpretation because the confidence limit surrounding the odds ratio for engaging in a complex task during the rain is also larger than it is for clear weather.

Table 3.8. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks by type of weather.

Type of Weather	Odds Ratio	Lower CL	Upper CL
Clear	**3.68**	**2.29**	**5.92**
Rain	**5.11**	**1.86**	**14.07**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

The odds ratio for engaging in moderate secondary tasks indicates that it may be safer to engage in moderate secondary tasks than complex secondary tasks (Table 3.9). Most of the odds ratios for moderate secondary tasks were not significantly different than 1.0 suggesting that engaging in moderate secondary tasks are not protective but rather are simply not riskier than driving while drowsy or engaging in complex secondary tasks.

Table 3.9. Odds ratio point estimates and 95 percent confidence limits for the interaction of moderate secondary tasks by type of weather.

Type of Weather	Odds Ratio	Lower CL	Upper CL
Clear	0.86	0.65	1.13
Rain	0.65	0.37	1.15

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

ROADWAY AND SURFACE CONDITIONS

Road Type

Road Type (called "Traffic Flow" in the GES Database) primarily refers to whether there is a physical barrier between traffic. The No Lanes category was added for parking lots and should be interpreted as "no barrier." One-way streets possess a barrier since all traffic is flowing in one direction. Table 3.10 shows the distribution of drowsiness- and secondary-task-related events and epochs that occurred on each type of traffic-flow roadway. Most secondary-task-related events and epochs occurred on divided roadways.

Table 3.10. The frequency of secondary-task-related events and epochs that were recorded for each road type.

Road Type	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task-Related Baseline Epochs
Divided	64	118	530	2,612
Undivided	43	95	199	1248
One-way	4	11	17	114
No Lanes	1	2	9	141
Total	112	226	755	4,115

Figure 3.3 presents the percent of total drowsiness-related epochs, secondary-task-related epochs, and total baseline epochs for the various road types. While divided roadways were most frequent for all categories, a substantial number of epochs also occurred on undivided roadways as well. One-way roadways and/or parking lots were represented in a smaller percentage of epochs. There were no practical differences between the percent of secondary task or drowsiness epochs as compared to total baseline epochs, which suggests that drivers are engaging in secondary tasks regardless of type of roadway that they happen to be navigating at the time. There was a slightly higher percent of occurrence for drowsiness-related epochs on divided roadways than on undivided roadways. One possible hypothesis for this result is that drivers are more relaxed and less active on divided roadways (i.e., interstates) because they do not have to monitor cross traffic as frequently as on undivided roadways. This feeling of relaxation may result in higher occurrence of drowsiness.

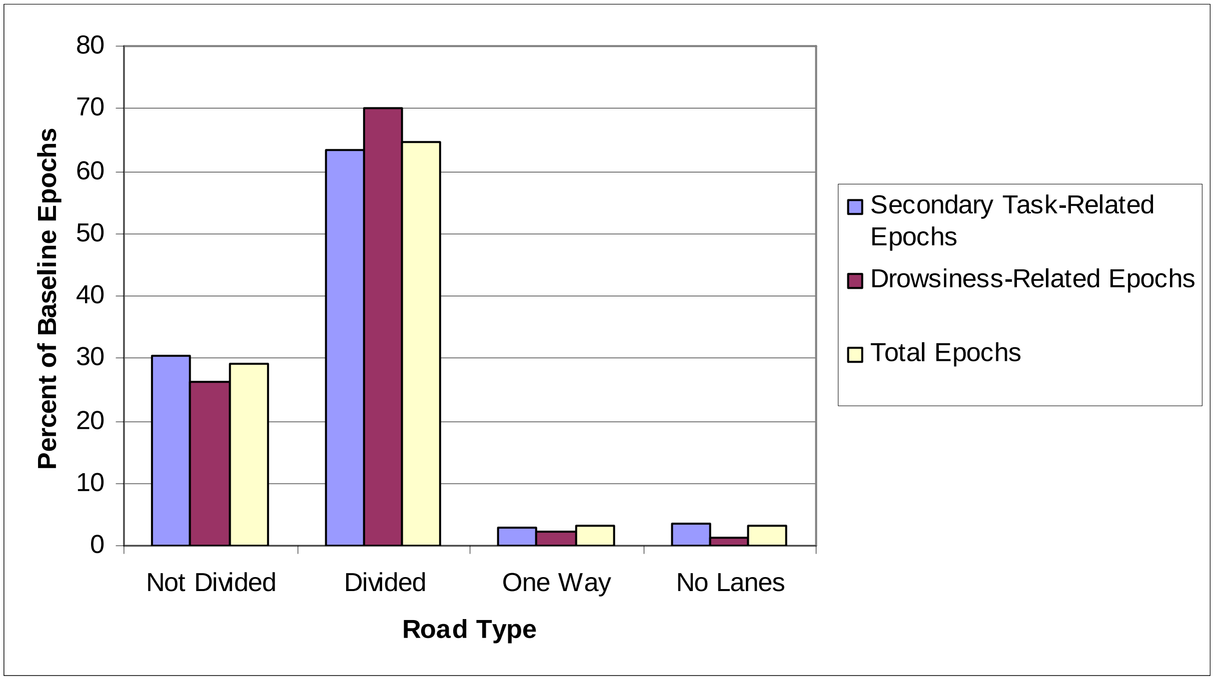

Figure 3.3. Percentage of secondary-task-related, drowsiness-related, and total baseline epochs by type of roadway.

Even though drivers appear to be engaging in secondary tasks or driving drowsy on these types of roadways equally, that does not necessarily mean that it is equally safe to do so. Odds ratios for drowsiness, complex-secondary-task and moderate-secondary-task engagement were calculated for each road type and are presented in Tables 3.11 through 3.13. All of the odds ratios for the interaction of drowsiness and road type were greater than 3.0, suggesting that driving while drowsy on any of these road types increases near-crash/crash risk by at least three times that of driving alert on the same types of roadways with the highest risk associated with undivided roadways.

Engaging in complex secondary tasks while driving on undivided roadways was slightly less dangerous than engaging in complex secondary tasks while driving on a divided roadway. While this may not make intuitive sense, this result may be an artifact of the higher percentage of driving on divided roadways and the higher traffic densities occurring on these roadways given the metropolitan environment where these data were collected. The odds ratios for engaging in moderate secondary tasks were not significantly different from 1.0 indicating that engaging in moderate secondary tasks is less risky than engaging in complex secondary tasks or driving drowsy.

Table 3.11. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness by road type.

Road Type	Odds Ratio	Lower CL	Upper CL
Divided	**3.73**	**2.61**	**5.34**
Undivided	**5.54**	**3.47**	**8.84**
One-Way	**3.40**	**1.76**	**6.59**
Parking Lots	N/A	N/A	N/A

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.12. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks by road type.

Road Type	Odds Ratio	Lower CL	Upper CL
Divided	**4.20**	**2.40**	**7.33**
Undivided	**3.60**	**1.89**	**6.79**
One-Way	**3.66**	**1.63**	**8.18**
Parking Lots	N/A	N/A	N/A

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.13. Odds ratio point estimates and 95 percent confidence intervals for the interaction of moderate secondary tasks by road type.

Road Type	Odds Ratio	Lower CL	Upper CL
Divided	0.79	0.57	1.10
Undivided	0.85	0.54	1.35
One-Way	0.94	0.48	1.84
Parking Lots	0.68	0.25	1.85

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Roadway Alignment

Roadway alignment is a GES Crash Database variable that refers to both the curvature and percent grade of the roadway. Both curvature and percent grade can dramatically shorten the driver's sight distance of the roadway and traffic patterns in front of them. Coupled with driver inattention or drowsiness, specific types of roadway alignment may increase near-crash/crash risk. Given reduced sight distance, do drivers tend not to engage in secondary tasks or attempt to become more alert, if even for a brief time?

Table 3.14 presents the frequency of secondary-task-related events and baseline epochs that were observed for each type of roadway alignment. Most events and epochs occurred on straight and level roadways. This is most likely an artifact of the geographic location where the data were collected (Northern Virginia/Washington, DC, metro area).

Table 3.14. The frequency of drowsiness and secondary-task-related events and epochs that were recorded for each type of roadway alignment.

Type of Roadway Alignment	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary-Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task-Related Baseline Epochs
Curve Grade	0	6	7	41
Curve Level	20	31	73	387
Straight Grade	1	4	15	95
Straight Level	90	184	659	3,587
Straight Hill Crest	0	0	0	1
Curve Hill Crest	0	0	0	0
Other	0	0	0	1
Total	111	225	754	4,112

Figure 3.4 compares the percentage of drowsiness-related, secondary-task-related, and total baseline epochs for different levels of roadway alignment. While 90 percent of drowsiness-, secondary-task-related, and total baseline epochs occur on straight and level roadways, other roadway alignments did occur in the dataset. The percentages for each type of alignment were nearly identical for all three groups. This suggests that drivers are not selecting to engage in secondary-task-related activities based upon the alignment of the roadway, nor are there differences in driver drowsiness on these different roadway alignments.

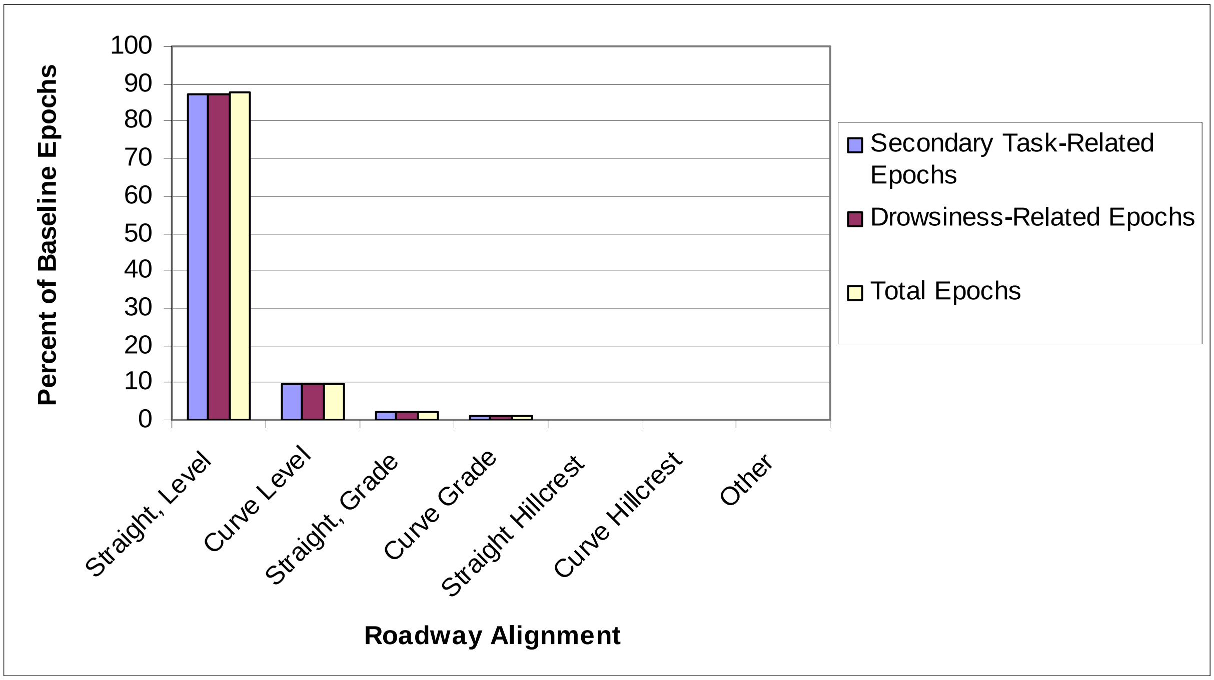

Figure 3.4. Percentage of secondary-task-related, drowsiness-related, and total baseline epochs by type of roadway alignment.

To determine whether there is increased individual near-crash/crash risk for driving drowsy or engaging in secondary-task-related activities for particular types of roadway alignment, odds ratios were calculated and are presented in Tables 3.15 through 3.17. The odds ratio calculation for straight, grade had the highest near-crash/crash risk, suggesting that drowsy drivers are over six times as likely to be involved in a crash or near-crash as an alert driver on a straight, grade roadway (Table 3.15). The odds ratio for the straight, grade was not significantly higher than for curve, level or straight, level (since the confidence limits of all three roadway alignments overlap).

Engaging in complex secondary tasks on these four roadway alignments was also shown to be riskier than driving alert on the same roadway types (Table 3.16). The odds ratio for curve, level was nearly the same as the odds ratio for straight, level, suggesting that these two are equally riskier than driving while alert. The odds ratios for straight, grade was significantly higher than the other road alignments (except for straight, grade), suggesting that this road alignment is a riskier road environment for engaging in complex secondary tasks. The odds ratio for curve, grade was not significantly different than curve, level and straight, level. Driving while performing complex secondary tasks was at least three times riskier than driving while alert for all of these road alignments.

The odds ratios for moderate secondary tasks indicate that these types of tasks are not as risky as engaging in complex secondary tasks or driving drowsy on these road alignments.

Table 3.15. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness and roadway alignment.

Type of Roadway Alignment	Odds Ratio	Lower CL	Upper CL
Straight, Level	**3.96**	**2.93**	**5.34**
Curve, Level	**5.81**	**3.66**	**9.21**
Straight, Grade	**6.29**	**2.20**	**17.96**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.16. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks and roadway alignment.

Type of Roadway Alignment	Odds Ratio	Lower CL	Upper CL
Straight, Level	**3.59**	**2.20**	**5.84**
Curve, Level	**3.58**	**1.95**	**6.60**
Straight, Grade	**26.00**	**7.31**	**92.53**
Curve, Grade	**6.75**	**2.08**	**21.89**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.17. Odds ratio point estimates and 95 percent confidence intervals for the interaction of moderate secondary tasks and roadway alignment.

Type of Roadway Alignment	Odds Ratio	Lower CL	Upper CL
Straight, Level	0.79	0.60	1.03
Curve, Grade	1.69	0.56	5.09
Curve, Level	0.88	0.56	1.39
Straight, Grade	1.86	0.56	6.19

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Traffic Density

Traffic density was recorded by the data reductionists using the Transportation Research Board's (TRB) Level of Service (LOS) Definitions (*Highway Capacity Manual*, 2000). The LOS is a scale from 1 to 6 of *increasing* traffic density with 1 being free-flow traffic and 6 being stop-and-go traffic with extended stoppages. The six levels of traffic density are listed in Table 3.18 along with the frequency of drowsiness- and secondary-task-related events and epochs that were recorded at each level of traffic density.

Table 3.18. The frequency of secondary-task-related events and epochs that were recorded at each level of traffic density.

Traffic Density	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task-Related Baseline Epochs
LOS A: Free Flow	44	84	430	2,013
LOS B: Flow with Some Restrictions	31	73	237	1,529
LOS C: Stable Flow – Maneuverability and Speed are more Restricted	20	43	56	391
LOS D: Flow is Unstable – Vehicles are unable to pass with temporary stoppages.	10	19	14	84
LOS E: Unstable Flow- Temporary restrictions, substantially slow drivers	5	7	10	55
LOS F: Forced Traffic Flow Conditions with Low Speeds and Traffic Volumes Below Capacity	2	0	8	43
Total	112	226	755	4,115

Note: inattention is defined as only those events where drivers were involved in secondary tasks or were severely drowsy.

Figure 3.5 presents the percentage of drowsiness-related, secondary-task-related, and total baseline epochs that occurred at each level of traffic density. As traffic density increased, the frequency of drowsiness- and secondary-task-related epochs decreased. The percentage for secondary-task-related epochs and total epochs did not differ, indicating that drivers are not choosing to engage in complex or moderate secondary tasks differently for these traffic densities. The drowsiness-related epochs were slightly different, with more drowsiness-related events occurring during free-flow and fewer occurring during flow with restrictions and stable traffic flow. One hypothesis for this result is that driving in free-flow traffic is less interesting and requires less activity by the driver. Therefore, these types of traffic flow may help induce drowsiness because the driver is under-stimulated.

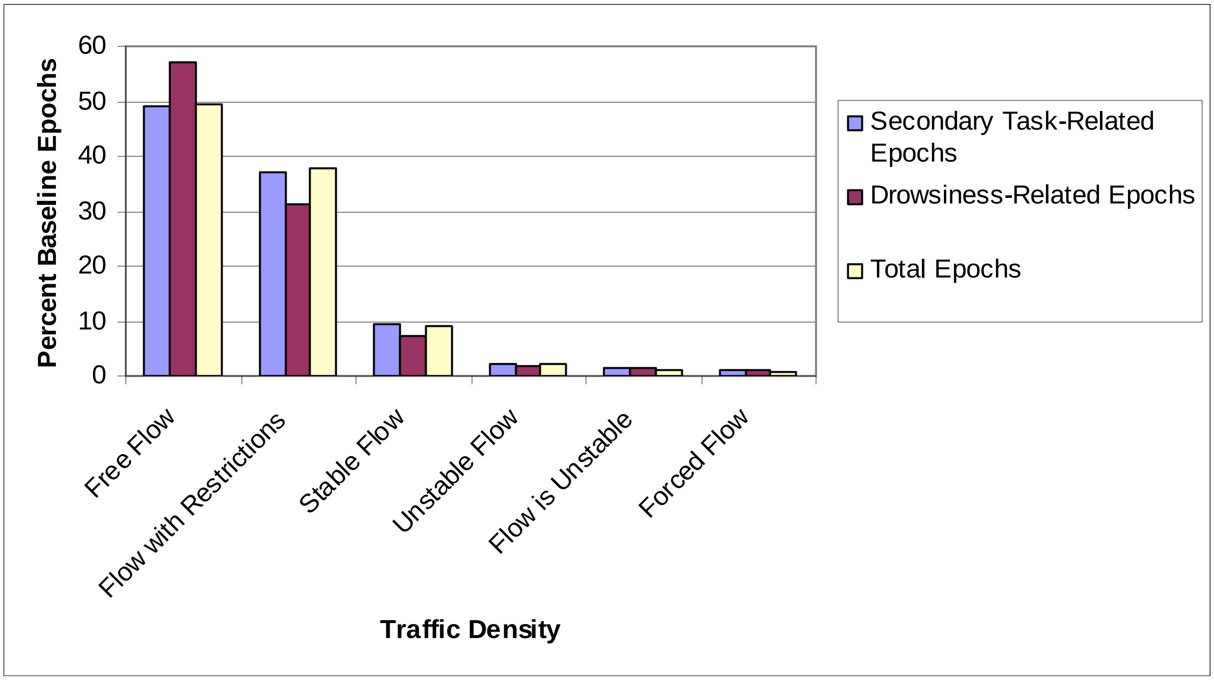

Figure 3.5. Percentage of secondary-task-related, drowsiness-related, and total baseline epochs by type of traffic density.

Odds ratios were calculated to determine if any of these traffic densities present greater individual near-crash/crash risk. Tables 3.19 through 3.21 present the odds ratio calculations for each level of density for drowsiness. The odds ratio calculations for driving drowsy at each level of traffic density suggest that driving drowsy is at least three times riskier than driving while alert during the same level of traffic density. None of the traffic densities were significantly riskier than any another level of traffic density.

Similar results were found for engaging in complex secondary tasks where this activity was found to increase near-crash/crash risk by at least three times that of alert driving during the same traffic density. Again, engaging in complex secondary tasks was equally risky at all levels of traffic density, except for LOS D.

The odds ratios for moderate secondary tasks did not demonstrate similar risk levels and thus engaging in moderate secondary tasks during these traffic levels is not as risky and does not elevate near-crash/crash risk to the extent as driving drowsy or engaging in complex secondary tasks. This result was found to be true across all levels of traffic density for moderate-secondary-task engagement.

Table 3.19. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness and traffic density.

Type of Traffic Density	Odds Ratio	Lower CL	Upper CL
LOS A: Free Flow	**4.67**	**3.02**	**7.21**
LOS B: Flow with Some Restrictions	**4.81**	**2.70**	**8.58**
LOS C: Stable Flow – Maneuverability and Speed are more Restricted	**3.63**	**2.01**	**6.54**
LOS D: Flow is Unstable – Vehicles are unable to pass with temporary stoppages	**4.29**	**1.88**	**9.80**
LOS E: Unstable Flow-Temporary restrictions, substantially slow drivers	**3.71**	**1.93**	**7.13**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.20. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks and traffic density.

Type of Traffic Density	Odds Ratio	Lower CL	Upper CL
LOS A: Free Flow	**4.67**	**2.32**	**9.38**
LOS B: Flow with Some Restrictions	**3.67**	**1.65**	**8.19**
LOS C: Stable Flow – Maneuverability and Speed are more Restricted	**3.80**	**1.68**	**8.58**
LOS D: Flow is Unstable – Vehicles are unable to pass with temporary stoppages	1.75	0.61	5.01
LOS E: Unstable Flow-Temporary restrictions, substantially slow drivers	**2.45**	**1.01**	**5.93**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.21. Odds ratio point estimates and 95 percent confidence intervals for the interaction of moderate secondary task and traffic density.

Type of Traffic Density	Odds Ratio	Lower CL	Upper CL
LOS A: Free Flow	0.95	0.63	1.45
LOS B: Flow with Some Restrictions	0.69	0.39	1.23
LOS C: Stable Flow – Maneuverability and Speed are more Restricted	0.69	0.38	1.26
LOS D: Flow is Unstable – Vehicles are unable to pass with temporary stoppages	0.31	0.13	0.76
LOS E: Unstable Flow- Temporary restrictions, substantially slow drivers	1.18	0.59	2.34

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Surface Condition

The surface condition of roadways has been identified as a frequent contributing factor for crashes and near-crashes. Reductionists used the video and driving performance sensors to assess the status of the roadway surfaces. This analysis was conducted to determine whether drivers engaged in inattentive driving on roads with poor surface conditions. Table 3.22 shows the frequency of the drowsiness and secondary-task-related events and baseline epochs for all six surface condition types. Nearly all of the events and epochs occurred on dry pavement.

Table 3.22. The frequency of drowsiness- and secondary-task-related epochs that occurred at each roadway surface condition level.

Surface Condition	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary-Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task -Related Baseline Epochs
Dry	98	197	666	3681
Wet	13	29	83	395
Icy	1	1	0	3
Snowy	0	0	6	35
Muddy	0	0	0	0
Other	0	0	0	1
Total	112	227	755	4115

Figure 3.6 shows the percentages of drowsiness-related, secondary-task-related, and total baseline epochs that occurred for each type of surface condition. Nearly 90 percent of all drowsiness-related, secondary-task-related, and total baseline epochs occurred on dry pavement, while very low percentages occurred on icy, snowy, and muddy roads. Nearly identical patterns

were observed for percent of drowsiness-related and total number of baseline epochs, as well as for secondary-task-related and total number of baseline epochs. This indicates that drivers did not choose to engage in secondary tasks or drive drowsy as a function of the surface condition of the roadway.

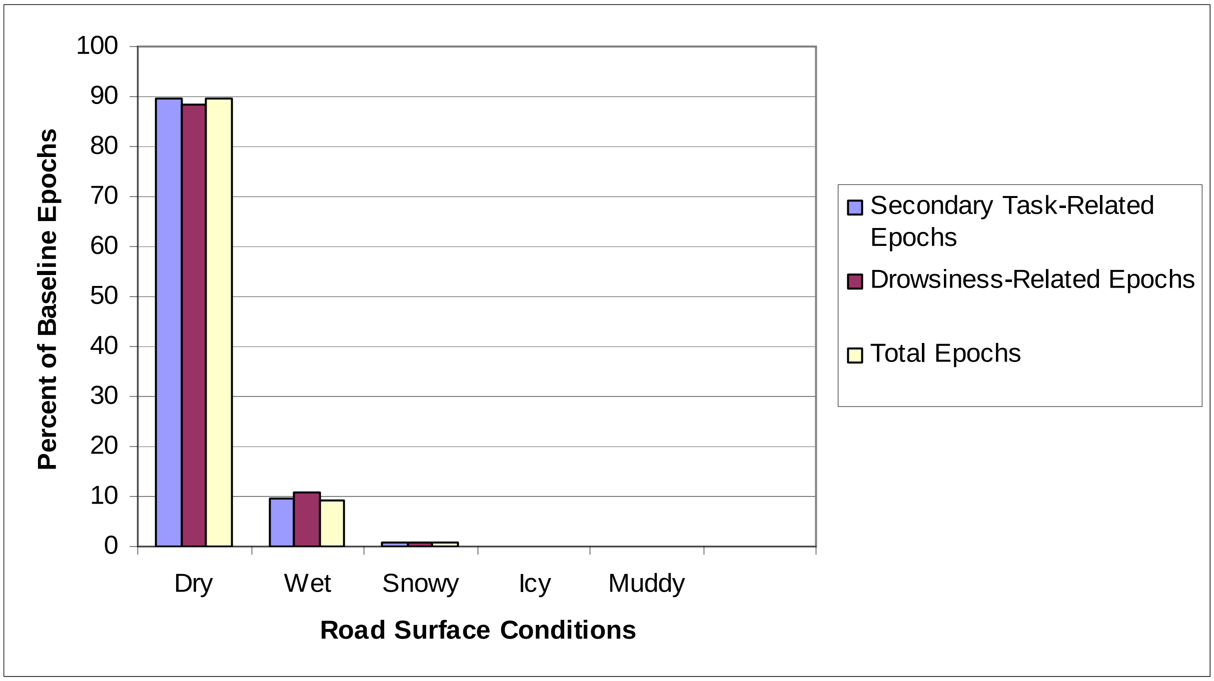

Figure 3.6. Percentage of secondary-task-, drowsiness-related and total baseline epochs for all surface conditions.

Odds ratio calculations were conducted to determine whether the near-crash/crash risks associated with driving drowsy or while engaging in complex or moderate secondary tasks were different as a function of poor surface conditions. Table 3.23 presents the odds ratios calculated for driving drowsy on dry, wet, and icy surface conditions. (Odds ratios were not calculated for the other surface conditions because there were either no baseline epochs or no crash or near-crash events observed for these conditions.) Driving while drowsy on either dry or wet roadways increased near-crash/crash risk by at least three times over that of driving alert on a dry or wet roadway.

The odds ratios for engaging in complex secondary tasks on dry roadways increased near-crash/crash risk by four times over that of driving alert on dry roadways (Table 3.24). The relative near-crash/crash risk of engaging in complex secondary tasks on wet roadways was neither significantly different from 1.0 nor significantly different than driving alert on a wet roadway. This result is also not intuitive, but may be due in part to slower speeds and increased headway distances commonly occurring on rainy roadways.

A similar pattern was found for engaging in moderate secondary tasks, which was found to not be as risky as driving drowsy or while engaging in complex secondary tasks (Table 3.25). Dry and wet roadways were also not significantly riskier than one another, suggesting that the interaction found for the complex secondary task and surface condition is unique to complex-secondary-task engagement.

Table 3.23. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness and surface condition.

Type of Surface Condition	Odds Ratio	Lower CL	Upper CL
Dry	4.52	3.39	6.03
Wet	**3.17**	**2.03**	**4.95**
Icy	N/A	N/A	N/A

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.24. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks and surface condition.

Type of Surface Condition	Odds Ratio	Lower CL	Upper CL
Dry	**4.44**	**2.88**	**6.84**
Wet	1.03	0.58	1.80
Icy	N/A	N/A	N/A

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.25. Odds ratio point estimates and 95 percent confidence intervals for the interaction of moderate secondary tasks and surface condition.

Type of Surface Condition	Odds Ratio	Lower CL	Upper CL
Dry	0.85	0.65	1.12
Wet	0.73	0.47	1.15
Icy	N/A	N/A	N/A

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

ROADWAY INFRASTRUCTURE

Traffic Control

The type of traffic control device that a driver needed to heed either 5 seconds prior to or during the course of the crash or near-crash was recorded by trained data reductionists for the events. If a driver needed to heed a traffic control device during the 6-second baseline segment, the reductionist also marked it accordingly. Otherwise, the reductionists recorded *No Traffic Control*.

Table 3.26 presents the frequency of drowsiness- and secondary-task-related events and baseline epochs where the driver was heeding a particular traffic-control device. Most of the events and epochs were marked as *No Traffic Control.*

Table 3.26. The frequency of secondary-task-related crash and near-crash events and baseline epochs that were recorded for each type of traffic-control device.

Type of Traffic Control Device	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task-Related Baseline Epochs
Traffic Signal	13	42	40	614
Stop Sign	2	5	3	73
Traffic Lanes Marked	2	4	28	273
Yield Sign	0	0	2	18
Slow or Warning Sign	0	0	2	7
No Passing Sign	0	0	0	1
One-way road	0	0	0	8
Officer or Watchman	0	0	0	3
No Traffic Control	91	169	676	3,609
Other	3	3	4	15
Total	108	223	755	4,114

Note: inattention is defined as only those events where drivers were involved in secondary tasks or were severely drowsy.

The comparisons between the percent of drowsiness-related, secondary-task-related, and total number of baseline epochs for each type of traffic-control device are shown in Figure 3.7. The percentages are very similar across the board, which indicates that drivers are not choosing to engage in secondary tasks or drive while drowsy differently when encountering any of these traffic control devices. This is not to say that drivers were not engaging in secondary tasks while safely sitting at a stop sign or traffic light. This type of analysis could not be performed because the vehicle needed to be moving during the 6 seconds of the epoch for that segment to qualify as a baseline epoch (as discussed in Chapter 1: Introduction and Method).

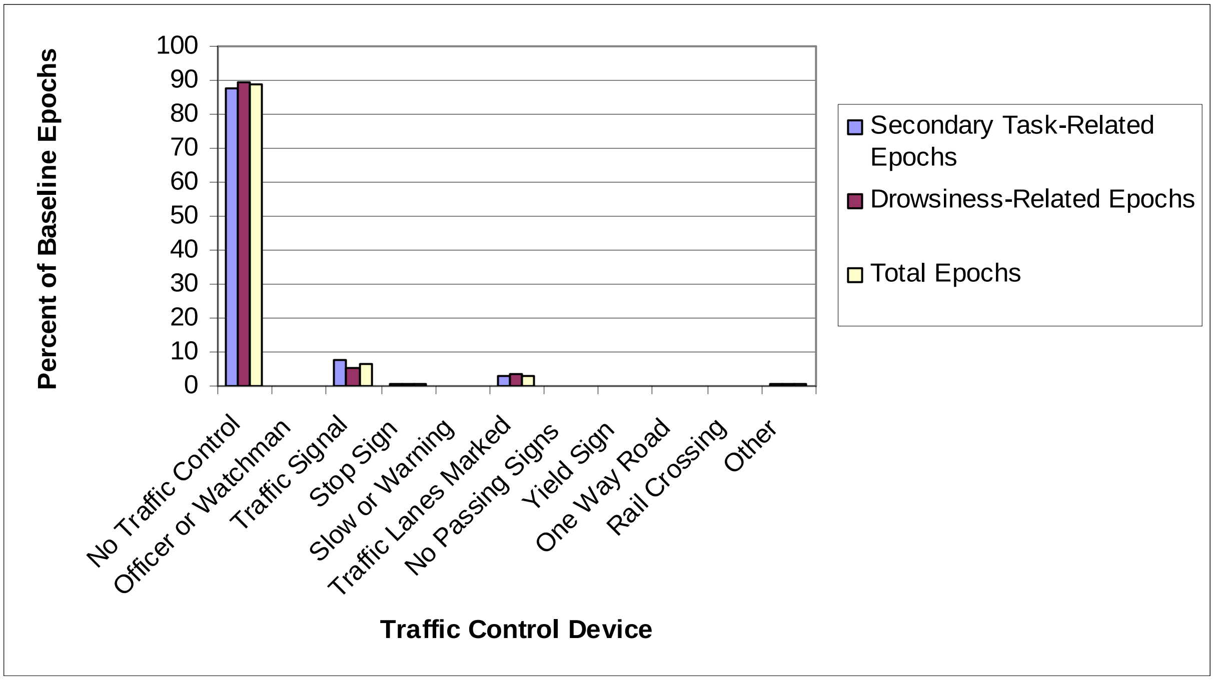

Figure 3.7. Percentage of secondary-task-related, drowsiness-related, and total number of baseline epochs for each type of traffic control device.

Odds ratios were calculated to determine whether engaging in complex or moderate secondary tasks or driving while drowsy while encountering any of these traffic control devices increased an individual's near-crash/crash risk (Tables 3.27 through 3.29). The odds ratio calculations for drowsiness suggest that drowsiness, by itself, increases an individual's risk of being involved in a crash or near-crash by at least 2.7 times over that of an alert driver encountering the same traffic-control device (Table 3.27). None of the traffic-control devices were significantly more risky in the presence of drowsiness than any other traffic-control device.

The odds ratios for complex-secondary-task engagement were similar. Engaging in complex secondary tasks in the presence of a traffic signal, stop sign, or no traffic-control device increased near-crash/crash risk by at least three times over that of an alert driver at a similar traffic-control device (Table 3.28). Stop signs or traffic signals were not significantly riskier than no traffic-control devices. Odds ratios for other traffic-control devices were not available due to low statistical power.

The odds ratios for moderate secondary task engagement were not significantly different from 1.0 except for traffic signal (Table 3.29). The odds ratio for traffic signals actually showed a protective effect, suggesting either that the traffic signal was perhaps able to redirect drivers' attention to the forward roadway or that the presence of a traffic signal was highly correlated with increased traffic, which redirected drivers' attention to the forward roadway. Overall, engaging in moderate secondary tasks is not as risky as driving drowsy or engaging in complex secondary tasks in the presence of any of these traffic-control devices.

Table 3.27. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness and each type of traffic-control device.

Type of Traffic-Control Device	Odds Ratio	Lower CL	Upper CL
Traffic Signal	**2.71**	**1.90**	**3.85**
Stop Sign	**5.55**	**2.71**	**11.36**
Traffic Lanes Marked	**5.57**	**2.43**	**12.78**
No Traffic Control	**4.83**	**3.60**	**6.48**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.28. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks and each type of traffic-control device.

Type of Traffic-Control Device	Odds Ratio	Lower CL	Upper CL
Traffic Signal	**3.14**	**2.15**	**4.58**
Stop Sign	**3.27**	**1.38**	**7.75**
No Traffic Control	**4.02**	**2.47**	**6.54**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.29. Odds ratio point estimates and 95 percent confidence intervals for the interaction of moderate secondary tasks and each type of traffic-control device.

Type of Traffic-Control Device	Odds Ratio	Lower CL	Upper CL
Traffic Signal	0.41	0.28	0.59
Stop Sign	0.73	0.34	1.56
Traffic Lanes Marked	2.29	0.98	5.31
No Traffic Control	0.92	0.70	1.22

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Relation to Junction

The *relation to junction* variable was also adapted from the GES Crash Database to refer to whether the driver was in close proximity to a roadway junction. If the onset of a crash or near-crash occurred in or near an intersection, merge ramp, or interchange, the event was recorded as such; otherwise it was recorded as a non-junction. Likewise, if the vehicle passed through an intersection, interchange, or entered a merge ramp during the 6-second segment of the baseline epochs, then the appropriate relation to junction variable was recorded. Otherwise, non-junction was recorded for that baseline epoch. The different types of junctions used by data reductionists are presented in Table 3.30 along with the frequency of secondary-task- and drowsiness-related events and baseline epochs. Note that most events and epochs were not near roadway junctions (i.e., they were "non-junction").

Table 3.30. The frequency of drowsiness- and secondary-task-related events and epochs that were recorded for each type of relation to junction.

Type of Relation to Junction	Frequency of Drowsiness-Related Crash and Near-Crash Events	Frequency of Secondary-Task-Related Crash and Near-Crash Events	Frequency of Drowsiness-Related Baseline Epochs	Frequency of Secondary-Task-Related Baseline Epochs
Intersection	17	42	30	257
Intersection-Related	11	22	28	232
Entrance/Exit Ramp	7	11	15	65
Parking Lot	0	5	4	112
Driveway/Alley Access	0	3	2	15
Interchange	1	2	1	10
Rail Grade Crossing	0	0	0	0
Other	0	0	1	12
Non-Junction	75	140	674	3,412
Total	111	226	755	4,115

Note: inattention is defined as only those events where drivers were involved in secondary tasks or were severely drowsy.

Figure 3.8 presents the percentages of drowsiness-related, inattention-related, and total number of baseline epochs occurring at each of the junction types. Note that non-junction accounted for 84 percent of the secondary-task-related baseline epochs as well as of the total baseline epochs. There were very small differences between the percentages of secondary-task-related and total number of baseline epochs, suggesting that there are only small differences between the percentages of time spent engaging in secondary tasks whereas encountering these junctions and how often drivers encounter these types of junctions. There were slight differences in the percentage of drowsiness-related epochs and total epochs, suggesting that a higher percentage of drowsiness-related epochs occurred at non-junctions than at or near intersections. This may suggest that drivers may be more relaxed (under-stimulated) and may succumb to drowsiness effects more often while navigating through less-demanding environments.

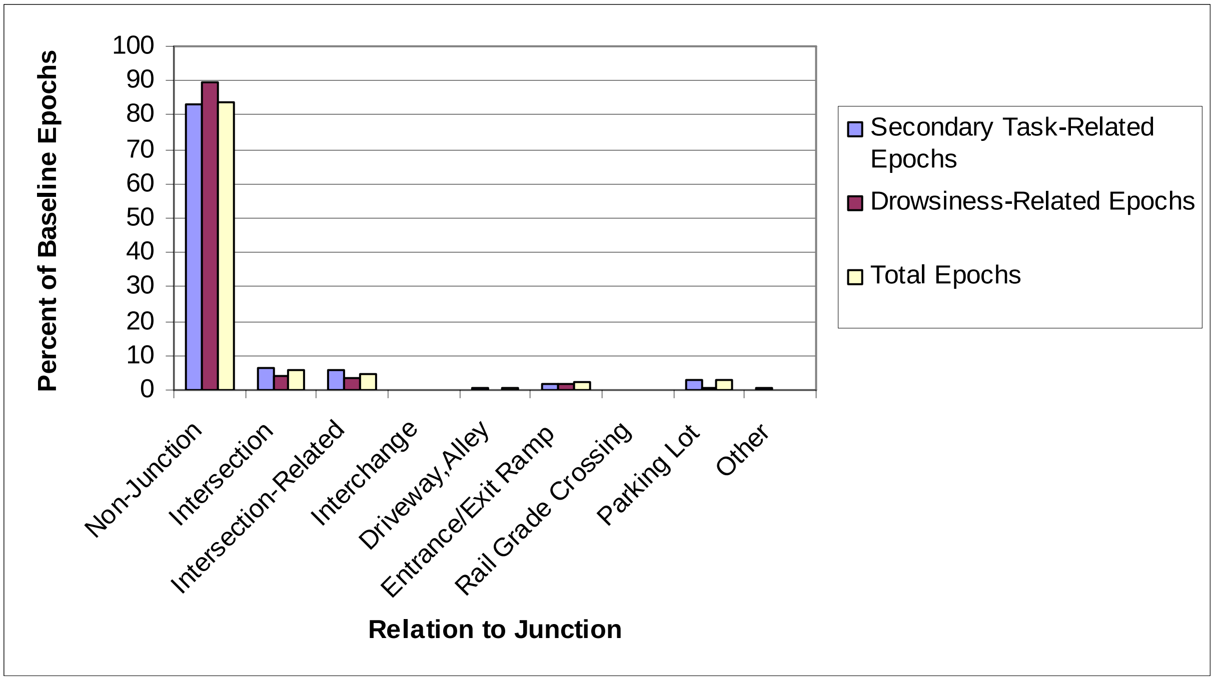

Figure 3.8. Percentage of secondary-task-related, drowsiness-related, and total number of baseline epochs for each relation to junction.

To determine whether any of these types of junctions present higher near-crash/crash risks for inattentive drivers, the odds ratios for each were calculated (Tables 3.31 through 3.33). The results for the drowsiness-related odds ratios indicate that near-crash/crash risk increased by at least three times for drivers who were navigating intersections, entrance ramps, and interchanges than for those drivers who were alert at similar junctions (Table 3.31). Also, driving while drowsy in general (i.e., non-junction) increases a driver's near-crash/crash risk by as much as five times over that of an alert driver encountering similar roadway junctions.

Engaging in complex secondary tasks while in a parking lot or near an intersection increased near-crash/crash risk over that of an alert driver at the junction type (Table 3.32). Somewhat surprisingly, the odds ratio for an intersection did not demonstrate an increased near-crash/crash risk. Drivers may be more careful or even avoid engaging in complex tasks during intersections as these are visually and cognitively demanding environments. The odds ratio for engaging in complex secondary tasks in a parking lot was very high, with an increased near-crash/crash risk of nine times over that of an alert driver in a parking lot. This is somewhat higher than was expected, however, there is a wide confidence interval surrounding this point estimate.

The odds ratios for engaging in moderate secondary tasks showed a similar pattern to complex secondary tasks, in that the odds ratio for intersection was lower than for intersection-related or parking lot (Table 3.33). While the pattern is similar, generally the odds ratios for moderate secondary tasks are not significantly different from 1.0, with the exception of intersection. This suggests that engaging in moderate secondary tasks is not as risky as engaging in complex secondary tasks or driving while drowsy in the presence of these types of roadway junctions.

Table 3.31. Odds ratio point estimates and 95 percent confidence intervals for the interaction of drowsiness and each type of relation to junction.

Type of Relation to Junction	Odds Ratio	Lower CL	Upper CL
Intersection	**3.48**	**2.17**	**5.59**
Intersection-Related	**6.82**	**4.10**	**11.35**
Entrance/Exit Ramp	**3.21**	**1.81**	**5.71**
Interchange	**5.86**	**2.39**	**14.35**
Non-Junction	**5.02**	**3.65**	**6.90**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.32. Odds ratio point estimates and 95 percent confidence intervals for the interaction of complex secondary tasks and each type of relation to junction.

Type of Relation to Junction	Odds Ratio	Lower CL	Upper CL
Intersection	1.59	0.86	2.97
Intersection-Related	**3.32**	**1.73**	**6.38**
Parking Lot	**9.11**	**3.76**	**22.07**

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

Table 3.33. Odds ratio point estimates and 95 percent confidence intervals for the interaction of moderate secondary tasks and each type of relation to junction.

Type of Relation to Junction	Odds Ratio	Lower CL	Upper CL
Intersection	0.50	0.31	0.81
Intersection-Related	0.63	0.37	1.44
Entrance/Exit Ramp	1.12	0.61	2.05
Parking Lot	0.65	0.29	1.44
Driveway/Alley Access	2.00	0.64	6.28
Interchange	2.57	0.89	7.46
Non-Junction	0.95	0.70	1.30

Note: numbers in bold font indicate that the point estimate is significantly different than normal, baseline driving (or an odds ratio of 1.0).

SUMMARY

Two primary research questions were addressed in this chapter:

- Do drivers choose to engage in secondary tasks or drive drowsy during more dangerous or adverse environmental conditions?
- Are any of these environmental conditions riskier than others for inattentive drivers?

Both of these questions were addressed for eight different environmental conditions: ambient lighting, weather, road type, roadway alignment, traffic density, surface condition, traffic-control device, and relation to junction. The results for the first question indicate that far fewer drowsiness-related baseline epochs were observed during the daylight hours than drowsiness-related crashes and near-crashes. Secondly, a greater percentage of drowsiness-related baseline epochs were identified during darkness than drowsiness-related crashes and near-crashes. Drowsiness was also seen to slightly increase in the absence of high roadway or traffic demand. A higher percentage of drowsiness-related baseline epochs were found during free-flow traffic densities, on divided roadways, and areas free of roadway junctions.

The results for the second question were more varied. Each of the eight environmental conditions resulted in odds ratios greater than 1.0 for both drowsiness and engaging in complex secondary tasks. Engaging in moderate secondary tasks rarely resulted in odds ratios significantly greater than 1.0, indicating that these behaviors may not be as risky as driving drowsy or driving while engaging in complex secondary tasks.

In Chapter 2, *Objective 1*, the odds ratio for risk of driving while drowsy was four to six times that of normal, baseline driving, engaging in complex secondary task was three times, and engaging in moderate secondary tasks was two times that of an alert driver. In this chapter, these total odds ratios decreased when comparing across environmental conditions. While a decrease is to be expected when narrowing the focus of the analysis, it should also be noted all three types of tasks are still riskier than attentive driving.

The baseline dataset also provided some interesting results. For example, drivers are operating their vehicles during the daytime, on dry pavement, and on straight, non-junction roadways a majority of the time. While nighttime driving, adverse weather conditions, intersections, and other difficult roadway geometries increase individual near-crash/crash risk, it is important to note that many crashes and near-crashes occur in the *absence* of these adverse conditions.

While many of these results are of interest to human factors researchers, roadway designers, and urban planners, it is important to remember that these data were collected only in a metropolitan, urban driving environment (Northern Virginia/Washington, DC, metropolitan area). The results are only generalizable to other urban/metropolitan driving environments and not to the United States driving population in general.

It is important to note that the 20,000 baseline epochs used in these analyses and calculations of relative near-crash/crash risk were not selected based upon any of the above environmental variables. These epochs were selected at random and these environmental conditions were not used in the sampling procedure. Some degree of caution is suggested in the interpretation of these relative near-crash/crash risks given that the baseline epochs were not selected to specifically assess environmental variables.

While population attributable risk percentages were calculated in Chapter 2 when assessing the general effects of the four types of driver inattention, population attributable risk percentages were not calculated for the environmental conditions discussed in the current chapter. Because the environmental conditions were not considered when selecting the baseline sample, a population attributable risk percentage calculation would only be a gross estimate.

Even after collecting data for 12 months on 100 vehicles, there were still many environmental variables with insufficient statistical power to accurately calculate odds ratios. A larger scale naturalistic driving study is needed to not only obtain accurate and valid measures for many of the variables presented in this chapter, but also for more generalizable results to the United States driving population.

CHAPTER 4: *OBJECTIVE 3*, DETERMINE THE DIFFERENCES IN DEMOGRAPHIC DATA, TEST BATTERY RESULTS, AND PERFORMANCE-BASED MEASURES BETWEEN INATTENTIVE AND ATTENTIVE DRIVERS. HOW MIGHT THIS KNOWLEDGE BE USED TO MITIGATE THE POTENTIAL NEGATIVE CONSEQUENCES OF INATTENTIVE DRIVING BEHAVIORS? COULD THIS INFORMATION BE USED TO IMPROVE DRIVER EDUCATION COURSES OR TRAFFIC SCHOOLS?

For this research objective, statistical analyses were conducted using the frequency of drivers' involvement in inattention-related crashes and near-crashes compared to each driver's composite test battery score or relevant survey response (Table 4.1). The debrief form and the health assessment questionnaires were not included as they are not personality assessment tests. A discussion of how these results could be used to mitigate potential negative consequences of inattentive driving and/or used in traffic schools and drivers education courses will also be addressed in this chapter.

Table 4.1. Description of questionnaire and computer-based tests used for 100-Car Study.

	Name of Testing Procedure	Type of Test	Time test was administered	Brief description
1.	Driver demographic information	Paper/pencil	In-processing	General information on drivers age, gender, etc.
2.	Driving History	Paper/pencil	In-processing	General information on recent traffic violations and recent collisions.
3.	Health assessment questionnaire	Paper/pencil	In-processing	List of variety of illnesses/medical conditions/or any prescriptions that may affect driving performance.
4.	Dula Dangerous Driving Index	Paper/pencil	In-processing	One score that describes driver's tendencies toward aggressive driving.
5.	Sleep Hygiene	Paper/pencil	In-processing	List of questions that provide information about driver's general sleep habits/substance use/sleep disorders.
6.	Driver Stress Inventory	Paper/Pencil	In-processing	One score that describes the perceived stress levels drivers experience during their daily commutes.
7.	Life Stress Inventory	Paper/pencil	In-processing/Out-processing	One score that describes drivers stress levels based upon the occurrence of major life events.
8.	Useful Field-of-View	Computer-based test	In-processing	Assessment of driver's central vision and processing speed, divided and selective attention.
9.	Waypoint	Computer-based test	In-processing	Assessment of the speed of information processing and vigilance.
10.	NEO-FFI	Paper/pencil	In-processing	Personality test.
11.	General debrief questionnaire	Paper/pencil	Out-processing	List of questions ranging from seatbelt use, driving under the influence, and administration of experiment.

DATA INCLUDED IN THESE ANALYSES

For the analyses in this chapter, crashes and near-crashes only will be used (incidents will be excluded from the analyses). In Dingus et al., (2005) the analyses indicated that the kinematic signatures of both crashes and near-crashes were nearly identical; whereas the kinematic signature of incidents were more variable. Given this result and to increase statistical power, the data from both crashes and near-crashes will be used in the comparison of questionnaire data to the frequency of driver involvement in inattention-related crashes and near-crashes.

Note that inattention-related crashes and near-crashes are defined as those events that involve the driver engaging in complex, moderate, or simple secondary tasks or driving while drowsy. Please note that in Chapter 2, *driving-related inattention to the forward roadway* was determined to possess a protective effect and therefore was removed from the definition of driving inattention. *Non-specific eyeglance away from the forward roadway* was also shown to not be significantly different from normal, baseline driving; therefore, these events were also removed from the analysis.

ASSIGNMENT OF INVOLVEMENT LEVEL FOR DRIVERS

The first step to conduct the analyses for this research objective is to logically split the subjects into groups of involvement in inattention-related crashes and near-crashes. Figure 4.1 shows the distribution of all of the primary drivers and the frequency of involvement in inattention-related crashes and near-crashes for this study. The median and mean levels are marked on the figure. Note that there are 36 primary drivers who were not involved in any inattention-related crashes or near-crashes. The rest of the primary drivers were involved in 1 to 15 inattention-related crashes and/or near-crashes.

The mean frequency value was used to separate the drivers into two groups: those drivers who had "high involvement" in inattention-related crashes and near-crashes and those drivers who had "low involvement" in inattention-related crashes and near-crashes. Therefore, any driver who was involved in four or more inattention-related crashes and/or near-crashes was labeled as "high involvement" and drivers who were involved in fewer than four inattention-related crashes and/or near-crashes were labeled as having "low involvement." A separate secondary analysis where the drivers were separated into three levels of involvement will be discussed at the end of this chapter.

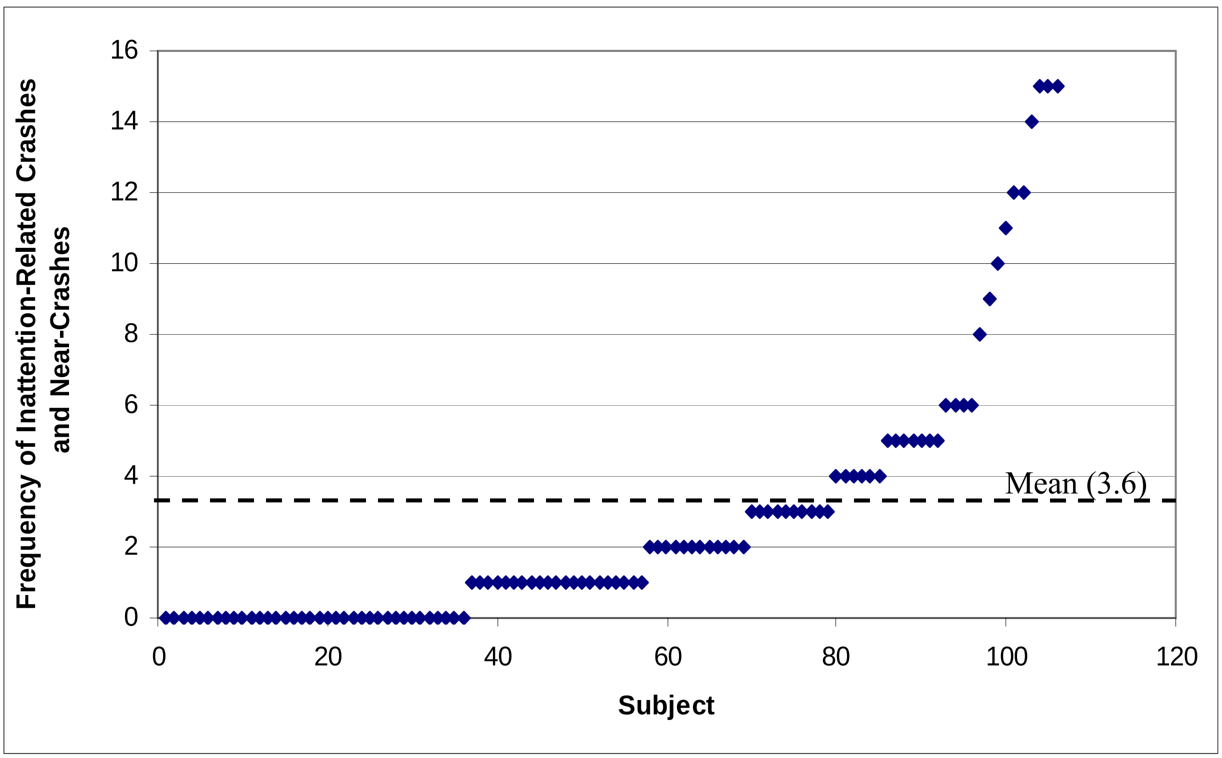

Figure 4.1. The frequency of inattention-related crashes and near-crashes by driver in order from low frequency to high frequency.

While it is apparent that there are several ways to define "high" and "low" levels of involvement in inattention-related crashes and near-crashes, using the mean as a dividing point has been used by many other researchers, and given the exploratory nature of these analyses, it provides a fairly conservative measure upon which to divide the drivers, yet still preserves any differences that may exist between those drivers who have tendencies to be involved in frequent inattention-related crashes and near-crashes and those who exhibit fewer tendencies. Table 4.2 provides the descriptive statistics for the drivers' respective group divisions.

This chapter will first present results using t-tests and correlations to describe any demographic or test battery score differences that exist between drivers with high and low involvement in inattention-related crashes and near-crashes. A separate analysis using analysis of variance and correlations will then be conducted to describe any demographic or test battery differences among high, moderate, and low involvement in inattention-related crashes and near-crashes. Given that these analyses are exploratory in nature, two analyses were conducted to provide a thorough investigation of the demographic and test battery scores for these drivers. Finally, a logistic regression analysis will be presented to assess the predictability of any of these demographic data or test battery scores. After these analyses, a discussion on the usefulness of these test batteries for mitigating distracted driving as well as suggestions for improving driver education programs will be presented.

Table 4.2. Descriptive statistics on drivers labeled "high involvement" and "low involvement" in inattention-related crashes and near-crashes.

Statistic	High Involvement	Low Involvement
Number of drivers	27	78
Mean (# of Inattention-Related Crashes and Near-crashes)	7.6	0.95
Median	6	1
Mode	5	0
Standard deviation	3.9	1.1
Minimum	4	0
Maximum number of events	15	3
Number of crashes	25	14
Number of near-crashes	179	61

ANALYSIS ONE: T-TEST ANALYSIS FOR THE "LOW AND HIGH INVOLVEMENT IN INATTENTION-RELATED CRASHES AND NEAR-CRASHES"

Demographic Data Analyses

The list of driver self-reported demographic data and survey data is shown in Table 4.3.

Table 4.3. Driver self-reported demographic data summary.

	Demographic/Survey Data	Information Presented
1.	Driver Demographic Information	Age Gender Years of driving experience
2.	Driving History	Number of traffic violations in past 5 years Number of accidents in past 5 years
3.	Health Assessment	Frequency of health conditions Frequency of type of health condition
4.	Sleep Hygiene	Daytime sleepiness scale Number of hours of sleep per night

Drivers reported their respective demographic data, driving history (e.g., number of citations received in the past 5 years), health status, and sleep hygiene using four separate surveys. T-tests were conducted to determine if any statistical differences existed between the inattentive and attentive drivers. A complete listing of all t-tests and ANOVA tables is in Appendix D.

Driver Age. Figure 4.2 shows the average age of the high- and low- involvement drivers. A t-test was conducted to determine whether there were significant differences in age between groups. The results suggest that the high-involvement drivers were significantly younger than the low-involvement drivers, $t(102) = 7.07$, $p = 0.009$.

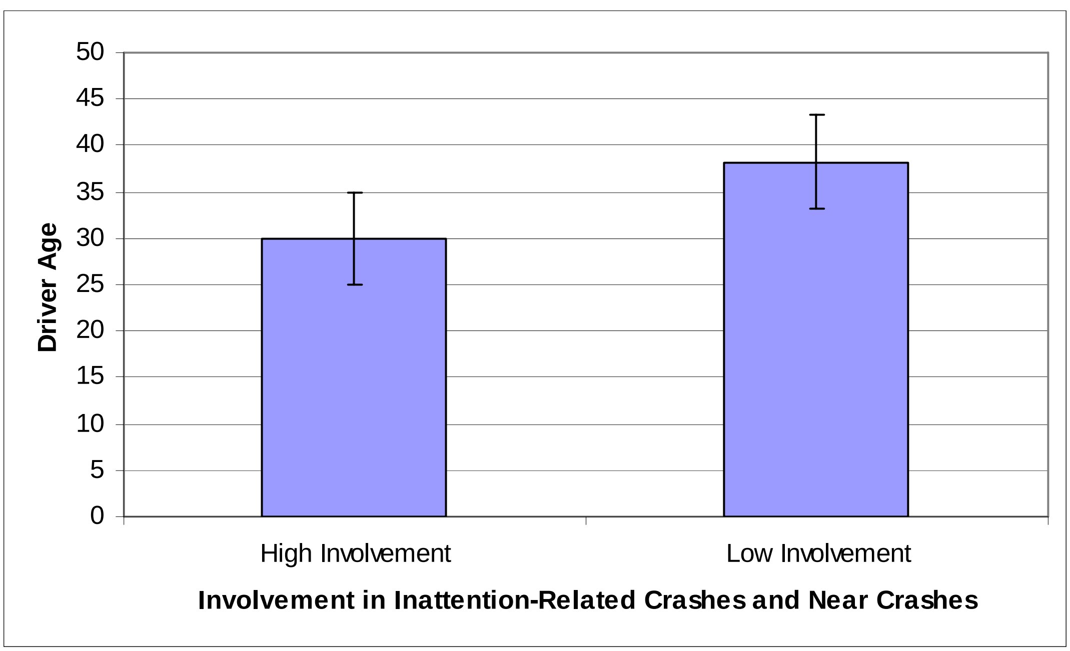

Figure 4.2. Average age of the high- and low-involvement drivers in inattention-related crashes and near-crashes.

To determine whether particular age groups were more likely to drive while inattentive, the drivers were split up into six age groups and the number of events for each group was calculated and plotted in Figure 4.3. Results from a chi-square statistical test indicated that the 18- to 20-year-old drivers had significantly more inattentive events than did any of the other age groups: χ (5) = 39.93, $p > 0.01$.

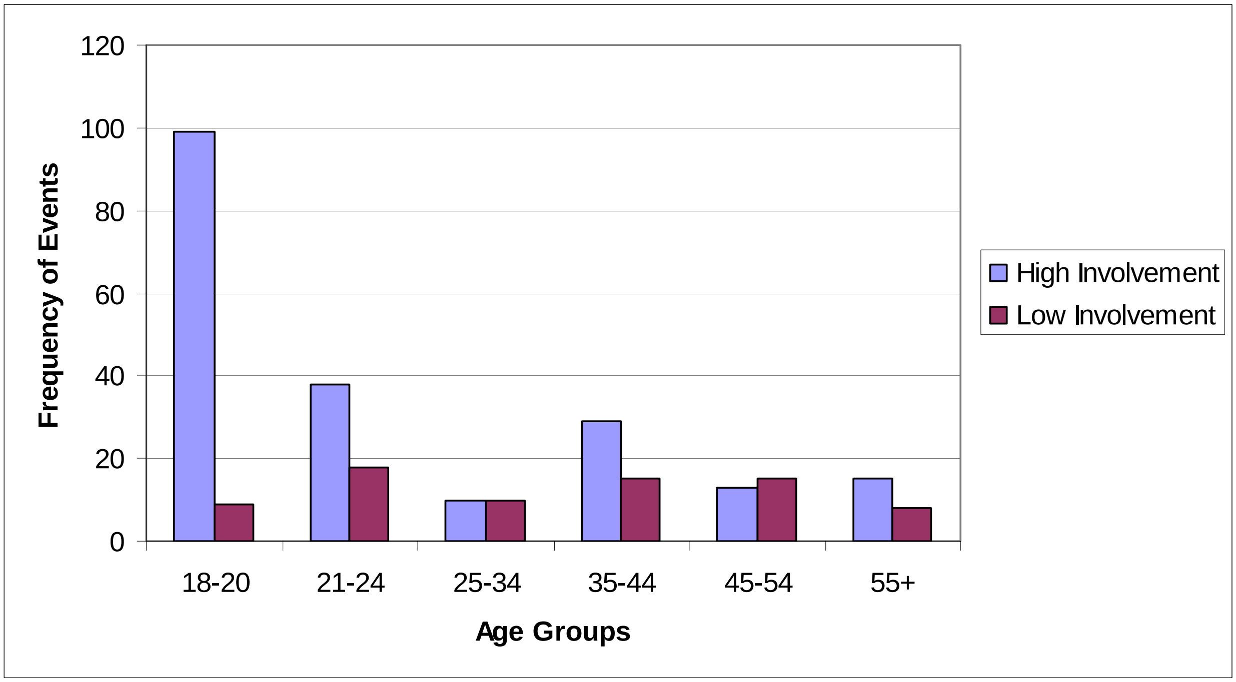

Figure 4.3. The frequency of inattention-related crashes and near-crashes for each age group by involvement group.

Gender. An analysis of the gender make-up of both the high- and low-involvement drivers was also conducted. Note that 60.6 percent of all primary drivers were male and 39.4 percent were female. The breakdown for high- and low-involvement drivers is shown in Figure 4.4. Males were involved in more crashes and near-crashes than were the female drivers. However, it appears that the female drivers were involved in a higher percentage of inattention events than were the male drivers. This suggests that when females are involved in crashes and near-crashes, they are more likely to be inattention-related. Males, on the other hand, have a higher rate of crash and near-crash involvement but a slightly lower likelihood of inattention serving as a contributing factor.

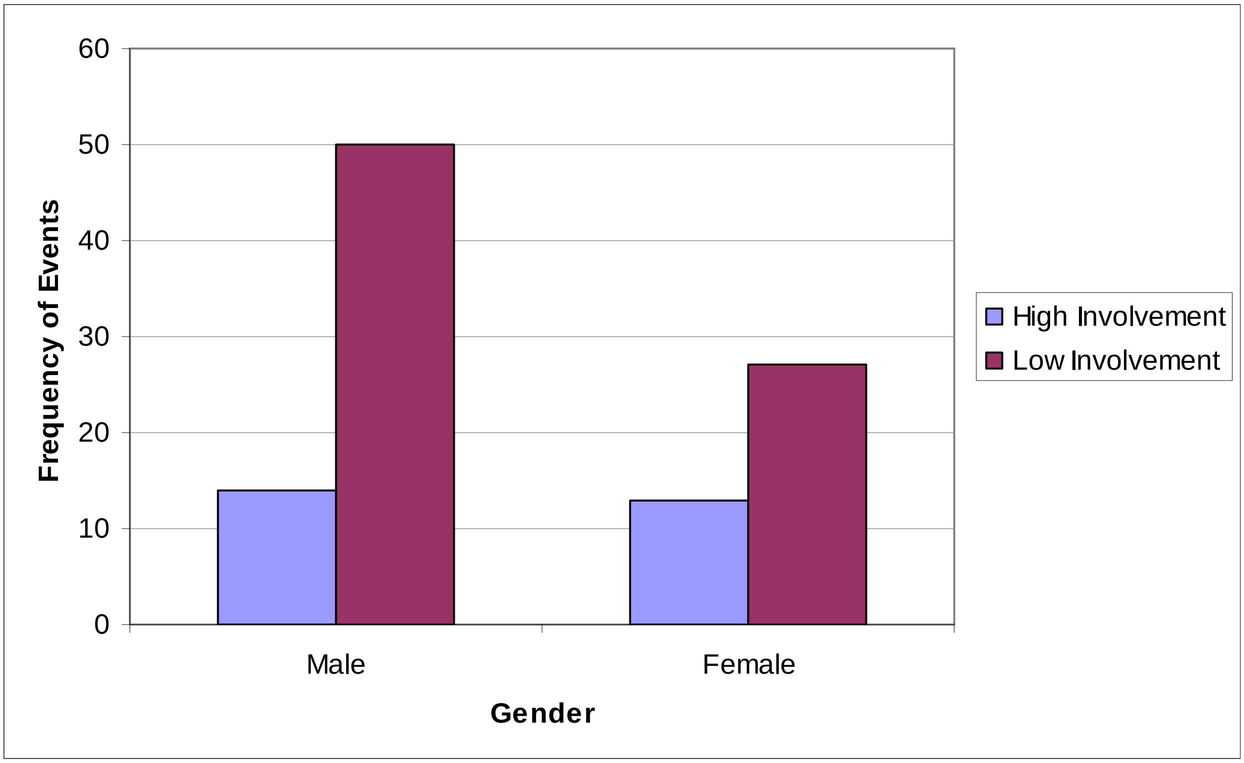

Figure 4.4. Gender breakdown of high-involvement drivers.

Years of Driving Experience. An analysis of the number of years of driving experience was also conducted. Figure 4.5 shows that high-involvement drivers had fewer years of driving experience than did the low-involvement drivers. Again, a t-test was conducted and the results suggest that the high-involvement drivers had significantly fewer years of experience than did the low-involvement drivers: t(99) 7.6, p = 0.007. Given that drivers in the United States generally receive their driver's licenses at age 16, this result is most likely correlated with age.

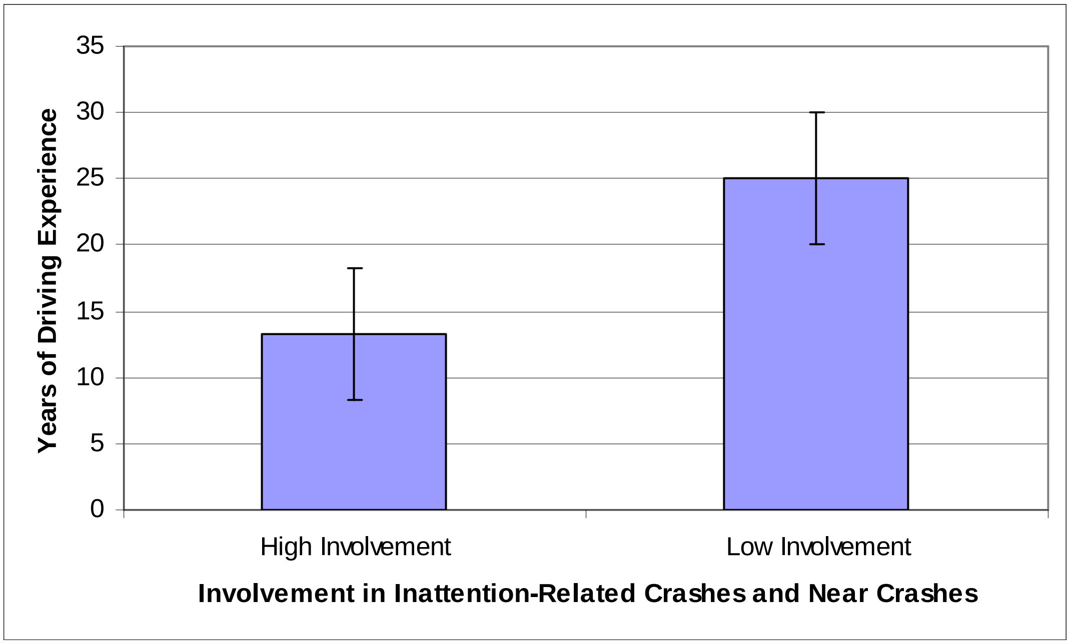

Figure 4.5. Average years of driving experience for drivers with high- and low-involvement in inattention-related crashes and near-crashes.

Drowsiness. Drivers were administered an abbreviated version of the Walter Reed Sleep Hygiene Questionnaire to assess their sleep habits. An abbreviated version was used to reduce the amount of time required of drivers during in-processing. There were 31 questions on this abbreviated questionnaire. This questionnaire was not designed to provide one composite score or rank driver drowsiness on several scales. Therefore, to explore the relevance of this questionnaire to inattention-related events, two of the questions have been identified as the most representative of the entire questionnaire. These two questions are:

> 1. Rank <on a scale of 1 to 10> the extent to which you currently experience daytime sleepiness?
>
> 2. How many hours do you sleep <per night>?

<u>Daytime Sleepiness.</u> The average scores that the high- and low-involvement drivers provided when rating their daytime sleepiness levels on a scale from 1 to 10 indicated that high-involvement drivers rated themselves slightly higher (i.e., more sleepy) than the low-involvement drivers (inattentive = 4.8, attentive drivers = 3.9). While this result was not significant, the t-value approached significance: $t(99) = 3.6$, $p = 0.06$.

<u>Hours of Sleep</u>**.** An analysis of the average number of hours of sleep experienced by high- and low-involvement drivers was also conducted. Both high- and low-involvement drivers' average hours of sleep reported were 7.0 hours, which was not significant. Given that no significant results were obtained for these two questions, no further analyses using this questionnaire were conducted.

Driving History

Number of Traffic Violations. All drivers were asked to report the number of traffic-violation citations that they had received during the 5 years prior to the start of the 100-Car Study. This self-reported value was analyzed by comparing the number of high-involvement driver violations to low-involvement driver violations. Figure 4.6 shows that high-involvement drivers had a higher average number of violations than did the low-involvement drivers. A t-test was conducted which resulted in a significant finding, t(101) 4.9, p = 0.03.

Number of Collisions. All drivers were also asked to report the number of collisions that they had been involved during the 5 years prior to the start of the study. Figure 4.6 also shows that high-involvement drivers reported involvement in only slightly more collisions than the low-involvement drivers. This result was not significant at a 0.05 probability level.

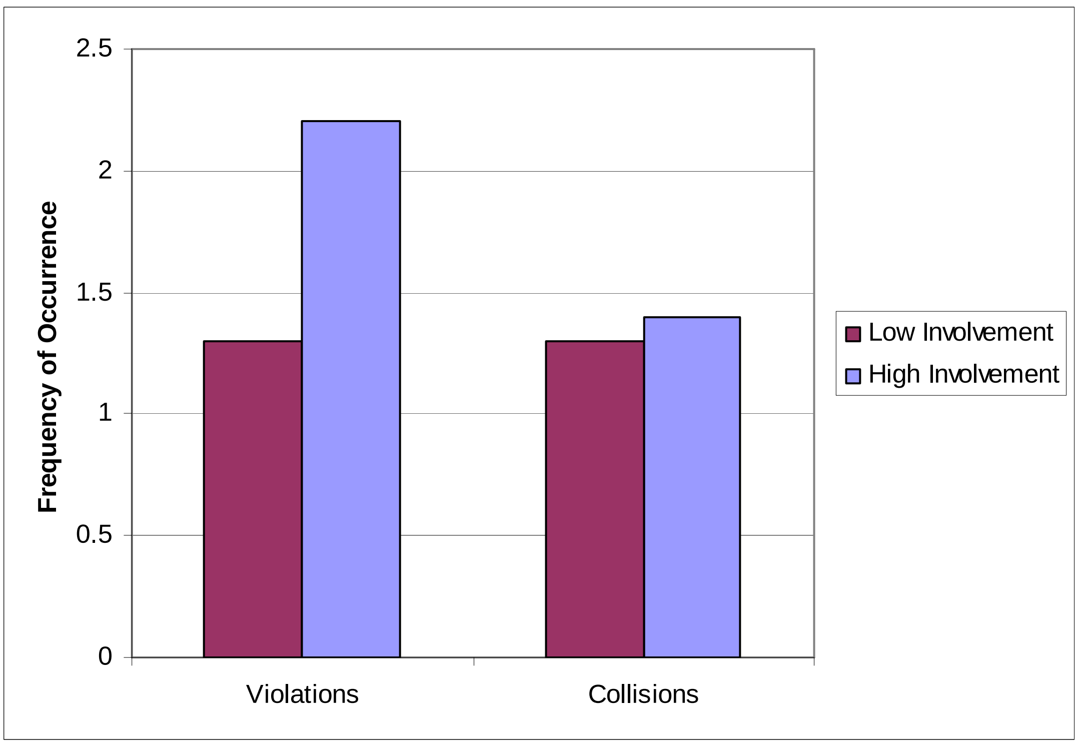

Figure 4.6. Self-reported involvement in traffic violations and collisions for 5 years prior to the onset of the 100-Car Study.

Test Battery Analyses

Table 4.4 provides a list of the test batteries that were administered to the drivers either prior to the onset of the study or at the completion of the study. Analyses of each of these test batteries will follow.

Table 4.4. Test battery names and scores.

Test Battery Name	Test Battery Score
Life Stress Inventory	• Life Stress Score
Driver Stress Inventory	• Aggression • Dislike of Driving • Hazard Monitoring • Thrill-Seeking • Drowsiness-Proneness
Dula Dangerous Driving Inventory	• DDDI Dangerous Driving Total Score • Negative Emotional Driving Subscore • Aggressive Driving Subscore • Risky Driving Subscore
NEO Five Factor Inventory	• Neuroticism • Extroversion • Openness to Experience • Agreeableness • Conscientiousness

Life Stress Inventory. The Life Stress Inventory was administered to the drivers after data collection as the entire questionnaire instructed the drivers to record life stressors experienced during the past 12 months, which corresponded to the duration of data collection. A composite score was then calculated based upon the type of stressors that each driver experienced and an overall life stress score ranged from 0 to 300. Unfortunately, only 65 primary drivers returned after data collection to complete this questionnaire.

T-tests were conducted to determine whether the overall Life Stress Inventory scores were significantly different between the high- and low-involvement drivers. No significant differences were observed as both groups scored in the low stress level category (high-involvement = 154.6 and low-involvement = 125.4). Other descriptive statistics of the Life Stress Inventory are provided in Table 4.5. Note that the highest Life Stress Score was for a low-involvement driver.

Table 4.5. Life Stress Inventory descriptive statistics.

Statistic	High Involvement	Low Involvement
N	15	50
Mean	154.6	125.4
Standard Deviation	104.1	113.0

Driver Stress Inventory. The Driver Stress Inventory was developed by Matthews, Desmond, Joyner, Carcary, and Gilliland (1996) to assess an individual driver's vulnerability to commonplace stress reactions while driving, such as frustration, anxiety, and boredom. The five driver stress factors that the Driver Stress Inventory assesses are (1) aggression, (2) dislike of driving, (3) hazard-monitoring, (4) thrill-seeking, and (5) fatigue proneness. Composite scores for each driver stress factor are provided. The Driver Stress Inventory was originally validated by correlating responses with driver's self-report of violations and collisions, other driver behavior scales (Driver Coping Questionnaire) and the NEO Five-Factor Inventory. The Driver Stress Inventory has been used widely in transportation research.

T-tests were conducted to see whether any significant differences occurred for the high- and low-involvement drivers for each of the five driving stress factor scores. None of the t-tests indicated significant differences between driver groups. One possibility for this result is that these drivers are all urban and may all be fairly uniform on scales such as hazard monitoring and aggressive driving; therefore, no differences existed in this population for these driver assessment scales. Descriptive statistics for each of the five driver stress factors is provided in Tables 4.6 through 4.10 below. These results suggest that the Driver Stress Inventory scores for any of the five driver stress factors show no association with the occurrence of inattention-related crashes and near-crashes.

Table 4.6. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the driver stress factor scale of *aggression*.

Statistic	High Involvement	Low Involvement
N	27	76
Mean	48.5	46.4
Standard Deviation	12.1	15.5

Table 4.7. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the driver stress factor scale of *dislike of driving*.

Statistic	High Involvement	Low Involvement
N	26	76
Mean	33.0	31.9
Standard Deviation	10.1	10.3

Table 4.8. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the driver stress factor scale of *hazard monitoring*.

Statistic	High Involvement	Low Involvement
N	27	76
Mean	64.9	68.9
Standard Deviation	11.2	11.8

Table 4.9. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the driver stress factor scale of *fatigue proneness*.

Statistic	High Involvement	Low Involvement
N	26	76
Mean	39.7	36.7
Standard Deviation	13.6	13.1

Table 4.10. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the driver stress factor scale of *thrill-seeking*.

Statistic	High Involvement	Low Involvement
N	27	75
Mean	28.5	25.1
Standard Deviation	16.6	16.3

Dula Dangerous Driving Inventory. The Dula Dangerous Driving Inventory provides a measure of a driver's likelihood to engage in dangerous behaviors. While the scale maintained strong internal reliability, it was validated using a driving simulator and not any actual driving on a test track or on actual roadways (Dula and Ballard, 2003). The current analysis is one of the first analyses of this inventory using driving data on real roadways and in real traffic conditions. There are four scales that the Dula Dangerous Driving Index measures, these are (1) Overall Dula Dangerous Driving Index, (2) Negative Emotional Driving Subscale, (3) Aggressive Driving Subscale, and (4) Risky Driving Subscale.

T-tests were conducted on each of the four scales to determine whether high-involvement drivers had a significantly different likelihood of engaging in dangerous behavior than did the low-involvement drivers. No significant differences on any of the four scales were observed. The descriptive statistics for each of the four scales are presented in Tables 4.11 through 4.14.

Table 4.11. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the Dula Dangerous Driving Scale for *Dula Dangerous Driving Index*.

Statistic	High Involvement	Low Involvement
N	27	77
Mean	54.04	51.61
Standard Deviation	10.46	11.42

Table 4.12. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the Dula Dangerous Driving Scale *Negative Emotional Driving Index*.

Statistic	High Involvement	Low Involvement
N	27	77
Mean	22.11	21.23
Standard Deviation	4.59	4.9

Table 4.13. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the Dula Dangerous Driving Scale *Aggressive Driving*.

Statistic	High Involvement	Low Involvement
N	27	77
Mean	11.89	11.51
Standard Deviation	4.15	3.78

Table 4.14. Descriptive statistics on the drivers with high and low involvement in inattention-related crashes and near-crashes for the Dula Dangerous Driving Scale *Risky Driving.*

Statistic	High Involvement	Low Involvement
N	27	77
Mean	20.04	18.94
Standard Deviation	3.88	4.48

NEO Personality Inventory -- Revised. The NEO Five-Factor Inventory is a five-factor personality inventory that obtains individual's ranking on the following five scales: neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness.

Extensive research has been conducted correlating the personality scales of neuroticism, extraversion, agreeableness, and conscientiousness to crash involvement (Arthur and Graziano, 1996; Fine, 1963; Loo, 1979; and Shaw and Sichel, 1971). While the hypothesis that drivers with certain personalities would more likely be involved in accidents seems reasonable, the results of this research are mixed. Some of the issues involved with these mixed results are that self-reported driving histories and driving behavior questionnaires have been correlated with personality scales but very little actual driving data has been used.

Neuroticism. The neuroticism scale is primarily a scale contrasting emotional stability with severe emotional maladjustment (depression, borderline hostility). High scorers may be at risk for some kinds of psychiatric problems (Costa and McCrae, 1992).

T-tests were conducted comparing the high- and low-involvement drivers. These results indicated that there were no significant differences with the low-involvement drivers obtaining mean scores of 26.7 and the high-involvement drivers obtaining a mean score of 20.6. The low-involvement drivers' average score of 26.7 places them in the "high" neuroticism category on a scale from Very High (67-75) to Very Low (25-34). The high-involvement drivers average score placed them in the category of "Average" which ranged in scores from 14 to 21.

Extraversion. The extraversion scale is a scale that measures not only sociability but also assertiveness, general optimism and cheerfulness. People who score lower on this scale are not pessimists but rather prefer solitude, are generally more subdued in expressing emotion and demonstrate higher levels of cynicism (Costa and McCrae, 1992).

T-tests conducted on the extraversion scale showed that low-involvement drivers rated significantly higher than did the high-involvement drivers, $t(103) = 7.03$, $p = 0.01$. Figure 4.7

shows the two groups scores with high-involvement drivers ranking as “Average” and the low-involvement drivers ranking “High.”

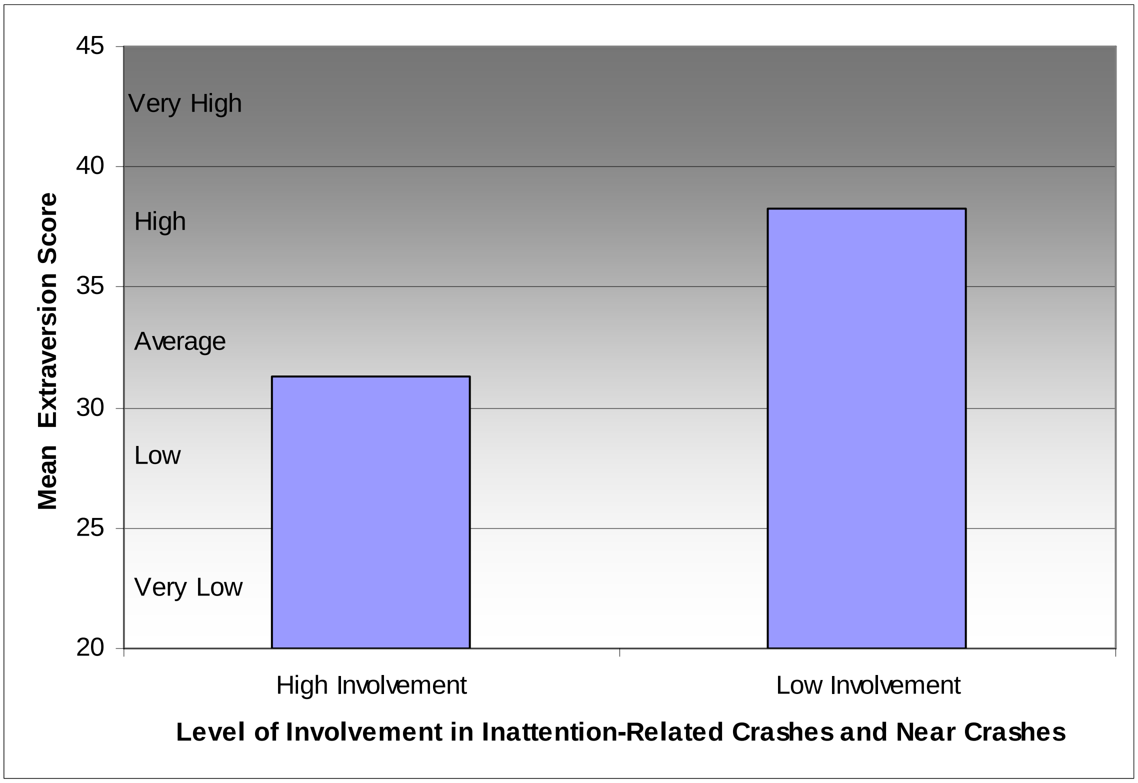

Figure 4.7. Personality scores for the extraversion scale demonstrating significant differences between drivers with high and low involvement in inattention-related crashes and near-crashes.

Openness to Experience**.** The openness to experience scale is a measure of one’s willingness to explore, entertain novel ideas, and accept unconventional values. Those who score lower on this scale uphold more conventional values and are more conservative in action and beliefs. While some intelligence measures are correlated with scoring high on the “openness to experience” scale, this is not a measure of intelligence on its own (Costa and McCrae, 1992).

Results from a t-test on the Openness to Experience scale also revealed statistically significant differences between the high- and low-involvement drivers, $t(103) = 4.03$, $p = 0.05$. Figure 4.8 shows mean scores for both groups. These mean scores suggest that the high-involvement drivers scored in the “Average Openness to Experience Range” but that the low-involvement drivers scored in the high range.

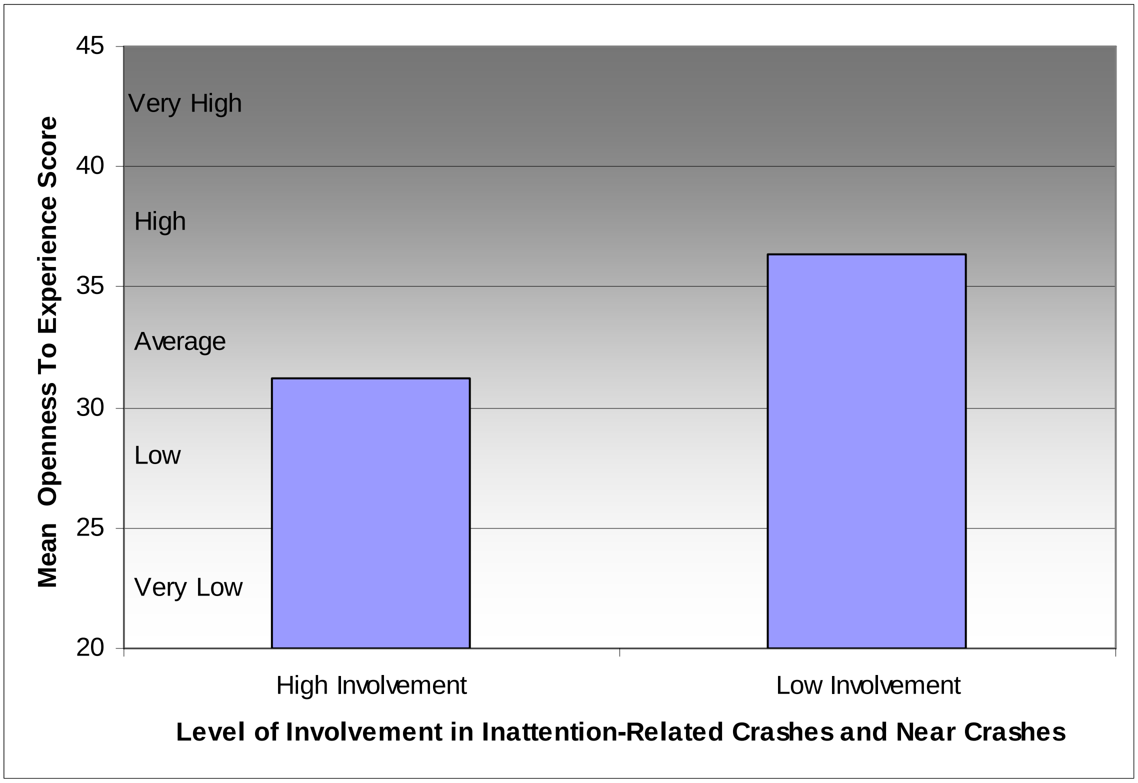

Figure 4.8. Personality scores for the openness to experience scale demonstrating significant differences between drivers with high and low involvement in inattention-related crashes and near-crashes.

Agreeableness. The agreeableness scale is a measure of altruistic and sympathetic tendencies versus egocentric and competitive tendencies. Those drivers who score higher on this scale may be more concerned about the drivers in their vicinity while those who score lower may view driving more as a competition (Costa and McCrae, 1992).

The mean scores on the agreeableness scale for both high- and low-involvement drivers indicated that the low-involvement drivers scored significantly higher on the agreeableness scale than did the high-involvement drivers, t (102) = 8.26, p = 0.005. High-involvement drivers scored solidly in the middle of the "Average" range while the low-involvement drivers scored near the top of the "High" range (Figure 4.9).

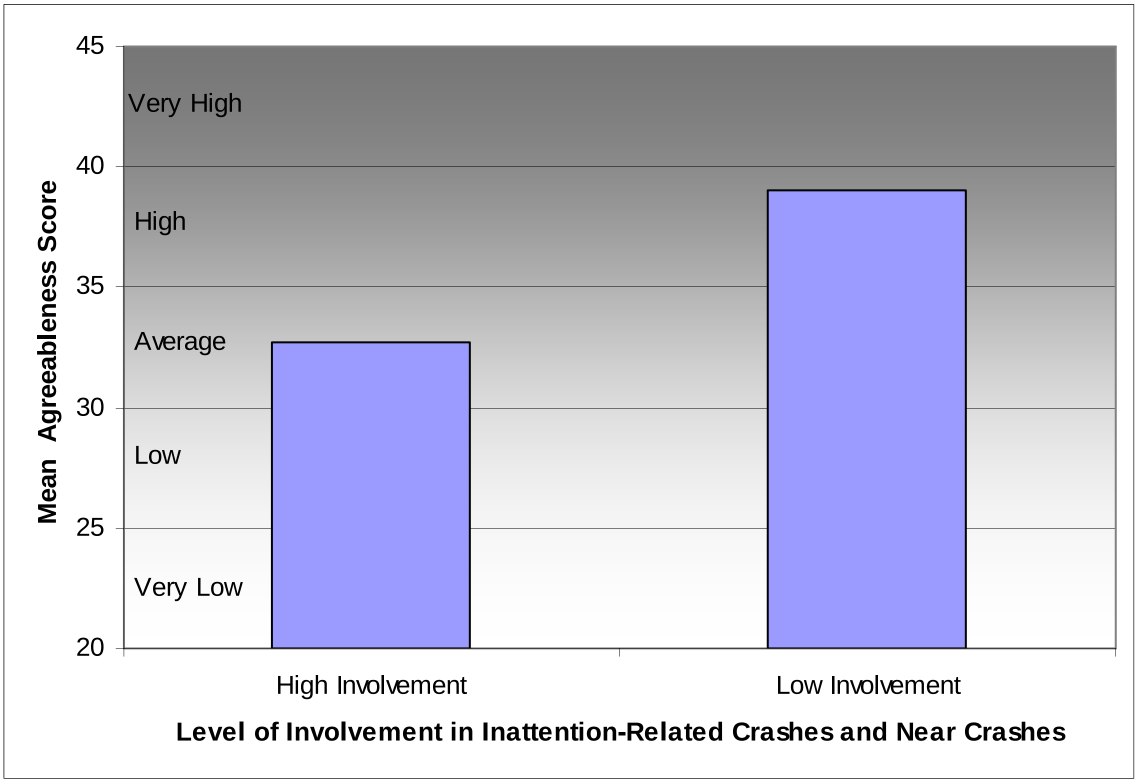

Figure 4.9. Personality scores for the agreeableness scale demonstrating significant differences between drivers with high and low involvement in inattention-related crashes and near-crashes.

Conscientiousness**.** The conscientiousness scale is not as much a measure of self-control but of individual differences in the tendencies and abilities to plan, organize, and perform tasks. Highly conscientious individuals are purposeful, strong-willed, and highly determined individuals who generally fall into categories of highly skilled musicians or athletes. Individuals who score lower on this scale are not as driven to achievement of goals and while they may possess goals, are less likely to maintain schedules and practices that will result in the achievement of these goals (Costa and McCrae, 1992).

The mean conscientiousness scores for both high- and low-involvement drivers also resulted in significant differences, $t(103) = 6.62$, $p = 0.01$. The mean score for the high-involvement group indicated that they scored near the top of "Average" and the low-involvement group scored in the middle of "High" (Figure 4.10).

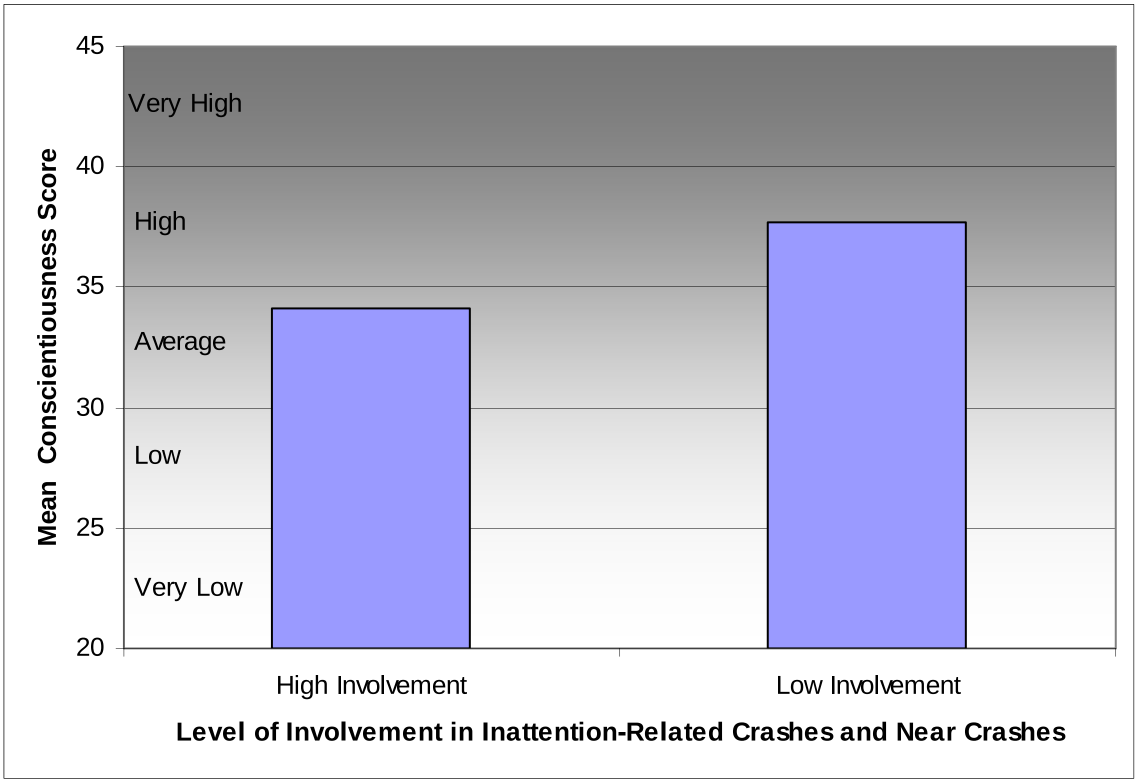

Figure 4.10. Personality scores for the conscientiousness scale demonstrating significant differences between drivers with high and low involvement in inattention-related crashes and near-crashes.

The results of the NEO Five-Factor Inventory suggest that some differences exist between the high- and low-involvement drivers. The low-involvement drivers scored in the "high" or "very high" levels of extroversion, openness to experience, agreeableness, and conscientiousness. The high-involvement drivers scored either "High" or "Average" on all of these scales indicating more moderate tendencies in each of these areas of personality.

Performance-based test analyses

<u>Waypoint.</u> The WayPoint computer-based test provides a composite score on four driver characteristics, as follows:

1. Channel capacity: Speed of information processing.
2. Preventable near-crash/crash risk: Ranks a driver on a scale of 1 to 4 from significantly lower than average (odds ratio of 0.4) to greatly above average (odds ratio of 6.2 or higher).
3. The expected number of moving violations in the next 5 years.
4. Expected seat belt use.

Previous testing by NHTSA indicated that this test could identify high-risk drivers 62.2 percent of the time with a false alarm rate of 19.9 percent; however, these results were based on older drivers. T-tests were conducted to determine whether the high-involvement drivers scored significantly different on any of these four scales than did the low-involvement drivers. None of the t-tests showed significant differences between the high- and low-involvement drivers. This is an interesting result given that drivers' self-reported moving violations were significantly different for these two groups. The descriptive statistics for each of these scales are presented in Tables 4.15 through 4.18.

Table 4.15. Descriptive statistics for the drivers with low and high involvement in inattention–related crashes and near-crashes for the *Channel Capacity Score*.

Statistic	High Involvement	Low Involvement
N	23	69
Mean	5.48	5.31
Standard Deviation	1.86	2.17

Table 4.16. Descriptive statistics for the drivers with low and high involvement in inattention–related crashes and near-crashes for the *Preventable Crash Risk*.

Statistic	High Involvement	Low Involvement
N	23	69
Mean	0.30	1.55
Standard Deviation	1.55	0.76

Table 4.17. Descriptive statistics for the drivers with low and high involvement in inattention–related crashes and near-crashes for the *Expected Number of Moving Violations*.

Statistic	High Involvement	Low Involvement
N	23	69
Mean	1.30	1.31
Standard Deviation	0.63	0.70

Table 4.18. Descriptive statistics for the drivers with low and high involvement in inattention–related crashes and near-crashes for the *Expected Seatbelt Use*.

Statistic	High Involvement	Low Involvement
N	23	67
Mean	1.10	1.15
Standard Deviation	029	0.36

Useful Field of View (UFOV). The Useful Field of View test is also a computer-based performance test that measures an individual's central visual processing speed, divided attention, and selective attention. The participant is required to select rapidly presented target objects that are flashed on a computer monitor while simultaneously attending to other stimuli. Using this test, near-crash/crash risks are assigned to each individual.

T-tests were conducted for the composite UFOV score to determine whether significant differences in the high- versus low-involvement drivers existed in their central visual processing speed, divided attention, and selective attention abilities. No significant differences between the high- and low-involvement drivers were observed for the UFOV test. Descriptive statistics are presented in Table 4.19.

Table 4.19. Descriptive statistics for the drivers with low and high involvement in inattention–related crashes and near-crashes for the UFOV.

Statistic	High Involvement	Low Involvement
N	27	81
Mean	1.78	2.32
Standard Deviation	1.80	2.15

ANALYSIS ONE: CORRELATION ANALYSIS FOR THE HIGH- AND LOW-INVOLVEMENT GROUPS

Spearman correlations were conducted to determine whether there were any linear relationships between the frequency of involvement in inattention-related events and survey responses/test scores for both the high- and low-involvement groups. Table 4.20 presents only those test scores/survey responses that were significant.

Note that none of the low-involvement group's correlations were significant with only accident involvement approaching significance at a 0.06 probability level. The rest of the significant correlation coefficients were for the high-involvement group. Those scores or responses that demonstrated a linear relationship with inattention-related crash and near-crash involvement were Driver Age, Driving Experience, and Neuroticism Scale. Driver age has been found in the past to be highly inversely related to crash involvement. Given that most of the drivers probably received their driver's license in the United States at approximately age 16, these two responses are probably highly correlated with each other. The neuroticism scale has been found in previous research to correspond to drivers self-reported crash involvement; this is an interesting finding in that this demonstrates high correlation to actual crash and near-crash involvement.

Table 4.20. Correlation coefficients and probability values for the test batteries that obtained statistical significance.

	Attentive		Inattentive	
Test Score/Survey Response	Correlation Coefficient	Probability Value	Correlation Coefficient	Probability Value
Driver Age	-0.13	0.24	**-0.37**	**0.05**
Driver History	-0.14	0.24	**-0.49**	**0.01**
Accidents	0.21	0.06	0.18	0.36
Neuroticism	0.07	0.52	**0.45**	**0.02**

Note: Numbers in bold font indicate statistical significant using a 0.05 probability value.

ANALYSIS TWO: F-TEST ANALYSIS FOR THE LOW-, MODERATE-, AND HIGH-INVOLVEMENT GROUPS

As part of the exploratory nature of these analyses, a second analysis using three groups was also conducted. With three groups, some separation between the two tails of the distribution is present so that any differences in those drivers who are the most and least involved in inattention-related crashes and near-crashes may be more easily distinguished. The drivers were grouped into three levels of involvement in inattention-related crashes and near-crashes: low, moderate, and high involvement. These groups were based upon the number of inattention-related crashes and near-crashes that each driver was involved (Figure 4.11). "Low involvement" refers to those drivers who were not involved in any or were involved in one inattention-related crash and/or near-crash. The "moderate involvement" group was involved in two to four inattention-related crashes or near-crashes. The "high involvement" group was involved in five or more inattention-related crashes or near-crashes. Therefore, "high involvement" refers to those drivers with high numbers of inattention-related crashes and/or near-crashes and "low involvement" refers to those drivers with none or only one inattention-related crash and/or near-crash.

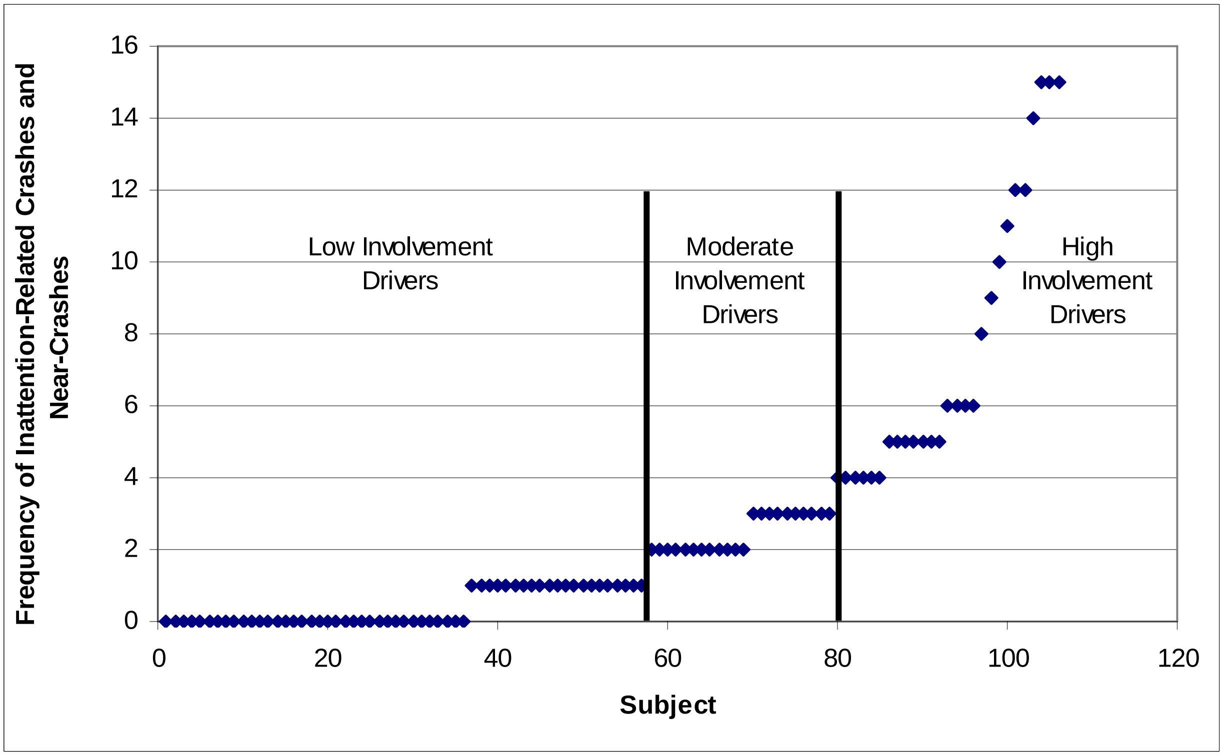

Figure 4.11. The frequency of inattention-related crashes and near-crashes by driver in order for Low, Moderate, and High frequency.

Univariate analyses of variance (ANOVA) tests were conducted using the three levels of inattention-related event involvement. All survey responses and test scores that were appropriate were used as dependent variables. Only those ANOVA tests that were significant will be reported in the following section. Table 4.21 provides the descriptive statistics for the drivers assigned to low-, medium-, and high-involvement groups.

Table 4.21. Descriptive statistics on drivers labeled "low involvement," "moderate involvement," and "high involvement" in inattention-related crashes and near-crashes.

Statistic	Low Involvement	Moderate Involvement	High Involvement
Number of Drivers	58	24	20
Mean (# of Inattention-Related Crashes and Near-crashes)	0.42	2.84	8.57
Median	0	3	6
Mode	0	3	5
Standard Deviation	0.56	0.78	3.88
Minimum	0	2	5
Maximum number of events	2	4	15
Number of crashes	8	9	4
Number of near-crashes	51	18	17

Results

The results of the univariate ANOVA tests using three involvement groups indicated that five of the test scores that were significantly different for the two-group analysis also proved to be significantly different for the three-group analysis. These five test scores/demographic data were mean driver age, years of driving experience, self-reported traffic violations, agreeableness, and conscientiousness. Two other test scores were found to be significantly different using three groups that were not significantly different using two groups: these two test scores were daytime sleepiness score and self-reported accident involvement. The three-group scores on extraversion and openness to experience were not significantly different even though these tests were significantly different with only two groups.

These results indicate that the extremely low- and extremely high-involvement groups were significantly different from each other for daytime sleepiness scores. For self-reported accident involvement, the two extreme groups were actually not significantly different from each other rather the moderate-involvement group actually reported significantly more accidents than did the high-involvement or the low-involvement groups. It could be hypothesized that this was an artifact of age in that the high-involvement drivers were, on average, 25 years old whereas the low- and moderate-involvement driver groups had an average age of 39 and 38, respectively.

Separating the drivers into three groups failed to find significant differences for the two personality inventory scales of extraversion and openness to experience. This result may be explained statistically in that by separating the drivers into three groups reduces the statistical power of the sample due to the decreased numbers of drivers in each group.

Most of the statistical tests that were significant with only two groups were also significant with three groups. All univariate analysis results are presented in Table 4.22. Given the exploratory nature of these analyses, conducting two analyses (a two-group and a three-group) was an important step in understanding these data. Both analyses have benefits. The two-group analysis, with a larger number of drivers per group, has better statistical power whereas the three-group analysis provides more separation between the extreme drivers. The significant results demonstrated that very few differences existed between the two- and three-group analyses; therefore, the results that were observed are stable and reliable for the driving population.

Table 4.22. Results from the univariate analyses of driver involvement in inattention-related crashes and near-crashes.

Two-Group Analysis of Mean Demographic Data/Test Score	t-Value	Probability Value	Three-Group Analysis of Mean Demographic Data /Test Score	F-Value	Probability Value
Driver Age	7.07	0.009	Driver Age	6.77	0.002
Years of Driving Experience	7.6	0.007	Years of Driving Experience	7.69	0.0008
N/A			Daytime Sleepiness Score	3.80	0.03
Self-reported traffic violations	4.9	0.03	Self-reported traffic violations	5.54	0.005
N/A			Self-reported accident involvement	4.88	0.009
Extroversion (Five-Factor Personality Inventory)	7.03	0.01	N/A		
Openness to Experience (Five-Factor Personality Inventory)	4.03	0.05	N/A		
Agreeableness (Five-Factor Personality Inventory)	8.26	0.005	Agreeableness (Five-Factor Personality Inventory)	3.77	0.03
Conscientiousness (Five-Factor Personality Inventory)	6.62	0.01	Conscientiousness (Five-Factor Personality Inventory)	3.05	0.05

ANALYSIS TWO: CORRELATION ANALYSIS FOR THOSE DRIVERS WITH LOW, MODERATE, AND HIGH INVOLVMENT IN INATTENTION-RELATED CRASHES AND NEAR-CRASHES.

Correlations were also conducted for each group of involvement. Correlations were performed using the frequency of involvement in inattention-related crashes and near-crashes versus driver survey responses or test battery scores. The significant results are shown in Table 4.23. Several more tests obtained or approached significant results with three groups. The Dula Dangerous Driving: Aggressive Driving Index, the Dula Dangerous Driving Overall Index, Neuroticism, Agreeableness, and Conscientiousness all demonstrated significant correlations for the high-involvement group only. The neuroticism scale also obtained significance for the moderate-involvement group. The Driving Stress Inventory: Thrill-Seeking Scale reached significance for the low-involvement group but no other group.

These results demonstrate that separating the mean values for the high- and low-involvement drivers are more easily differentiable with three groups then with only two groups as seven of the test scores/survey responses demonstrated significant correlation coefficients whereas only four test scores demonstrated significant correlation coefficients with two groups. Many of these correlation coefficients are over 0.4 or above, which are considered to be moderate correlations (Keppel and Wickens, 2004).

Table 4.23. Correlation coefficients for all test battery questionnaires.

	Low Involvement		**Moderate Involvement**		**High Involvement**	
Test Score/Survey Response	**Corr Coef**	**Prob Value**	**Corr Coef**	**Prob Value**	**Corr Coef**	**Prob Value**
Aggressive Driving – Dula Dangerous Driving	0.04	0.75	-0.13	0.52	**0.48**	**0.02**
Dula Dangerous Driving Index	0.13	0.34	-0.21	0.29	**0.46**	**0.03**
Thrill-Seeking	**0.26**	**0.5**	-0.03	0.89	-0.23	0.32
Neuroticism	0.01	0.94	**-0.40**	**0.04**	**0.62**	**0.003**
Agreeableness	-0.01	0.92	**-0.25**	**0.20**	**-0.42**	**0.06**
Conscientious-ness	-0.15	0.27	-0.9	0.63	**-0.42**	**0.06**

Note: Numbers in bold font indicate statistical significant using a 0.05 probability value

ANALYSIS THREE. ARE DRIVERS' RESPONSES TO THE DEMOGRAPHIC, TEST BATTERY, AND PERFORMANCE-BASED TESTS PREDICTIVE OF INVOLVEMENT IN INATTENTION-RELATED CRASHES AND NEAR-CRASHES?

A logistic regression was conducted to determine whether multiple data sources, all obtained from demographic data, test battery results, and performance-based tests, could be used to predict whether a driver was either highly involved in inattention-related crashes and near-crashes or not. Only the seven variables that demonstrated significant differences in involvement level for the above tested t-tests or ANOVAs were used in the analysis. These variables were:

1. Driver Age
2. Driving Experience
3. Number of moving violations in the past 5 years
4. Extraversion score from the NEO Five-Factor Inventory

5. Openness to Experience from the NEO Five-Factor Inventory
6. Agreeableness from the NEO Five-Factor Inventory
7. Conscientiousness from the NEO Five-Factor Inventory

None of the correlation coefficients for any of the above variables or test battery results was greater than ±0.4, which is considered to be a small to moderate effect size in the behavioral sciences. Nevertheless, these variables were used in the logistic regression analysis.

A backward selection technique was used to first identify those variables that make significant partial contributions to predicting whether a driver involvement was low or high. This procedure produced a logistic regression equation with two variables: Driver Age and Agreeableness. The resulting significant regression coefficients and relevant statistics are shown in Table 4.24.

Table 4.24. Results from the logistic regression analysis.

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Probability
Intercept	1	2.61	1.10	5.67	0.02
Driver Age	1	-0.04	0.02	4.77	0.03
Agreeableness	1	-0.06	0.03	5.35	0.02

A forward selection technique was then used to ensure that both of these variables were making significant partial contributions to the prediction equation. The results of this test resulted in the same regression equation, indicating that both Driver Age and Agreeableness are both predictive of a driver's level of involvement in inattention-related crashes and near-crashes.

The correlation coefficients for both Driver Age and Agreeableness were both negative, indicating that as Age or Agreeableness increases, involvement in inattention-related crashes and/or near-crashes will decrease. The odds ratio estimates, as calculated as part of the logistic regression, for Driver Age was 0.96 (Lower Confidence Limit = 0.92 and Upper Confidence Limit = 1.0), which was not significantly different from 1.0. The odds ratio estimate for Agreeableness was similar at 0.94 (Lower Confidence Limit = 0.89 and Upper Confidence Limit = 0.99). These results indicate a slight protective effect in that as an Age or Agreeableness score increases, there will be a decrease in involvement in inattention-related crashes and near-crashes.

DISCUSSION. HOW MIGHT THESE RESULTS BE USED TO MITIGATE THE POTENTIAL NEGATIVE CONSEQUENCES OF INATTENTIVE DRIVING BEHAVIORS AND COULD THIS INFORMATION BE USED TO IMPROVE DRIVER EDUCATION COURSES OR TRAFFIC SCHOOLS?

As part of this analysis, the health screening, questionnaires, and driving performance-based tests were all analyzed to determine if the scores obtained on any of these measures correlated or could determine differences in high- or low-involvement in inattention-related crashes and near-crashes. There were seven variables that produced significant t-tests: Driver Age, Driving Experience, number of moving violations in the past 5 years, and four of the personality scales from the NEO Five-Factor Inventory: Extroversion, Openness to Experience, Agreeableness, and Conscientiousness. When three groups were used, Daytime Sleepiness Rating and Accident Involvement also identified significant differences between groups. For the correlation analysis, several test batteries were significant with three groups that were not significant when using two groups of drivers. A logistic regression was conducted to determine if any of these seven variables were predictive of driver inattention. The results of this analysis indicate that Driver Age and Agreeableness both demonstrated some predictive nature to driver involvement in inattention-related crashes and near-crashes.

The results of the logistic regression indicate that none of the demographic data or test scores, except for Driver Age and the Agreeableness score from the NEO Five-Factor Inventory, demonstrate predictive abilities to pre-determine which drivers may be at greater risk of inattention-related crashes and near-crashes. Predictive qualities aside, obtaining significant differences and significant correlations using highly variable human performance data demonstrates that many of these surveys and test batteries do provide useful information about the driving population.

The significant results of Driver Age, for both the logistic regression and the t-tests, indicate that drivers' education of the dangers of distraction and drowsiness while driving is critical. Note that the younger drivers were over-represented in inattention-related crash and near-crash involvement (Figure 4.2). The significant results in Driving Experience are not surprising as this variable is highly correlated with Driver Age.

The significant t-tests and ANOVAs detecting that the high-involvement drivers were significantly younger than the other groups suggests that younger drivers are over-involved in inattention-related crashes and near-crashes. These results lend some support to those states who have already implemented graduated driver's licensure programs to restrict specific types of driver distraction. The results from this analysis also lend support to those studies that have already shown that these actions may in fact reduce younger drivers' involvement in crashes and near-crashes (Hedlund and Compton, 2005). As part of graduated licensure programs, some states have restricted the number of passengers in the vehicle and other states have banned hand-held-device use for teenage drivers. Conducting a naturalistic driving study with teen drivers would be the next research step to determine frequency of engagement in inattention-related tasks and the impact of inattention on driving.

It is very interesting that the self-reported variable, *number of traffic violations received in the past 5 years*, indicated that high-involvement drivers also had a higher frequency of traffic violations than the low-involvement drivers. This result suggests that those drivers who are attending traffic schools due to multiple traffic violations may indeed be those drivers who are more highly involved in inattention-related crashes and near-crashes. This also suggests that driver inattention is a topic that needs to be addressed in traffic school training. Based on results from other chapters in this report, one item of training may be to assist drivers in their decisions of when to engage in a secondary task, for example. Near-crash/crash risks are much higher in intersections, wet, snowy, or icy roadways, and in moderate traffic density that is moving faster than 25 miles per hour, etc. These are not times in which to engage in a secondary task if it is not necessary that a driver do so. Results from other chapters in this report suggest that eyeglances greater than 2 seconds away from the forward roadway increase near-crash/crash risk. Teaching drivers how to scan the roadway environment but returning to the forward roadway at least once every 2 seconds may also be useful information to incorporate into traffic school and driver's education programs. More research is required to determine how to best present this information and how to optimally incorporate this information into a driver training program.

SUMMARY

The results of this analysis indicated that Driver Age, Driving Experience, self-reported traffic violations and crashes, daytime sleepiness ratings, and personality inventory scores indicated significant differences between the high- and low-involvement drivers for both two and three groups of involvement in inattention-related crashes and near-crashes. Given the exploratory nature of these analyses, two separate analyses were conducted using two groups of involvement and three groups of involvement.

The main results from these analyses are as follows:

- The high-involvement drivers were significantly younger than the low-involvement drivers with average ages of 30 and 38, respectively. With three groups of drivers, the average ages for the three groups were still significant and the average ages of the groups were 39 (low involvement), 38 (moderate involvement), and 26 (high involvement) years old.
- The high-involvement drivers had significantly less driving experience than the low-involvement drivers with an average of 13 versus 25 years for the two groups. For the three-group analysis, the high-involvement group's average years of driving experience was 9.6 years while the moderate- and low-involvement group's averages were 22 and 23 years, respectively.
- High-involvement drivers (Mean = 2.2) reported receiving significantly more moving violations in the past 5 years than the low-involvement drivers (Mean = 1.4). For the three-group analysis, the high-involvement drivers had received an average of 2.6 violations, while the moderate-involvement and the low-involvement groups received an average of 1.8 and 1 violation(s), respectively.
- An interesting result occurred with the number of accidents in the past 5 years. When the drivers were separated into three groups, the average number of reported accidents was significantly different between the low-involvement and the moderate-involvement groups. The low-involvement group reported an average of 0.9 accidents in the past 5 years while the moderate-involvement group reported 1.9 crashes in the past 5 years. The high-involvement group only reported being involved in 1.4 accidents in the past 5 years. It may be that the high-involvement drivers were not truthful with their responses or were trying to impress the researchers.
- High-involvement drivers scored significantly lower on the personality factors of extraversion, openness to experience, agreeableness, and conscientiousness. The same was found when the drivers were separated into three groups, except that the extraversion and the openness to experiences scores were no longer significant. These results partially corroborate Arthur and Graziano (1996) results, in that conscientiousness scores were significantly different between the high-involvement and low-involvement groups; however their results did not include agreeableness, which was found in these analyses to be predictive of inattention-related crash and near-crash involvement.
- For the correlation analysis, only one scale maintained a significant correlation between the two analyses: the Neuroticism Scale from the NEO Five-Factor Inventory. Driver Age or Driving Experience yielded significant correlations when the drivers were separated into two groups, but not for three groups. While many of the significant

correlation coefficients were greater than 0.4 with three groups, these linear relationships do not appear to be stable.

- The only questionnaire data or test battery scores that were predictive of driver involvement in inattention-related crashes and near-crashes were driver age and scores on the agreeableness scale from the NEO Five-Factor Personality Inventory. Interestingly, agreeableness scores for the high- and low-involvement drivers (both two and three groups) were also found to be significantly different from one another.
- No differences were found between the high- and low-involvement drivers using the Driver Stress Inventory, Life Stress Inventory, the Dula Dangerous Driving Index, Waypoint, or the Useful Field of View. While none of these tests were written specifically to assess driver's likelihood of being involved in inattention-related crashes and near-crashes, it was hypothesized that these tests may measure some of the same traits that would increase a driver's willingness to engage in inattention-related tasks while driving.

CHAPTER 5: *OBJECTIVE 4,* WHAT IS THE RELATIONSHIP BETWEEN MEASURES OBTAINED FROM PRE-TEST BATTERIES (E.G., A LIFE STRESS TEST) AND THE FREQUENCY OF ENGAGEMENT IN DISTRACTING BEHAVIORS WHILE DRIVING? DOES THERE APPEAR TO BE ANY CORRELATION BETWEEN WILLINGNESS TO ENGAGE IN DISTRACTING BEHAVIORS AND MEASURES OBTAINED FROM PRE-TEST BATTERIES?

For this analysis, correlations were conducted using the frequency of involvement in *inattention-related baseline epochs* and each driver's composite score or relevant response for 9 of the 11 questionnaires and performance-based tests that were administered to the drivers (Table 5.1). A baseline epoch was deemed to be "inattention-related" if the driver engaged in a secondary task or was marked as drowsy at any point during the 6-second segment. The debrief form and the health assessment questionnaires were not included as they were not designed for this type of analysis.

Table 5.1. Description of questionnaire and computer-based tests used for 100-Car Study.

	Name of Testing Procedure	Type of Test	Time test was administered	Brief description
1.	Driver demographic information	Paper/pencil	In-processing	General information on drivers age, gender, etc.
2.	Driving History	Paper/pencil	In-processing	General information on recent traffic violations and recent collisions
3.	Health assessment questionnaire	Paper/pencil	In-processing	List of variety of illnesses/medical conditions/or any prescriptions that may affect driving performance.
4.	Dula Dangerous Driving Index	Paper/pencil	In-processing	One score that describes driver's tendencies toward aggressive driving.
5.	Sleep Hygiene	Paper/pencil	In-processing	List of questions that provide information about driver's general sleep habits/substance use/sleep disorders
6.	Driver Stress Inventory	Paper/Pencil	In-processing	One score that describes the perceived stress levels drivers experience during their daily commutes
7.	Life Stress Inventory	Paper/pencil	In-processing/Out-processing	One score that describes drivers stress levels based upon the occurrence of major life events
8.	Useful Field-of-View	Computer-based test	In-processing	Assessment of driver's central vision and processing speed, divided and selective attention.
9.	WayPoint	Computer-based test	In-processing	Assessment of the speed of information processing and vigilance.
10.	NEO-FFI	Paper/pencil	In-processing	Personality test
11.	General debrief questionnaire	Paper/pencil	Out-processing	List of questions ranging from seatbelt use, driving under the influence, and administration of experiment.

DATA USED IN THIS ANALYSIS

For the analyses in this chapter, crashes and near-crashes only will be used (incidents will be excluded from the analyses). In Chapter 6, *Objective 2* of the 100-Car Study Final Report, the analyses indicated that the kinematic signatures of both crashes and near-crashes were nearly identical; whereas the kinematic signatures of incidents were more variable. Given this result and to increase statistical power, the data from both crashes and near-crashes will be used in the comparison of questionnaire data to the frequency of involvement in inattention-related crashes and near-crashes.

Note that inattention-related crashes and near-crashes or inattention-related baseline epochs are defined as those events that involve the driver engaging in complex, moderate, or simple secondary tasks or driving while drowsy. Please note that in Chapter 2, *driving-related* *inattention to the forward roadway* was determined to possess a protective effect and therefore was removed from the definition of driving inattention. *Non-specific eyeglance away from the forward roadway* was also shown to not be significantly different from normal, baseline driving; therefore, these events were also removed from the analysis.

DESCRIPTION OF DATA

Figure 5.1 shows the distribution of the number of inattention-related baseline epochs that each driver was involved. Note that seven primary drivers were not involved in any inattention-related baseline epochs. The mean frequency of inattention-related baseline involvement is 87.2, the median frequency is 62, and the range of frequency counts is 0 to 322 baseline inattention epochs.

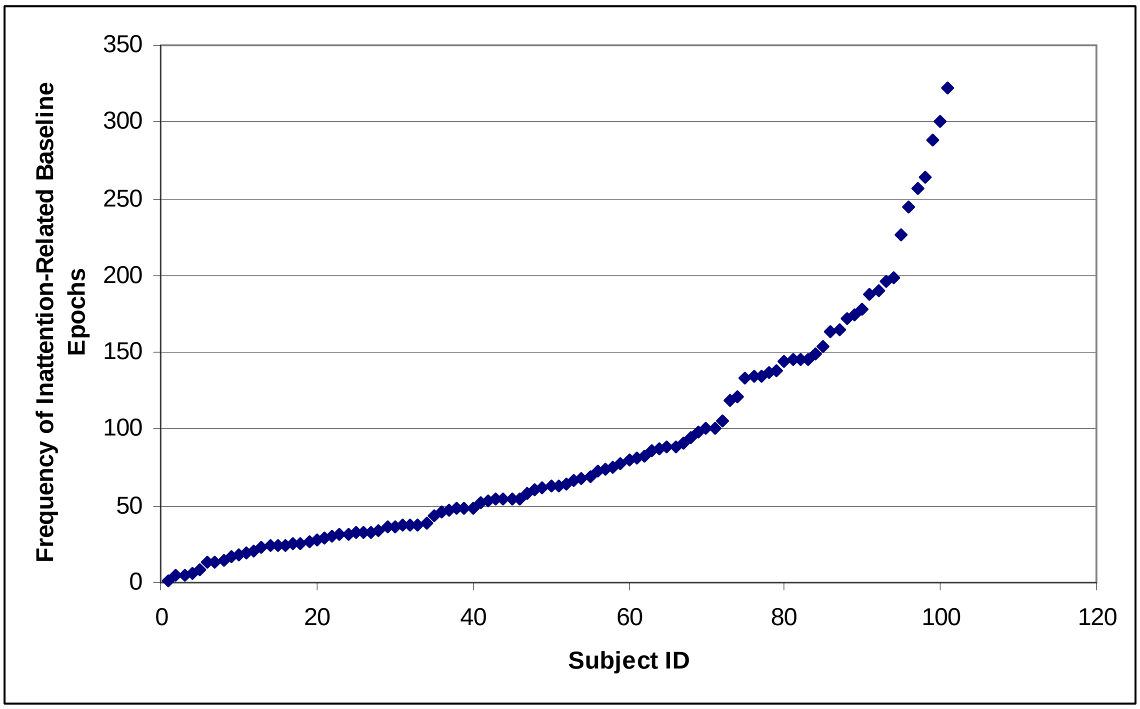

Figure 5.1. The frequency distribution of the number of inattention-related baseline epochs that each driver was involved (N = 101). Note: Subjects were sorted by frequency of involvement to allow the reader to see the range of values.

A Spearman correlation between the frequency of involvement in inattention-related crash and near-crash events and baseline epochs was performed. The results indicated a strong correlation with an R-value of 0.72, p = 0.0001. This suggests that drivers who are frequently engaging in inattention-related tasks, as shown by the baseline data, are also those that are more frequently involved in crashes and near-crashes. This also suggests that the better, safer drivers engage in secondary tasks and/or drive drowsy less often than do those drivers who were involved in multiple crashes and near-crashes.

Correlations were conducted using representative survey questions, composite scores from the test batteries, and scores from the computer-based tests and frequency of involvement in *inattention-related baseline epochs.* Table 5.2 presents the corresponding correlation coefficients and probability values for those test scores that were statistically significant. Note that *Driver Age* and *Driving Experience* obtained the highest correlation coefficient at -0.4 while the rest of the coefficients were very weak with R values under 0.3.

Table 5.2. The significant correlations between test battery, survey, and performance-based test scores to the frequency of inattention-related baseline epochs (N = 101).

Name of Testing Procedure	Question/Score	Correlation Coefficient	Probability Value
Driver demographic information	Driver Age	-0.41	<0.0001
	Years of driving experience	-0.44	<0.0001
Dula Dangerous Driving Index	DDDI	0.29	0.004
	Risky Driving	0.26	0.01
Sleep Hygiene	Daytime Sleepiness	0.22	0.03
Driver Stress Inventory	Aggression	0.23	0.02
	Thrill-Seeking	0.26	0.01
NEO-FFI	Extroversion	-0.21	0.03
	Agreeableness	-0.27	0.007
	Conscientiousness	-0.22	0.03
Waypoint	Channel	0.34	0.0014

Correlations were also conducted using the frequency of driver involvement in inattention-related crashes and near-crashes to the relevant responses from the surveys, test batteries, and performance-based tests. This analysis is different from the one conducted in Chapter 4, *Objective 3* in that the drivers are no longer separated into "high involvement" and "low involvement" drivers. Table 5.3 presents only those correlations that were statistically significant. Note that some of the correlations no longer were significant, i.e., Dula Dangerous Driving, Driver Stress Inventory, and Waypoint. Also note that some of the correlations, while still significant, were slightly weaker for the crashes and near-crashes, i.e., Driver Age and Driving Experience.

Table 5.3. The significant correlations between test battery, survey, and performance-based test scores to the frequency of inattention-related crash and near-crash events (N = 101).

Name of Testing Procedure	Question/Score	Correlation Coefficient	Probability Value
Driver Demographic Information	Driver Age	-0.29	<0.004
	Years of driving experience	-0.31	<0.001
Sleep Hygiene	Daytime Sleepiness	0.20	0.05
NEO-FFI	Extroversion	-0.23	0.02
	Agreeableness	-0.26	0.007
	Conscientiousness	-0.20	0.03

CONCLUSIONS

These results suggest a clear relationship between engagement in secondary tasks or driving while drowsy to selected survey responses and test battery scores. According to Keppel and Wickens (2004), correlation coefficients of 0.4 to 0.2 represent small effect sizes as they account for 4 to 16 percent of the variance among these values. While these relationships or associations are small, the fact that these relationships are obtaining statistical significance given the high variability among drivers is a result that should not be overlooked. These results, taken with the results from Chapter 4, *Objective 3* indicate that driver demographic data, driving history data, sleep hygiene data and the NEO Five-Factor Inventory all demonstrate linear relationships to driving performance. Apart from age and driving experience, it is unfortunately unknown how this information could be used to predict which drivers will be high-risk drivers (i.e., those who demonstrate tendencies to drive while they are engaging in secondary tasks or drowsy).

The high correlation of 0.72 between the frequency of driver's involvement in inattention-related crashes and near-crashes and baseline epochs suggests that those drivers who frequently engage in inattention-related activities are also frequently involved in crashes and near-crashes. Those drivers who are not engaging in inattention-related tasks frequently are not frequently involved in inattention-related crashes and near-crashes. Therefore, if an inattention mitigation device was developed, the highly inattentive drivers could possibly benefit from such a device.

CHAPTER 6: *OBJECTIVE 5,* WHAT IS THE RELATIVE NEAR-CRASH/CRASH RISK OF EYES OFF THE FORWARD ROADWAY? DO EYES OFF THE FORWARD ROADWAY SIGNIFICANTLY AFFECT SAFETY AND/OR DRIVING PERFORMANCE?

While eyeglance analyses have been used in transportation research for a variety of purposes and goals, this analysis is the first to establish a direct link between a driver's eyeglance behavior and crash and near-crash causation. Odds ratios were calculated to estimate the relative near-crash/crash risk of *eyes off the forward roadway*. Odds ratios were also calculated to estimate the relative risk for a crash or near-crash of different durations of *eyes off the forward roadway* as well. ANOVAs were conducted to determine if significant differences exist for several measures of eyeglance behavior. These measures include *total time eyes off forward roadway*, *number of glances away from forward roadway*, *glance length*, and *length of longest glance* away from the forward roadway.

Please note that there are some important and significant differences in the method used to conduct the analyses in this chapter and the method used in the previous chapters. First, in Chapters 3, 4, and 5, *driving inattention* was primarily defined as secondary task engagement or the presence of moderate to severe drowsiness. In Chapter 2, inattention also included *driving-related inattention to the forward roadway* and *non-specific eyeglance*. In this chapter, only eyeglance data will be considered. Therefore, any time a driver is not looking forward, regardless of the reason, is considered *eyes off the forward roadway*. Conducting the analysis in this manner completes the analysis of driver inattention in that Chapter 2, *Objective 1* included all four types of inattention. Chapter 3, *Objective 2*, Chapter 4, *Objective 3*, and Chapter 5, *Objective 4* all considered *driver inattention* primarily as *secondary task engagement* and *drowsiness*. Finally, this chapter will include any time the driver's eyes are off the forward roadway, which incorporates part of secondary task and drowsiness but will also encompass *driving-related inattention to the forward roadway* and *non-specific eyeglance.*

To first begin this analysis, an operational definition of "*eyes off forward roadway*" was determined. This metric is time dependent and a relevant time frame surrounding the crash or near-crash was also operationally defined. While some epidemiological studies have used time segments of 5 to 10 minutes prior to a crash (McEvoy et al, 2005; Riedelmeier and Tibshirani, 1997), the 100-Car Study examines within 5 seconds of the onset of the precipitating factor. Recall from the method section that the precipitating factor is the action that initiated the driving event (e.g., lead-vehicle braking) and circumstances that comprise the crash, near-crash, or incident. Therefore, all *eyes off forward roadway* calculations will be based upon a total time of 5 seconds prior and 1 second after the onset of the precipitating factor or *onset of the conflict*. Please note that this is not the instant the crash occurred. The data in which we are primarily interested is the pre-crash data or the seconds leading up to the crash. Therefore the onset of the conflict is used. Table 6.1 presents the metric calculations for the dependent variables that are used in the following analyses.

Table 6.1. Eyes off the forward roadway metrics.

	Eyes Off Forward Roadway Metric	Operational Definition
1.	Total Time Eyes Off Forward Roadway	The number of seconds that the driver's eyes were off the forward roadway during the 5 seconds prior and 1 second after the onset of the precipitating factor.
2.	Number of Glances Away From the Forward Roadway	The number of glances away from the forward roadway during the 5 seconds prior and 1 second after the precipitating factor.
3.	Length of Longest Glance Away from the Forward Roadway	The length of the longest glance that was *initiated* during the 5 seconds prior and 1 second after the onset of the precipitating factor.
4.	Location of Longest Glance Away from the Forward Roadway	The location of the longest glance (as defined by Length of Longest Glance). Location will be based upon distance (in degrees) from center forward and will be in one of three categories: less than 15°, greater than 15° but less than 30°, greater than 30°.

Data Used in These Analyses

Eyeglance analysis was conducted on all crashes, near-crashes, and incidents as well as 5,000 (as opposed to the entire set of 20,000) baseline epochs. Project resources restricted the number of baseline epochs for which eyeglance data reduction could be performed.

To determine the relative near-crash/crash risk of *eyes off forward roadway*, the data was parsed to exclude those events in which the driver of the instrumented vehicle was 1. not at fault and/or 2. was involved in a rear-end-struck crash or near-crash with a following vehicle. For the rear-end-struck crashes, eyeglance data was not available on the following driver, which prevented their inclusion in the analyses.

For the relative risk analyses in this chapter, crashes and near-crashes only will be used (incidents will be excluded from the analyses). In Chapter 6, *Objective 2* of the 100-Car Study Final Report, the analyses indicated that the kinematic signatures of both crashes and near-crashes were nearly identical; whereas the kinematic signatures of incidents were more variable. Given this result and to increase statistical power, the data from both crashes and near-crashes will be used in the calculation of relative near-crash/crash risk and population attributable risk percentage.

QUESTION 1. WHAT IS THE RELATIVE NEAR-CRASH/CRASH RISK OF EYES OFF THE FORWARD ROADWAY?

To answer this question, the odds ratios associated with *eyes off the forward roadway* were calculated since odds ratios are appropriate approximations of relative near-crash/crash risk for rare events (Greenberg et al., 2001). The odds ratios were calculated for all instances of *eyes off the forward roadway* as well as for five ranges of time that the drivers' eyes were off the forward roadway. These five time segments are as follows:

- Less than or equal to 0.5 seconds
- Greater than 0.5 seconds but less than or equal to 1.0 second
- Greater than 1.0 second but less than or equal to 1.5 seconds
- Greater than 1.5 seconds but less than or equal to 2.0 seconds
- Greater than 2.0 seconds

The odds ratios were calculated by using the following equation:

Odds Ratio = (A x D)/(B x C) *Equation 6.1*

Where:
A = the number of events where driver's eyes were off the forward roadway <x total time>
B = the number of events where driver's eyes were not off the forward roadway
C = the number of baseline epochs where driver's eyes were off the forward roadway <x total time>
D = the number of baseline epochs where driver's eyes were not off the forward roadway

Table 6.2 presents the odds ratios for the five segments of time as well as an overall odds ratio for *eyes off the forward roadway*. Note that the odds ratios for eyeglances equal to or less than 2 seconds were less than or not significantly different than 1.0. This may indicate that drivers who are scanning their environment are potentially safer drivers. However, eyeglances away from the forward roadway greater than 2 seconds, regardless of location of eyeglance, are clearly not safe glances as the relative near-crash/crash risk sharply increases to over two times the risk of normal, baseline driving. It is important to note that the confidence limits surrounding the point estimate odds ratio values are fairly large, indicating the odds ratio may in fact be somewhat higher or lower. However, the trend does appear to indicate that shorter glances are safer than longer eyeglances away from the forward roadway. The population attributable risk percentage calculations suggest that 23 percent of the crashes and near-crashes that occur in a metropolitan environment are attributable to *eyes off the forward roadway* greater than 2 seconds (Table 6.3).

Table 6.2. Odds ratios and 95 percent confidence intervals for eyes off the forward roadway.

	Total Time of Eyes Off the Forward Roadway	Odds Ratio	Lower CL	Upper CL
1.	Less than or equal to 0.5 seconds	1.31	0.91	1.89
2.	Greater than 0.5 seconds but less than or equal to 1.0 second	0.82	0.60	1.13
3.	Greater than 1.0 second but less than or equal to 1.5 s	0.92	0.65	1.31
4.	Greater than 1.5 seconds but less than or equal to 2.0 seconds	1.26	0.89	1.79
5.	**Greater than 2.0 seconds**	**2.19**	**1.72**	**2.78**
6.	**OR for Eye Glance (all durations)**	**1.32**	**1.09**	**1.60**

Note: only the crashes and near-crashes where the subject driver is at fault are included in these data. Those numbers in bold font are significantly different from normal, baseline driving or 1.0.

Table 6.3. Population attributable risk percentage ratios and 95 percent confidence intervals for eyes off the forward roadway.

	Total Time of Eyes Off the Forward Roadway	Population Attributable Risk Percentage	Lower CL	Upper CL
1.	Less than or equal to 0.5 seconds	4.27	3.66	4.88
2.	Greater than 0.5 seconds but less than or equal to 1.0 second	N/A	N/A	N/A
3.	Greater than 1.0 second but less than or equal to 2.0 s	N/A	N/A	N/A
4.	Greater than 1.5 seconds but less than or equal to 2.0 seconds	3.93	3.29	4.56
5.	**Greater than 2.0 seconds**	**23.26**	**22.50**	**24.01**
	PAR% for Eye Glance (all durations)	**15.47**	**14.45**	**16.49**

Note: only the crashes and near-crashes where the subject driver is at fault are included in these data. Those numbers in bold font are significantly different from normal, baseline driving or 1.0.

While the above results are indicative of any time that a driver's eyes were averted from the forward roadway, regardless of the reason, near-crash/crash risk increases when the eyeglance is over 2 seconds. However eyeglances away from the forward roadway, specifically those to check rear-view mirrors, are important to safe driving. A driver who is glancing at one of the rear-view mirrors, for example, is exhibiting attentive and safe driving. Therefore, odds ratio calculations were also conducted to account for these behaviors. The following odds ratios were calculated for eyes off the forward roadway except when the driver was looking at the center, right, or left rear-view mirrors or checking traffic out the right or left windows. Please note that these glances were shown previously to possess a protective effect on driving safety (Chapter 2, *Objective 1*).

The resulting odds ratios (Table 6.4) demonstrate more effectively that as length of eyeglance from the forward roadway increases, the odds of being in a crash or near-crash also increases. Also note that the eyeglances away from the forward roadway greater than 2 seconds increase an individual's relative near-crash/crash risk by two times that of normal, baseline driving. An overall odds ratio associated with eyeglance away from the forward roadway was also over 1.5 indicating that, eyes off the forward roadway greater than 2 seconds was a strong enough effect to boost the overall odds ratio significantly over 1.0.

The population attributable risk percentages, as shown in Table 6.5, indicated that over 18 percent of all at-fault crashes and near-crashes occurring in an urban environment are attributable to eyes off the forward roadway. Eighteen percent of these crashes and near-crashes were attributable to eyeglances away from the forward roadway greater than 2 seconds. This finding demonstrates that eyes off the forward roadway, especially eyeglances greater than 2 seconds, is a key issue in crash causation. Recall that this estimate does not include those crashes where the driver was not at fault and rear-end struck crashes since eyeglance data were not available. Therefore, it is possible that this estimate could be higher than is currently estimated.

Table 6.4. Odds ratios and 95 percent confidence intervals for eyes off forward roadway excluding eyeglances to center, right, and left rear-view mirrors.

	Total Time of Eyes Off Forward Roadway	**Odds Ratio**	**Lower CL**	**Upper CL**
1.	Less than or equal to 0.5 seconds	1.13	0.67	1.92
2.	Greater than 0.5 seconds but less than or equal to 1.0 second	1.12	0.79	1.59
3.	Greater than 1.0 second but less than or equal to 1.5 seconds	1.14	0.79	1.65
4.	Greater than 1.5 but less than or equal to 2.0	1.41	0.98	2.04
5.	**Greater than 2.0 seconds**	**2.27**	**1.79**	**2.86**
6.	**OR for Eye Glance Away From the Forward Roadway**	**1.56**	**1.29**	**1.88**

Note: only the crashes and near-crashes where the subject driver is at fault and the driver is not looking at a rear-view mirror are included in this table. Those numbers in bold font are significantly different from normal, baseline driving or 1.0.

Table 6.5. Population attributable risk percentage ratios and 95 percent confidence intervals for eyes off the forward roadway excluding eyeglances to center, right, and left rear-view mirrors.

	Total Time of Eyes Off Forward Roadway	**Population Attributable Risk Percentage**	**Lower CL**	**Upper CL**
1.	Less than or equal to 0.5 seconds	0.74	0.41	1.06
2.	Greater than 0.5 seconds but less than or equal to 1.0 second	1.53	1.04	2.02
3.	Greater than 1.0 second but less than or equal to 2.0 seconds	1.56	1.10	2.03
4.	Greater than 1.5 seconds but less than or equal to 2.0 seconds	3.81	3.35	4.26
5.	**Greater than 2.0 seconds**	**18.88**	**18.27**	**19.49**
6.	**PAR% for Eye Glance**	**18.25**	**17.49**	**19.01**

Note: only the crashes and near-crashes where the subject driver is at fault and the driver is not looking at a rear-view mirror are included in this table. Those numbers in bold font are significantly different from normal, baseline driving or 1.0.

QUESTION 2. DO EYES OFF THE FORWARD ROADWAY SIGNIFICANTLY AFFECT SAFETY AND/OR DRIVING PERFORMANCE?

To answer this research question, four metrics of *eyes off the forward roadway* were calculated and ANOVAs were conducted to determine if significant differences exist between the crashes, near-crashes, and incidents plus baseline driving epochs. The first ANOVA was conducted using *total time eyes off forward roadway*. The ANOVA indicated significant differences among the four levels of severity as shown in Figure 6.1 ($F(3, 11{,}174) = 33.36$, $p < 0.0001$). Tukey post-hoc t-tests indicate that significant differences were present between all pairs as shown in Table 6.6. These results indicate that drivers involved in crashes had their eyes off the forward roadway a significantly longer portion of the 6 seconds prior to the conflict than did those drivers involved in near-crashes or incidents. Interestingly, drivers' eyes were off the roadway a significantly smaller portion of the 6-second segment than those drivers involved in safety-relevant conflicts.

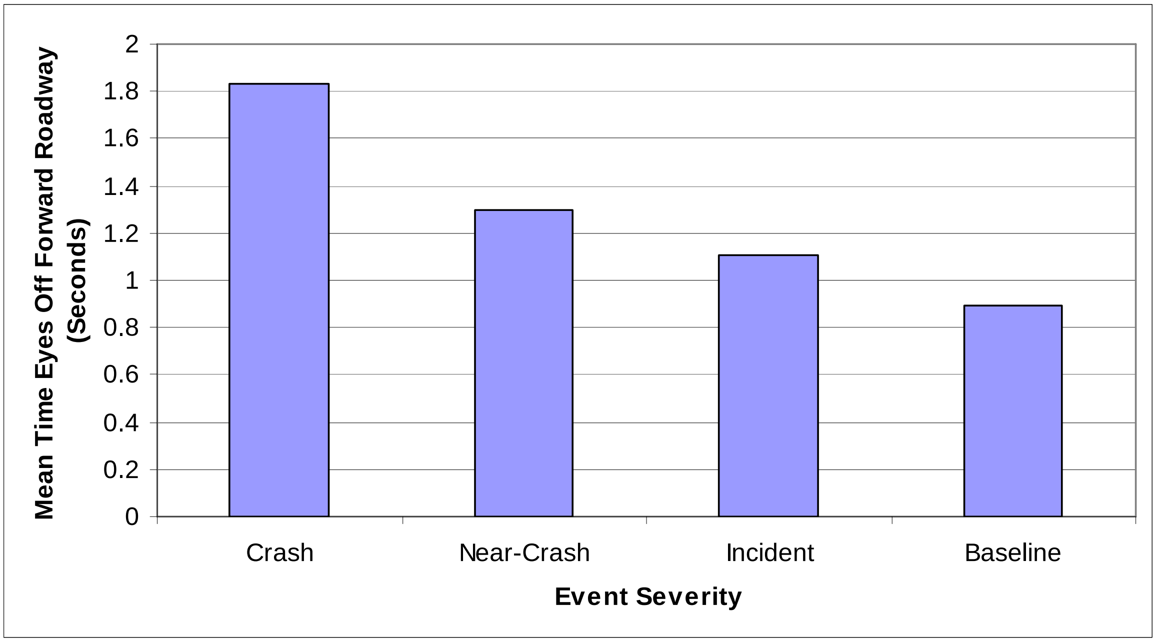

Figure 6.1. The total mean time drivers' eyes were off the forward roadway during the 6-second segment of time prior to the onset of the conflict.

Table 6.6. T-test results for total time eyes off the forward roadway.

	Severity	**dF**	**t-value**	**p-value**
1.	Crash and Near-crash	11,174	2.74	0.03
2.	Crash and Incident	11,174	3.79	0.009
3.	Crash and Baseline	11,174	4.87	< 0.0001
4.	Near-crash and Incident	11,174	2.57	0.05
5.	Near-crash and Baseline	11,174	5.60	<0.0001
6.	Baseline and Incident	11,174	8.10	<0.0001

The second metric involved the number of glances away from the forward roadway that occurred during the 5 seconds prior and 1 second after the onset of the conflict. Figure 6.2 shows the mean number of glances made by drivers just prior to involvement in crashes, near-crashes, incidents, and baseline events. An ANOVA indicated statistical significance among these four levels of event severity, $F(3, 11{,}174) = 22.02$, $p < 0.0001$. Post hoc Tukey t-tests were conducted on all pair combinations which indicated that near-crashes were significantly different from the baseline epochs, ($t(11{,}174) = 2.83$ $p < 0.05$) and incidents were significantly different from baseline epochs ($t(11{,}174) = 7.93$, $p < 0.0001$).

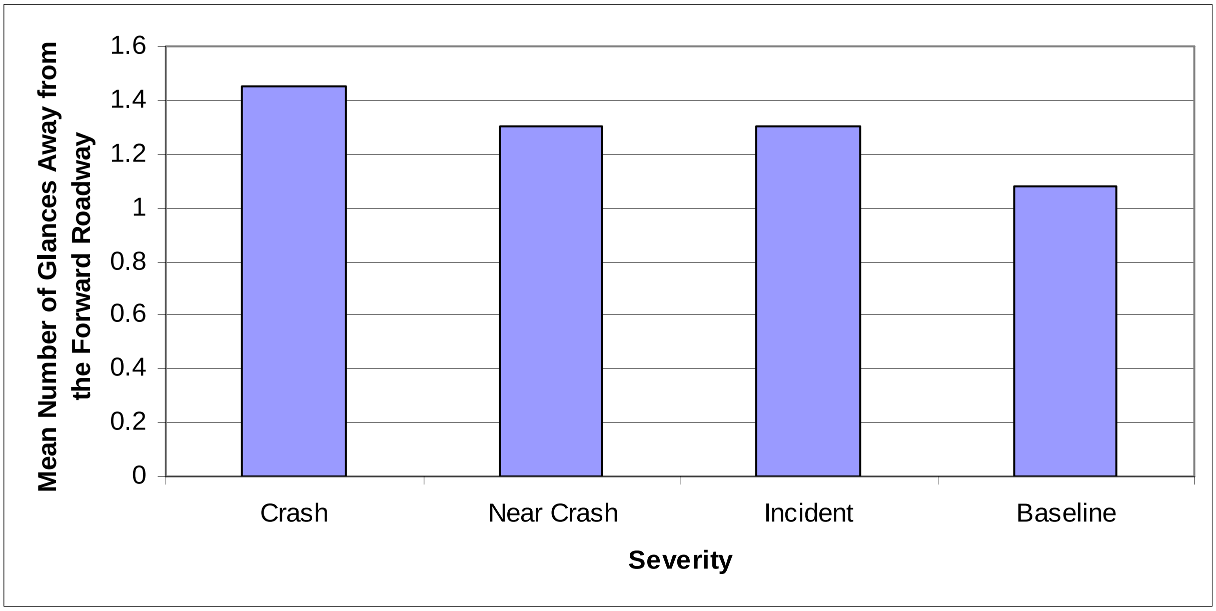

Figure 6.2. Mean number of glances away from the forward roadway occurring during 5 seconds prior and 1 second after the onset of the conflict or during a 6-second baseline driving epoch.

The mean length of longest glance away from the forward roadway is the only metric not confined to the 5 seconds prior and 1 second after the onset of the conflict. Rather, the longest glance away simply has to be initiated within the 5 seconds prior and 1 second after but may extend into the actual conflict. This metric was calculated since there were many crashes that occurred in which the driver was looking away from the forward roadway up to the moment of the crash. This eyeglance behavior would be missed if restricted to the 6-second period of time surrounding the *onset of the conflict*.

Figure 6.3 shows the results of the ANOVA which indicates that drivers' mean length of longest glance was over 0.5 seconds longer for crashes than for near-crashes ($F(3, 11{,}177) = 34.94$, $p < 0.0001$). Post hoc Tukey t-tests indicated that all four groups were significantly different from each other. The results from the post hoc Tukey t-tests are shown in Table 6.7. Note that these results are similar to those found by Dingus, Antin, Hulse and Wierwille, (1989) that stated that drivers do not tend to look away from the forward roadway greater than 1 or 1.5 seconds for any given glance. Figure 6.3 supports this earlier result in that the mean length of any one glance was between 1.6 and 0.7 seconds.

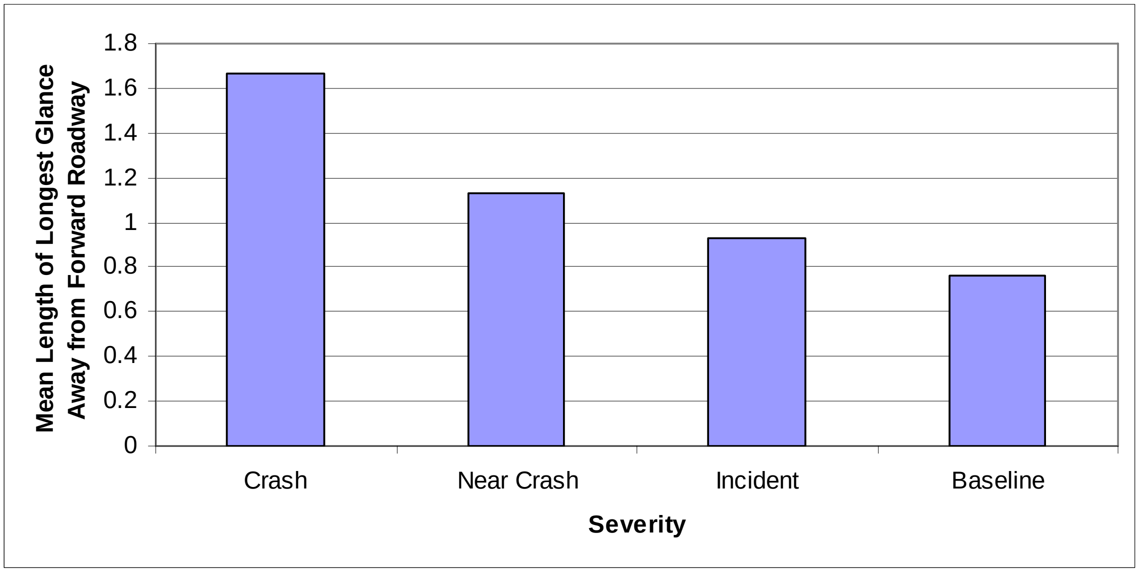

Figure 6.3. Mean length of longest glance initiated during the 5 seconds prior and 1 second after the onset of the conflict.

Table 6.7. Results from the Tukey post hoc T-Tests.

	Severity	dF	t-value	p-value
1.	Crash and Near-crash	11,177	3.16	0.0087
2.	Crash and Incident	11,177	4.52	<0.0001
3.	Crash and Baseline	11,177	5.53	< 0.0001
4.	Near-crash and Incident	11,177	3.38	0.0040
5.	Near-crash and Baseline	11,177	6.22	<0.0001
6.	Baseline and Incident	11,177	7.60	<0.0001

Eye-Glance Location Analysis

The eyeglance location analysis was an analysis of the location of the longest glance away from the forward roadway that was initiated during the 5 seconds prior and 1 second after the onset of the conflict. Eyeglance data reduction was conducted using the following locations of eyeglance:

- Left window
- Left mirror
- Left Forward
- Center Forward
- Center Mirror
- Right Forward
- Right mirror
- Right Window
- Instrument Panel
- Radio/HVAC
- Passenger in right-hand seat

- Hand-held device
- Object/Other
- Eyes closed

These locations were split into three general locations based upon degrees of visual angle away from center forward (illustrated in Figure 6.4). The first group, called Ellipse 1, included all locations that were 20° or less away from center forward. Ellipse 2 included all locations that were up to 40° but greater than 20°. The last Ellipse includes all locations greater than 40° as well as hand-held device, object, and eyes closed. The eyeglance categories that were assigned to each ellipse are as follows:

Ellipse 1: Left Forward, Right Forward, and Instrument Panel
Ellipse 2: Center Mirror, Radio/HVAC, and Left Mirror
Ellipse 3: Left Window, Right Mirror, Right Window, Passenger in Right-Hand Seat, Hand-Held Device, Object/Other, and Eyes Closed.

While there is some overlap in these ellipse selections, the eyeglance location was placed in the ellipse closer to the central field of view than further away.

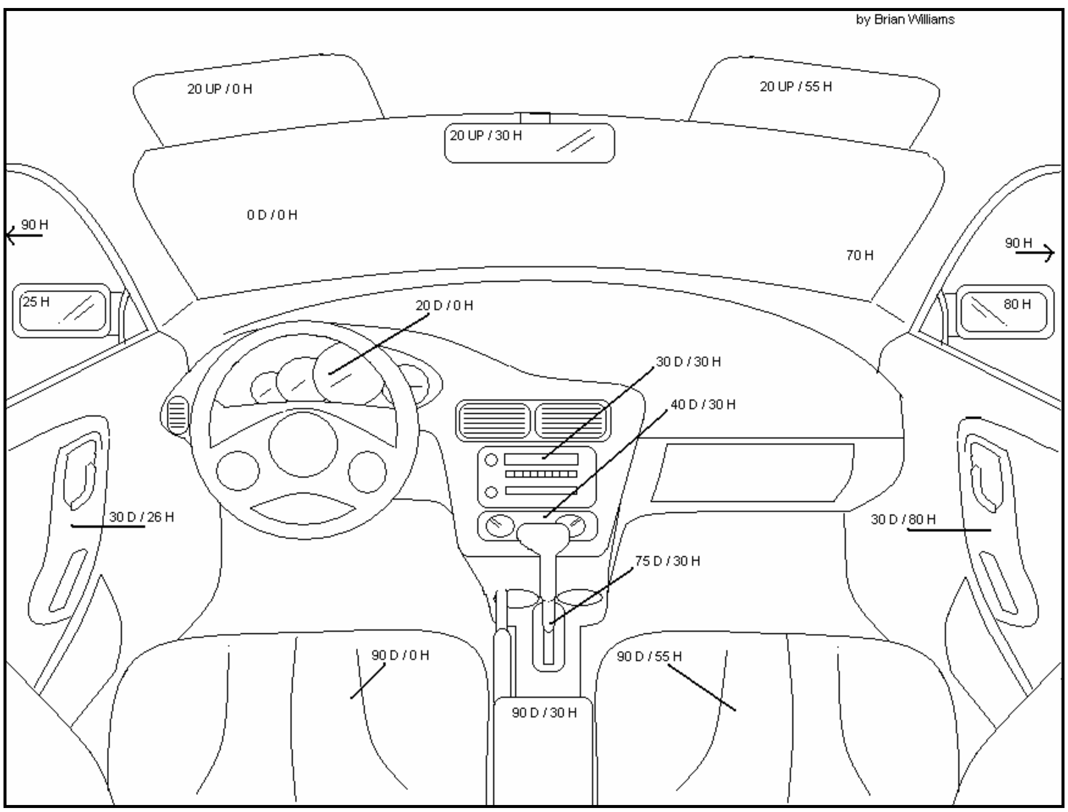

Figure 6.4. Depiction of degrees of visual angle from center forward that objects in the cockpit of an automobile are generally located.

Figure 6.5 presents the percent of crashes, near-crashes, incidents, and baseline epochs in which the longest glance away from the forward roadway was within each ellipse. A chi-square analysis was conducted to determine if there were significant differences in the frequency of events or epochs at these locations, and the results indicated that there are significant differences (χ (9) = 208.42, p > 0.0001). Note that for incidents, the driver's longest glances away from the forward roadway are spread fairly evenly across all three ellipse locations, however for crashes and near-crashes, drivers' longest glances were most frequently between 20° and 40° away from center forward. Baseline epochs had the most glances in Ellipse 3; however it is unknown whether the differences among the three ellipse locations for baseline epochs are significantly different. These results may indicate that many crashes and near-crashes could potentially be avoided if the driver's gaze could be re-directed when gaze direction resides between 20 and 40° away from center forward.

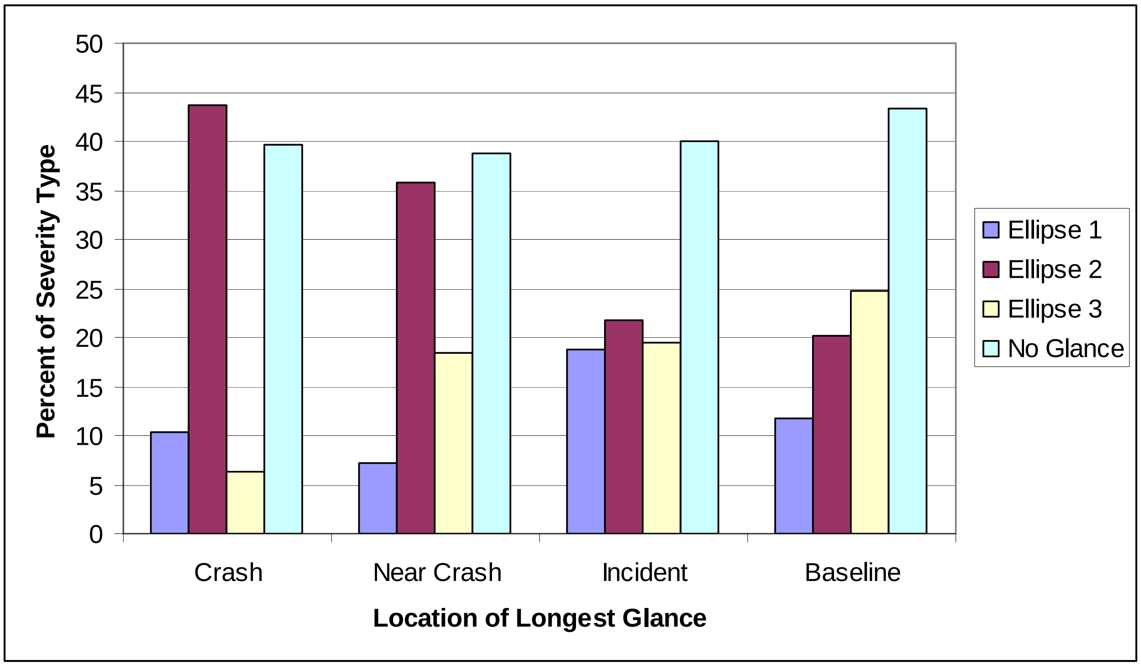

Figure 6.5. The percentage of the location of the longest glance away from the forward roadway by severity.

CONCLUSIONS

The use of eyeglance behavior in driving research is a complicated construct. W*hy* the driver was looking away from the forward roadway can not be ignored from the analysis if one is interested in driving inattention. In driving research it is commonly written that a driver looking away from the forward roadway is an *inattentive driver*. It is also commonly written that a driver who is systematically scanning his/her environment (i.e., looking away from the forward roadway) is an *attentive driver*.

The total time eyes are away from the forward roadway may or may not be a source of potential inattention, depending upon the *purpose* for looking away. The results, using the metric *total time eyes are away from the forward roadway*, indicate that viewing the rear-view mirror or windows to check traffic were safe actions that resulted in a relative near-crash/crash risk of less than 1.0. When the *total time eyes were off the forward roadway* was greater than 2seconds, regardless of where the driver was looking, an increased risk of crash or near-crash involvement (OR = 2.3) was observed.

Statistically significant differences were identified using the four eyeglance behavior metrics for crashes, near-crashes, incidents, and baseline epochs. These results indicated that the longer eyeglances and longer periods of time that the drivers' eyes were away from the forward roadway significantly impacted driving performance. Drivers who were involved in crashes had an average total time eyes away from the forward roadway of nearly 2 seconds with 1.5 seconds mean length of longest glances. Drivers involved in near-crashes had an average total time away from the forward roadway closer to 1 second and the same for mean longest glance length. While statistically significant differences were observed for number of glances, caution may be required as the practical differences between 1.4 glances and 1.2 glances away from the forward roadway.

Interesting results were also obtained when analyzing the location of the longest glance away from the forward roadway. Note that for crashes and near-crashes, drivers were more far more frequently looking in Ellipse 2 than other locations. The frequency of longest-glance location for incidents and baseline epochs appeared to be somewhat more evenly spread across the three ellipses. One issue with this analysis was that if the driver was looking at a hand-held device or at another object, the distance away from center forward is unknown and may not be located within Ellipse 3. It was decided to put these two categories in Ellipse 3 as it appeared that drivers usually were looking at objects in their lap or the seat next to them, and dialed their hand-held device near their lap. It is doubtful that this discrepancy in the operational definition had a very large impact as the frequencies for the category was fairly low for the crashes and near-crashes, especially.

These results demonstrate that eyeglances away from the forward roadway, especially those that do not involve checking rear-view mirrors, may be contributing factors to a high percentage of crashes. Please note that for 40 percent of the crashes, near-crashes, and incidents, the driver did not look away from the forward roadway for the 5 seconds prior and 1 second after the onset of the conflict. This result leaves 60 percent, a majority of the crashes, near-crashes, and incidents, where glances away from the forward roadway were a contributing factor. This result has implications for collision-avoidance-warning designers in that if they could incorporate where the driver is looking in their warning algorithms, their systems could be vastly improved by reducing false alarms and also reducing crash involvement and/or injuries.

CHAPTER 7: *OBJECTIVE 6*, ARE THERE DIFFERENCES IN DRIVING PERFORMANCE FOR DRIVERS WHO ARE ENGAGING IN A DISTRACTION TASK VERSUS THOSE DRIVERS WHO ARE ATTENDING TO DRIVING? ARE SOME OF THE SAFETY SURROGATE MEASURES MORE SENSITIVE TO DRIVING PERFORMANCE DIFFERENCES WHEN DRIVING DISTRACTED VERSUS OTHER SAFETY SURROGATE MEASURES?

To determine whether there were any differences in driving performance between inattentive and attentive drivers, the baseline database was evaluated. A discriminant analysis was conducted to determine if any statistically significant differences were present between the baseline epochs that involved drivers engaging in secondary tasks and/or driving while drowsy and those baseline epochs where the driver was attentive. Prior to conducting the discriminant analysis, a stepwise selection procedure was conducted to determine which driving performance measures were accounting for the highest percentage of variance. This provided insight into which driving performance measures (surrogate safety measures) are most sensitive to inattentive driving.

DATA USED IN THIS ANALYSIS

Table 7.1 presents all the driving performance data that were used in the discriminant analysis. Please recall from Chapter 1: Introduction and Method that the vehicle speed could not be 0 mph for the duration of the epoch. The vehicle was in motion for at least a portion of the 6-second segment for all 20,000 epochs.

Table 7.1. Driving Performance Data Used in the Discrimnant Analysis.

	Driving Performance Measure	Description
1.	Average percent throttle	Percent that throttle pedal was depressed by driver over the duration of 6-second epoch.
2.	Maximum percent throttle	Maximum percent that throttle pedal was depressed by driver over the duration of the 6-second epoch.
3.	Minimum lateral acceleration	Minimum absolute value of lateral acceleration over the 6-second epoch.
4.	Average lateral acceleration	Average absolute value of lateral acceleration over the 6-second epoch.
5.	Maximum lateral acceleration	Maximum absolute value of lateral acceleration over the 6-second epoch.
6.	Maximum longitudinal acceleration	Maximum longitudinal positive acceleration across the 6-second epoch.
7.	Average longitudinal acceleration/deceleration	Average longitudinal acceleration/deceleration value across 6-second epoch.
8.	Maximum longitudinal deceleration	Maximum longitudinal negative deceleration across the 6-second epoch.
9.	Yaw time differential	Duration of the maximum peak-to-peak across the 6-second epoch (i.e., jerk).
10.	Average speed	Average vehicle speed across the 6-second epoch.
11.	Maximum speed	Maximum vehicle speed across the 6-second epoch.

There were some driving-performance measures that were not included in the analyses. Some of these measures include forward range, range-rate, and TTC. These dependent measures, while useful in identifying crashes, near-crashes, and incidents when used in conjunction with longitudinal deceleration, were too variable to use with the baseline data. There were many epochs with no lead vehicle present as well as difficulties in filtering spurious radar data when using only 6-second segments. Radar data is notoriously noisy and effectively filtering for this task proved to be too time consuming given the resources available. Even with effective filtering, we hypothesize that this data would not have yielded different results than the results that will be presented with the data that were used.

STEPWISE SELECTION PROCEDURE AND CANONICAL DISCRIMINANT ANALYSIS

A stepwise selection procedure was conducted to determine if all of the above variables are necessary to distinguish between a driver who is engaging in a secondary task or is driving while drowsy to a driver who is attentive to the forward roadway. The stepwise selection procedure initially uses a forward selection procedure but after each selection, the procedure checks to ensure that all the variables previously selected remain significant (Johnson, 1998). In this manner, the stepwise selection procedure will select those driving performance variables or surrogate safety measures that can best discriminate between an attentive and an inattentive driver.

Table 7.2 presents those surrogate safety measures that the stepwise selection procedure selected. The standardized canonical coefficient can be used to interpret the relative contribution that each variable is making to the model. The magnitude and the sign of the value are both used in this interpretation; therefore, the average percent throttle is contributing the most to the model whereas yaw time differential is contributing the least.

Table 7.2 The safety surrogate measures that best discriminate between attentive and inattentive drivers.

Variable	**Standardized Canonical Coefficient**
Average Percent Throttle	0.81
Yaw time differential	0.29
Average Lateral Acceleration	-0.51
Maximum Longitudinal Deceleration	-0.44

The stepwise selection procedure also indicated that these four safety surrogate measures together achieved a multivariate measure analogous to an R-squared value of 0.004 indicating that these four variables account for less than 1 percent of the variance associated with inattentive and attentive driving. While differences are present between attentive and inattentive drivers, these surrogate safety measures are not adequately explaining these differences.

DISCRIMINANT ANALYSIS

The discriminant analysis was conducted to determine whether these surrogate safety measures were predictive of inattentive driving. Table 7.3 shows that 51.4 percent of the attentive epochs were correctly classified and 54.5 percent of the inattentive epochs were correctly classified. These results suggest that the predictive linear model using these surrogate safety measures is not able to accurately predict whether the driver is attentive or inattentive as these percentage values are too close to 50 percent accuracy or chance.

Table 7.3. The percent of baseline epochs that the linear discriminant analysis model was successfully able to distinguish.

	Attentive Baseline Epochs (percent)	**Inattentive Baseline Epochs (percent)**	**Total (percent)**
Attentive Baseline Epochs	51.4	48.6	100
Inattentive Baseline Epochs	45.8	54.2	100
Total	48.5	51.5	100

DISCUSSION

The stepwise selection procedure indicated that the average percent throttle, yaw time differential, average lateral acceleration, and maximum longitudinal deceleration were the safety surrogate measures most sensitive to inattentive driving. While these safety surrogate measures were most sensitive to inattentive driving, they were only able to account for less than 1 percent of the variance. The subsequent discriminant analysis indicated that the predictive abilities of these four safety surrogate measures to distinguish between attentive and inattentive driving was not better than chance or 50 percent accuracy.

Other discriminant analyses using the variance of the above safety surrogate measures were also attempted. These results were similar to the above results in that the surrogate safety measures selected in the stepwise selection procedure accounted for less than 1 percent of the variance. The discriminant analysis also indicated poor predictability that was not significantly different from chance (i.e., 50 percent were correctly identified and 50 percent were incorrectly identified).

There are several hypotheses as to why the surrogate safety measures did not adequately explain the differences in attentive versus inattentive driving. One hypothesis is that the results from these analyses are accurate and that inattentive driving does not in fact differ significantly from attentive driving. Rather it is only in the presence of multiple other contributing factors and extreme circumstances that differences exist in the inattentive driver's ability to effectively respond versus an attentive driver's ability to effectively respond to an emergency situation. Testing this hypothesis is possible with the 100-Car Study data but would require specific baseline events to be identified and reduced that match on a variety of environmental and situational variables per individual driver. This reduction and analysis effort is beyond the scope of this project but could be conducted in the future.

A second hypothesis is that there are differences that exist for these safety surrogate measures but these differences are not being captured adequately by using point estimates. A point estimate may not be accurately capturing the differences between inattentive and attentive drivers. A different statistical analysis or what is known as functional data analysis may produce different results. Functional data analysis would use overall rates of change for each baseline epoch rather than a point estimate to summarize the data for that epoch. While this technique could be used, it would require additional data reduction and time spent researching these relatively new data analysis methods. These techniques are generally not attempted unless the point estimate analysis produced some promising results; therefore, this hypothesis should only be tested as a last resort.

A third explanation for these findings is that the 6-second duration for the baseline epochs is too short to accurately assess driving performance. Recall that the baseline epochs were 6 seconds in duration to compare to the time frame used by trained data reductionists to assess whether a particular behavior or action by the driver contributed to the occurrence of the crash, near-crash, or incident. It is unknown whether a point estimate for a longer duration of time would be any better than the analysis already conducted. Also note that lengthening the time duration would require additional data reduction.

After conducting multiple discriminant analyses using a variety of surrogate safety measures, it is clear that the databases that currently exist are not adequate to test the above hypotheses that are listed here. More data reduction that is specifically designed to adequately assess driving performance for individual drivers during specific environmental conditions is required to further assess this research objective.

CHAPTER 8: CONCLUSIONS

GENERAL CONCLUSIONS

The analyses reported in this document are the first to evaluate driver inattention immediately prior to a crash and near-crash. These analyses used data collected as part of a large-scale naturalistic driving study. The analytical methods used were applied from epidemiology, empirical research, and qualitative research. The application of these analytical methods demonstrates the power of naturalistic driving data and its importance in relating driving behavior to crash and near-crash involvement.

Driver inattention was operationally defined at the beginning of this report as one of the following:

- Driver engagement in secondary task(s)
- Driver drowsiness
- Driving-related inattention to the forward roadway
- Non-specific eyeglance away from the forward roadway

These four types of inattention, either in isolation or in combination, were used to answer the research questions addressed in this letter report. Some of the important findings addressed as part of these questions are presented below:

- Due to the detailed pre-crash/near-crash data reduction, this study allowed for the calculation of relative near-crash/crash risk of engaging in various types of inattention-related activities. Some of the primary results were that driving while drowsy increases an individual's near-crash/crash risk by between four and six times that of normal, baseline driving, engaging in complex secondary tasks increases risk by three times and engaging in moderate secondary tasks increases risk by two times. *Driving-related inattention to the forward roadway* was actually shown to be safer than normal, baseline driving (odds ratio of 0.45). This was not surprising as drivers who are checking their rear-view mirrors are generally alert and engaging in environmental scanning behavior.

- This study also allowed for the calculation of population attributable risk percentages. This calculation produces an estimate of the percentage of crashes and near-crashes occurring in the population at-large that are attributable to the inattention-related activity. The results of this analysis indicated that driving while drowsy was a contributing factor for between 22 and 24 percent of the crashes and near-crashes, and secondary-task distraction contributed to over 22 percent of all crashes and near-crashes. This is a useful metric since odds ratios estimate risk on a per-task (or drowsiness episode) basis while the population attributable risk percentage accounts for the frequency of occurrence. Thus, some inattention-related activities that indicated high relative near-crash/crash risk had corresponding population attributable risk percentages indicating low total percentages. This was due to lower frequency of occurrence. Conversely, other more frequently performed inattention tasks, while obtaining lower relative near-crash/crash risks, obtained higher population attributable risk percentages.

- The prevalence of driving inattention was analyzed by using "normal baseline driving" (i.e., no crashes, near-crashes, or incidents present) as established by the baseline database. The four types of inattention were recorded alone and in combination with the other types of inattention. The percent of the total baseline epochs in which drivers were engaged in each type of inattention is as follows:

  secondary tasks – 54 percent of baseline epochs
  driving-related inattention – 44 percent of baseline epochs
  drowsiness – 4 percent of baseline epochs
  non-specific eyeglance – 2 percent of baseline epochs

  Note that the total is higher than 100 percent since drivers engaged in multiple types of inattention at one time. Also note that non-specific eyeglance was most frequently recorded as associated with the other types of inattention, but accounts for only 2 percent of the baseline epochs, singularly. Given that the baseline epochs most closely represent "normal baseline driving," these results suggest that drivers are engaging in inattention-related tasks a majority of the time.

- The analysis of eyeglance behavior indicates that total eyes-off-road durations of greater than 2 seconds significantly increased individual near-crash/crash risk; whereas eyeglance durations less than 2 seconds did not significantly increase risk relative to normal baseline driving. The purpose behind an eyeglance away from the roadway is important to consider, an eyeglance directed at a rear-view mirror is a safety-enhancing activity in the larger context of driving, while eyeglances at objects inside the vehicle are not safety-enhancing. It is important to remember that scanning the driving environment is an activity that enhances safety as long as it is systematic and the drivers' eyes return to the forward view in under 2 seconds.

- The results for the analysis investigating the impact of driver drowsiness on environmental conditions yielded many interesting findings. First, the relative near-crash/crash risks of driver drowsiness may vary depending on time of day or ambient lighting conditions. When compared to total baseline epochs, far fewer drowsiness-related baseline epochs were observed during the daylight hours while a greater number were identified during darkness. Drowsiness was also seen to slightly increase in the absence of high roadway or traffic demand. A higher percentage of drowsiness-related baseline epochs were found during free-flow traffic densities, on divided roadways, and areas free of roadway junctions.

- The results of the analysis investigating the impact of complex- or moderate-secondary-task engagement on various environmental conditions were more varied. Each of the eight environmental conditions resulted in odds ratios greater than 1.0 for engaging in complex secondary tasks. Engaging in moderate secondary tasks rarely resulted in odds ratios significantly greater than 1.0, indicating that these behaviors may not be as risky as driving drowsy or engaging in complex secondary tasks.

- The most frequent type of secondary task engagement, hand-held device use, also obtained odds ratios greater than 1.0 for both *dialing hand-held device* (CL = 1.6 – 4.9) and *talking/listening to a hand-held device* (CL = 0.9 – 1.8). *Talking/listening to a hand-held device* was not significantly different than 1.0, indicating that this task was not as risky as *dialing a hand-held device*. Regardless of the slightly different odds ratios, these two secondary tasks had nearly the identical population attributable risk percentages (each attributing to 3.6 percent of crashes and near-crashes). One hypothesis for this is that drivers were talking/listening to hand-held devices a much larger percentage of time than they were dialing hand-held devices. Thus, the percent of crashes and near-crashes that were attributable to these two actions was similar due to the fact that dialing was more dangerous but was performed less frequently whereas talking/listening was less dangerous but performed more frequently.

- The results from the survey and test battery response analyses indicate that driver age, driving experience, self-reported traffic violations, self-reported accidents, daytime sleepiness ratings, and personality inventory scores indicate significant differences between the drivers with high and low involvement in inattention-related crashes and near-crashes.

- A clear relationship between involvement in inattention-related crashes and near-crashes and engaging in inattention-related activities during baseline driving was observed. A correlation of 0.72 was obtained between the frequency of driver's involvement in inattention-related crashes and near-crashes and the frequency of involvement in inattention-related baseline epochs. This result, according to Keppel and Wickens (2004), is a large effect in the behavioral sciences. This suggests that those drivers who frequently engage in inattention-related activities are also more likely to be involved in inattention-related crashes and near-crashes. Those drivers who are not frequently engaging in inattention-related tasks frequently are less likely to be involved in inattention-related crashes and near-crashes.

RELATIVE RISK OF A CRASH OR NEAR-CRASH: CONCLUSIONS

Odds ratio calculations, or relative-risk calculations for a crash or near-crash, were conducted in three separate chapters. First, Chapter 2, *Objective 1,* odds ratios were calculated for three levels of secondary task complexity, two durations of time that eyes were off the forward roadway for *driving-related inattention to the forward roadway*, two durations of time for *non-specific eyeglance away from the forward view*, and *driver drowsiness* (moderate to severe). Odds ratio calculations were calculated in Chapter 3, *Objective 2* to determine whether driving while engaging in secondary tasks or drowsy through various types of driving environments produced higher near-crash/crash risks. Finally, odds ratios were also calculated for total length of time eyes were off the forward roadway by increments of 0.5 seconds in Chapter 6, *Objective 3*.

Data used to calculate the odds ratios included a subset of the 69 crashes and 761 near-crashes where the driver was at-fault that were collected as part of the 100-Car Study and 20,000 baseline epochs (5,000 baseline epochs for any odds ratios requiring eyeglance data only). Please note that the 20,000 baseline driving epochs were first selected based upon the number of crashes, near-crashes, and incidents that each vehicle (not driver) was involved and then randomly selected across the entire 12 months of data collection. Each baseline epoch was a 6-second segment when the vehicle was in motion. This stratification technique created a case-control data set as those vehicles who were more involved in crashes, near-crashes, and incidents also had more baseline events to compare. Case-control designs are optimal for calculating odds ratios due to the increased power that a case-control data set possesses. Greenberg et al. (2001) argue that using a case-control design allows for an efficient means to study rare events, such as automobile crashes. Thus, the causal relationships that exist for these events can be evaluated by using relatively smaller sample sizes than are used in typical crash database analyses where thousands of crashes may be used.

Table 8.1 presents the odds ratios for the different types of inattention that increase individual near-crash/crash risk. Please note that *driving-related inattention to the forward roadway* is not in this table as this type of inattention was found to be safer than normal, baseline driving. Tables 8.2 and 8.3 present the odds ratios for the interaction of drowsiness with various environment and road-type conditions and the interaction of complex secondary tasks with environmental conditions, respectively. The odds ratios for the interaction of moderate-secondary-task engagement and environmental variables will not be presented as a majority of these odds ratios were not significantly different from 1.0. Table 8.4 presents the odds ratios for the lengths of total time eyes were off the forward roadway. All tables present only those odds ratios that were greater than 1.0. In all tables, those that were significantly different from 1.0 are in bold font.

Table 8.1. Odds ratios and 95 percent confidence intervals for all types of driving inattention where odds ratios were greater than 1.0.

Type of Inattention	Odds Ratio	Lower CL	Upper CL
Complex Secondary Task	**3.10**	**1.72**	**5.47**
Moderate Secondary Task	**2.10**	**1.62**	**2.72**
Simple Secondary Task	1.18	0.88	1.57
Moderate to Severe Drowsiness (in isolation from other types of inattention)	**6.23**	**4.59**	**8.46**
Moderate to Severe Drowsiness (all occurrences)	**4.24**	**3.27**	**5.50**
Reaching for a Moving Object	**8.25**	**2.50**	**31.16**
Insect in Vehicle	6.37	0.76	53.13
Looking at External Object	**3.70**	**1.13**	**12.18**
Reading	**3.38**	**1.74**	**6.54**
Applying Makeup	**3.13**	**1.25**	**7.87**
Dialing Hand-Held Device	**2.79**	**1.60**	**4.87**
Handling CD	2.25	0.30	16.97
Eating	1.57	0.92	2.67
Reaching for Object (not moving)	1.38	0.75	2.56
Talking/Listening to a Hand-Held Device	1.29	0.93	1.80
Drinking from Open Container	1.03	0.33	3.28

Table 8.2. Odds ratios and 95 percent confidence intervals for the interaction of drowsiness by environmental conditions where odds ratios were greater than 1.0.

Type of Roadway/ Environment	Odds Ratio	Lower CL	Upper CL
Lighting Levels			
Dawn	**2.43**	**0.96**	**6.17**
Daylight	**5.27**	**3.55**	**7.82**
Dusk	**6.99**	**3.82**	**12.80**
Darkness-Lighted	**3.24**	**1.92**	**5.47**
Darkness-Not Lighted	**3.26**	**1.82**	**5.86**
Weather			
Clear	**4.34**	**3.22**	**5.86**

Rain	**4.41**	**2.41**	**8.08**
Road Type			
Divided	**3.73**	**2.61**	**5.34**
Undivided	**5.54**	**3.47**	**8.84**
One-Way	**3.40**	**1.76**	**6.59**
Roadway Alignment			
Straight Level	**3.96**	**2.93**	**5.34**
Curve Level	**5.81**	**3.66**	**9.21**
Straight Grade	**6.29**	**2.20**	**17.96**
Traffic Density			
LOS A: Free Flow	**4.67**	**3.02**	**7.21**
LOS B: Flow with Some Restrictions	**4.81**	**2.70**	**8.58**
LOS C: Stable Flow – Maneuverability and speed are more restricted	**3.63**	**2.01**	**6.54**
LOS D: Flow is Unstable – Vehicles are unable to pass with temporary stoppages	**4.29**	**1.88**	**9.80**
LOS F: Unstable Flow- Temporary restrictions, substantially slow drivers	**3.71**	**1.93**	**7.13**
Roadway Surface Conditions			
Dry	**4.52**	**3.39**	**6.03**
Wet	**3.17**	**2.03**	**4.95**
Traffic Control Device			
Traffic Signal	**2.71**	**1.90**	**3.85**
Stop Sign	**5.55**	**2.71**	**11.36**
Traffic Lanes Marked	**5.57**	**2.43**	**12.78**
No Traffic Control	**4.83**	**3.60**	**6.48**
Relation to Junction			
Intersection	**3.48**	**2.17**	**5.59**
Intersection-Related	**6.82**	**4.10**	**11.35**
Entrance/Exit Ramp	**3.21**	**1.81**	**5.71**
Interchange	**5.86**	**2.39**	**14.35**
Non-Junction	**5.02**	**3.65**	**6.90**

Table 8.3. Odds ratios and 95 percent confidence intervals for the interaction of complex secondary task engagement and environmental variables where odds ratios were greater than 1.0.

Type of Roadway/ Environment	Odds Ratio	Lower CL	Upper CL
Lighting Levels			
Daylight	**3.06**	**1.84**	**5.06**
Dusk	**8.91**	**4.41**	**18.03**
Darkness-Lighted	**4.58**	**2.46**	**8.52**
Darkness-Not Lighted	**24.43**	**12.40**	**48.10**
Weather			
Clear	**3.68**	**2.29**	**5.92**
Rain	**5.11**	**1.86**	**14.07**
Road Type			
Divided	**4.20**	**2.40**	**7.33**
Undivided	**3.60**	**1.89**	**6.79**
One-Way	**3.66**	**1.63**	**8.18**
Roadway Alignment			
Straight Level	**3.59**	**2.20**	**5.84**
Curve Level	**3.58**	**1.95**	**6.60**
Straight Grade	**26.00**	**7.31**	**92.53**
Curve Grade	**6.75**	**2.08**	**21.89**
Traffic Density			
LOS A: Free Flow	**4.67**	**2.32**	**9.38**
LOS B: Flow with Some Restrictions	**3.67**	**1.65**	**8.19**
LOS C: Stable Flow – Maneuverability and speed are more restricted	**3.80**	**1.68**	**8.58**
LOS D: Flow is Unstable – Vehicles are unable to pass with temporary stoppages	1.75	0.61	5.01
LOS F: Unstable Flow- Temporary restrictions, substantially slow drivers	**2.45**	**1.01**	**5.93**
Roadway Surface Conditions			
Dry	**4.44**	**2.88**	**6.84**
Wet	1.03	0.58	1.80

Traffic Control Device			
Traffic Signal	**3.14**	**2.15**	**4.58**
Stop Sign	**3.27**	**1.38**	**7.75**
Traffic Lanes Marked	**4.02**	**2.47**	**6.54**
No Traffic Control	**4.83**	**3.60**	**6.48**
Relation to Junction			
Intersection	1.59	0.86	2.97
Intersection-Related	**3.32**	**1.73**	**6.38**
Parking Lot	**9.11**	**3.76**	**22.07**

The odds ratios presented for the time eyes were off the forward roadway suggests that any time driver's eyes were off the forward roadway greater than 2 seconds increases near-crash/crash risk by two times (Table 8.4). None of the eyeglances away from the forward roadway that were less than 1.5 seconds were significantly different from 1.0.

Table 8.4. Odds Ratios and 95 percent confidence intervals for Eyes Off Forward Roadway Excluding Eye Glances to Center, Right, and Left Rear-View Mirrors.

Total Time of Eyes Off the Forward Roadway	Odds Ratio	Lower CL	Upper CL
Less than or equal to 0.5 s	1.13	0.67	1.92
Greater than 0.5 seconds but less than or equal to 1.0 s	1.12	0.79	1.59
Greater than 1.0 seconds but less than 1.5 seconds.	1.14	0.79	1.65
Greater than 1.5 seconds but less than or equal to 2.0 s	1.41	0.98	2.04
Greater than 2.0 s	**2.27**	**1.79**	**2.86**
OR for Eye Glance Away From the Forward Roadway	**1.56**	**1.29**	**1.88**

POPULATION ATTRIBUTABLE RISK PERCENTAGE CONCLUSIONS

A population attributable risk percentage calculation is a measure of the percentage of crashes and near-crashes that could be attributed to the variable being measured. Population attributable risk percentages are useful when interpreting odds ratios, or relative risk calculations for a crash or near-crash. Some odds ratios may have a very high individual risk; however that behavior/situation does not occur frequently in nature and therefore attributes to very few crashes in the population. An example of high odds ratios leading to low population attributable risk percentage includes the secondary tasks of *reaching for a moving object, external distraction, reading, applying makeup,* and *eating.* Even though each of these tasks obtained very high individual near-crash/crash risk, these factors did not account for a large percentage of actual crashes and near-crashes as shown by the population attributable risk percentage calculations in Table 8.5. Drowsiness, in contrast, resulted in a high relative near-crash/crash risk value and attributed to between 22 and 24 percent of the crashes and near-crashes in the population. This finding is important since these values are much higher than most crash database research has shown (Campbell, Smith, and Najm, 2003).

Also note that while the odds ratio for t*alking/listening to a hand-held device* was only slightly above 1.0 and much lower than *dialing a hand-held device*, the population attributable risk percentage was similar for both actions. This result may be due primarily to the relative frequency of occurrence of both actions. *Dialing a hand-held device* may be more dangerous but it requires less time whereas *talking/listening to a hand-held device* occurred frequently and perhaps, for long periods of time. *Talking/listening to a hand-held device* was the most frequent type of secondary task distraction observed.

Table 8.5. The population attributable risk percentage ratios and 95 percent confidence intervals for the types of driver inattention.

Type of Inattention	**Population Attributable Risk Percentage**	**Lower CL**	**Upper CL**
Complex Secondary Task	4.26	3.95	4.57
Moderate Secondary Task	15.23	14.63	15.83
Simple Secondary Task	3.32	2.72	3.92
Moderate to Severe Drowsiness (in isolation from other types of inattention)	22.16	21.65	22.68
Moderate to Severe Drowsiness (all occurrences)	24.67	21.12	26.23
Complex Secondary Tasks			
Dialing Hand-Held Device	3.58	3.29	3.87
Reading	2.85	2.60	3.10
Applying Makeup	1.41	1.23	1.59
Reaching for a Moving Object	1.11	0.97	1.25
Insect in Vehicle	0.35	0.27	0.44
Moderate Secondary Tasks			
Talking/Listening to a Hand-Held Device	3.56	3.10	4.10
Eating	2.15	1.85	2.46
Reaching for Object (not moving)	1.23	0.96	1.50
Looking at External Object	0.91	0.77	1.05
Handling CD	0.23	0.15	0.32

An important result from these analyses is that eyeglances greater than 2 seconds contributed to 18 percent of all crashes and near-crashes and eyeglances in general attributed to 18 percent of all crashes and near-crashes that occur in a metropolitan driving environment (Table 8.6). While the purpose or location of eyeglance does matter, the longer the time away from the forward roadway, the more dangerous the activity becomes. It is apparent that many crashes are attributable to long glances away from the forward roadway.

Table 8.6. Population attributable risk percentage ratios and 95 percent confidence intervals for eyes off forward roadway excluding eyeglances to center, right, and left rear-view mirrors.

Total Time of Eyes Off the Forward Roadway	Population Attributable Risk Percentage	Lower CL	Upper CL
Less than or equal to 0.5 seconds	0.74	0.41	1.06
Greater than 0.5 seconds but less than or equal to 1.0 second	1.53	1.04	2.02
Greater than 1.0 second but less than 1.5 seconds.	1.56	1.10	2.03
Greater than 1.5 seconds but less than or equal to 2.0 seconds	3.81	3.35	4.26
Greater than 2.0 seconds	18.88	18.27	19.49
OR for Eye Glance Away From the Forward Roadway	18.25	17.49	19.01

LIMITATIONS OF THE STUDY

Please note that there are some limitations of the given data set that must be considered when interpreting these results. First, the 100-Car Study was conducted in one geographical area of the country and that location was a metropolitan area; therefore, the odds ratios and the population attributable risk percentages are generalizable to a metropolitan environment and probably less so to the United States driving population at-large.

Further analyses need to be conducted to determine how all of these individual odds ratio and population attributable risk percentage calculations interact with each other. Please note that many of these odds ratios were individually calculated and do not account for any correlations that probably exist between many of these variables, i.e., weather conditions and roadway surface conditions. A logistic regression could be performed to assess the odds ratios and population attributable risk percentages accounting for these naturally occurring correlations. Please note that measures were taken to reduce the amount of correlation by using only those events where one type of inattention was present. For example, the odds ratios that were calculated on *drowsiness* or one of the levels of *secondary task*, *driving-related inattention*, or *non-specific eyeglance* used only those events that contained a single type of inattention. Therefore, the correlations between these odds ratios are somewhat controlled. The odds ratios that were calculated on each secondary task type (i.e., *dialing hand-held device*) are not as controlled and correlations probably do exist among some of these. While this should not detract from the odds ratio calculation itself, these odds ratio calculations and subsequent population attributable risk percentage calculations should not be summed to assess an overall impact of secondary task engagement, for example.

While eyeglance duration was used in two chapters of this report, secondary task duration analysis was not presented. Project resources limited this reduction task primarily because of the difficulties involved in operationally defining “task duration.” While others have operationally defined secondary task duration (Stutts, et al., 2003), there were many issues in the data collection and reduction procedures that created obstacles for this type of reduction. For example, there were only cameras pointing at the driver which made a length of *conversation with passenger* difficult to assess. Also no continuous audio channel was present which also hindered a calculation of *duration of conversation with passenger, radio usage,* and *hands-free devices*. The use of 90-second segments of crash and near-crash events and 6-second baseline epochs also precluded the determination of length of hand-held device conversations, and sometimes eating, drinking, or more lengthy secondary-task types. While some of these issues could be alleviated with more time (i.e., reducing the entire trip file rather than a 90-second segment), the issues of no audio or view of the passenger seating in the vehicle will be difficult to overcome. Future research may attempt to overcome these issues with either a snapshot of the passenger compartment to determine number of passengers in the vehicle or brief but frequent bursts of an audio channel to help determine conversation length, whether the stereo is in use, etc.

APPLICATION OF RESULTS

As was repeatedly found throughout these analyses, drivers are inattentive and/or looking away from the forward roadway during a significant portion of the events and baseline epochs. While some of this inattention may be due to systematic scanning of the driving environment or engagement in secondary tasks or drowsiness, any eyeglance away from the forward roadway greater than 2 seconds greatly increases near-crash/crash risk. Developers of collision avoidance warning systems should incorporate these findings into newer generations of warning systems. If the system can incorporate driver eyeglance location prior to a crash, the false alarm rate of these warning systems could be greatly reduced thus increasing their effectiveness.

It is apparent from the results of the analyses in Chapter 3, *Objective 2,* that there are roadway and traffic environments that are better suited to engage in secondary tasks (Tables 8.3 and 8.5). Generally, it appears that engaging in secondary tasks during more visually cluttered, lower sight-distance, or demanding traffic environments (intersections, entrance/exit ramps, curved roadways), poor weather or roadway conditions (rainy weather, icy or wet road surfaces) are not the optimal locations and/or moments to engage in secondary tasks. This information could be used to better educate young drivers or those drivers who are attending traffic schools about the dangers of distracted driving and how to avoid crashes and near-crashes due to distraction. It was also found that near-crash/crash risk due to drowsiness increased when drivers were on straight/level roadways and less visually demanding environments (i.e., low traffic densities). Drivers should be aware that it may be harder to fight the effects of drowsiness and that near-crash/crash risk does increase despite the less-demanding driving environment.

The strong correlation obtained between involvement in inattention-related crashes and near-crashes and involvement in inattention-related baseline epochs has several implications on driving behavior. First, this strong correlation implies that those drivers who are getting caught, per se, by involvement in inattention-related crashes and near-crashes, are also those who frequently engage in secondary tasks or drive drowsy on a regular basis. This may also indicate that there are not very many drivers who do engage in secondary tasks and/or drive drowsy frequently while driving that are *never or rarely* involved in inattention-related crashes and near-crashes. This relationship will be further explored in Task 5 of this research contract.

REFERENCES

Campbell, B.N., Smith, J.D., and Najm, W.G. (2003). *Examination of Crash Contributing Factors Using National Crash Databases.* (Technical Report No. DOT HS 809 664). Washington DC: National Highway Traffic Safety Administration.

Cicchetti, D.V., and Feinstein, A.R. (1990) "High agreement but low kappa: The problems of two paradoxes." *Journal of Clinical Epidemiology*, 43, 543-549.

Costa, P. T., and McCrae, R. R. (1992). *Revised NEO Personality Inventory and NEO Five Factor Inventory: Professional Manual.* Psychological Assessment Resources. Lutz, Florida.

Dingus, T. A., Klauer, S. G., Neale, V. L., Petersen, A., Lee, S. E., Sudweeks, J., Perez, M. A., Hankey, J., Ramsey, D., Gupta, S., Bucher, C., Doerzaph, Z. R., Jermeland, J., and Knipling, R.R. (under review). *The 100-Car Naturalistic Driving Study: Phase II – Results of the 100-Car Field Experiment.* (Interim Project Report for DTNH22-00-C-07007, Task Order 6; Report No. TBD). Washington, DC: National Highway Traffic Safety Administration.

Dingus, T. A., Neale, V. L., Garness, S. A., Hanowski, R.J., Kiesler, A. S., Lee, S.E., Perez, M. A., Robinson, G.S., Belz, S.M., Casali, J.G., Pace-Schott, E.F., Stickgold, R.A., and Hobson, J.A. (2001). *Impact of sleeper berth usage on driver fatigue.* (Technical Contract Report No DTFH61-96-00068). Washington, DC: Federal Motor Carriers Safety Administration.

Dingus, T.A. (1995). Moving from measures of performance to measures of effectiveness in the safety evaluation of Intelligent Transpiration System products and demonstrations. *Proceedings of the ITS Safety Evaluation Workshop*. ITS America and the National Highway Traffic Safety Administration.

Dingus, T. A., Antin, J. F., Hulse, M.C., and Wierwille, W. W. (1989). Attentional demand requirements of an automobile moving map navigation system. *Transportation Research, A23 (4*), p. 301-315.

Dula, C. S., and Ballard, M. E. (2003). Development and evaluation of a measure of dangerous, aggressive, negative emotional, and risky driving. *Journal of Applied Social Psychology, 33, (2)*, pp. 263-282.

Greenberg, R.S., Daniels, S. R., Flanders, W. D., Eley, J. W., and Boring, J. R. (2001). *Medical Epidemiology, 3rd Edition.* McGraw-Hill, New York City, New York.

Hancock, P.A., Lesch, M., and Simmons, L. (2003). The distraction effects of phone use during a crucial driving maneuver. *Accident Analysis & Prevention, 35,* 501-514.

Hedlund, J., and Compton, R. (2005). Graduated driver licensing research in 2004 and 2005. *Journal of Safety Research, 36*, pp. 109-119.

Keppel, G., and Wickens, T.D. (2004). *Design & Analysis: A Researcher's Handbook.4th. Edition.* Prentice-Hall: Upper Saddle River, New Jersey.

Lee, S.E., Olsen, E.C.B., and Wierwille, W.W. (2003). *A comprehensive examination of naturalistic lane-changes.* (Technical Contract Report No DTNH22-00-C-07007). Washington, DC: National Highway Traffic Safety Administration.

Matthews, G., Desmond, P. A., Joyner, L., Carcary, B., and Gilliland, K. (1996). Validation of the driver stress inventory and driver coping questionnaire. Paper presented at the *International Conference on Traffic and Transport Psychology*, Valencia, Spain.

McCarley, J. S., Vais, M. J., Pringle, H., Kramer, A.F., Irwin, D. E., and Strayer, D.L. (2004). Conversation disrupts change detection in complex traffic scenes. *Human Factors, 46, (3),* pp.424 – 436.

Sahai, H. and Khurshid, A. (1996). *Statistics in Epidemiology: Methods, Techniques, and Applications.* CRC Press, Boca Raton, Florida.

Strayer, D. L. and Drews, F. A. (2004). Profiles in driver distraction: Effects of cell phone conversations in younger and older drivers. *Human Factors, 46, (4),* pp. 640-649.

Stutts, J., Feaganes, J., Rodgman, E., Hamlett, C., Meadows, T., Reinfurt, D., Gish, K., Mercadante, M., Staplin, L (2003). *Distractions in Everyday Driving.* Washington, DC: AAA Foundation for Traffic Safety.

Transportation Research Board (2000). *Highway Capacity Manual.* Washington, DC: United States Department of Transportation

Wang, J. S., Knipling, R. R., and Goodman, M.J. (1996). The role of driver inattention in crashes: New statistics from the 1995 crashworthiness data system. *In 40th Annual Proceedings of the Association for the Advancement of Automotive Medicine*, Vancouver, British Columbia.

Wierwille, W. (1993). Visual and manual demands of in-car controls and displays. In Eds. Peacock and Karkowski's *Automotive Ergonomics.* Taylor & Francis: London, England.

Wierwille, W. W., and Ellsworth, L. A. (1994). Evaluation of driver drowsiness by trained raters. Accident Analysis and Prevention, 26(4), 571-578.

APPENDIX A: SECONDARY TASKS

Table A-1. Secondary tasks recorded during data reduction.

	Passenger-Related Secondary Task	
	Passenger in adjacent seat	***Driver is talking to a passenger sitting in adjacent seat that can be identified by the person encroaching into the camera view or the driver is clearly looking and talking to the passenger.***
	Passenger in rear seat	***Driver is talking to a passenger sitting in rear seat that can be identified by the person encroaching into the camera view or the driver is clearly looking and talking to the passenger seated in the rear.***
	Child in adjacent seat	***Driver is talking to a child sitting in the adjacent seat who can be identified by the child encroaching into the camera view or the driver is clearly looking and talking to the child.***
	Child in rear seat	***Driver is talking to a child sitting in the rear seat who can be identified by the child or child related paraphernalia encroaching into the camera view or the driver is clearly looking and talking to the passenger seated in the rear.***
	Talking/Singing: No Passenger Apparent	
	Talking/singing/dancing	***Driver appears to be vocalizing either to an unknown passenger, to self, or singing to the radio. Also, in this category are instances where the driver exhibits dancing behavior.***
	Internal Distraction: Not vehicle or passenger related.	
	Reading	***Driver is reading papers, a magazine, a book, or a map***
	Moving object in vehicle	***Driver is distracted by stationary objects suddenly in motion due to hard braking, accelerating, or turning corner.***
	Object dropped by driver	***Driver dropped an object and is now looking for it or reaching for it.***
	Reaching for object in vehicle (not cell phone)	***Driver is attempting to locate an object while driving.***
	Insect in vehicle	***Driver is distracted by a flying insect that is in the cabin of the vehicle.***

	Pet in vehicle	***Driver is distracted by a pet that is in the cabin of the vehicle.***
	Wireless Device	
	Talking/listening	***Driver is clearly conversing on the cell phone.***
	Head-set on/conversation unknown	***Driver has a hands-free head-set on but the conversation is unknown***
	Dialing hand-held cell phone	***Driver is attempting to dial a hand-held cell phone while the vehicle is in gear.***
	Dialing hand-held cell phone using quick keys	***Driver is attempting to use quick keys to dial a hand-held cell phone while the vehicle is in gear.***
	Dialing hands-free cell phone using voice activated software	***Driver is attempting to dial a hands-free cell phone using voice activation while the vehicle is in gear.***
	Locating/reaching/answering cell phone	***Driver is attempting to locate the cell phone by reaching for it in order to use it or answer it while the vehicle is in gear.***
	Cell phone: other	***Any other activity associated with a cell phone i.e., looking at a cell phone for time, or screening calls but not dialing, or talking while the vehicle is in gear.***
	Locating/reaching for PDA	***Driver is attempting to locate a PDA by reaching for it in order to use it or to answer it while the vehicle is in gear.***
	Operating PDA	***Driver is using (looking at, using stylus, or pressing buttons) while the vehicle is in gear.***
	Viewing PDA	***Driver is only looking at a PDA, no stylus or button presses, while the vehicle is in gear.***
	Vehicle-Related Secondary Task	
	Adjusting climate control	***Driver is looking at and/or reaching to adjust the HVAC system while the vehicle is in gear.***
	Adjusting the radio	***Driver is looking at and/or reaching to adjust the radio/stereo system while the vehicle is in gear.***
	Inserting/retrieving cassette	***Driver is inserting or retrieving a cassette while the vehicle is in gear.***
	Inserting/retrieving CD	***Driver is inserting or retrieving a compact disc while the***

		vehicle is in gear.
	Adjusting other devices integral to vehicle	***Driver is looking at and/or reaching to adjust another in-dash system while the vehicle is in gear.***
	Adjusting other known in-vehicle devices	***Driver is looking at and/or reaching to adjust another in-vehicle system (i.e., XM Radio) while the vehicle is in gear.***
	Dining	
	Eating with a utensil	***Driver is eating food with a utensil while the vehicle is in gear.***
	Eating without a utensil	***Driver is eating food without utensil while the vehicle is in gear.***
	Drinking with a covered/ straw	***Driver is drinking out of a covered container (travel mug) or covered container with a straw while the vehicle is in gear.***
	Drinking out of open cup/ container	***Driver is drinking out of an open cup or container that can be easily spilled while the vehicle is in gear.***
	Smoking	
	Reaching for cigar/cigarette	***Driver is reaching for cigar/cigarette/pipe while the vehicle is in gear.***
	Lighting cigar/cigarette	***Driver is lighting the cigar/cigarette/pipe while the vehicle is in gear.***
	Smoking cigar/cigarette	***Driver is smoking the cigar/cigarette/pipe while the vehicle is in gear.***
	Extinguishing cigar/cigarette	***Driver is putting the cigar/cigarette out in an ashtray while the vehicle is in gear.***
	Daydreaming	
	Lost in thought	***Driver is haphazardly looking around but not at any single distraction.***
	Looked but did not see	***Driver is looking in the direction of a conflict but does not react in a timely manner. Driver may also exhibit a surprised look at the moment of realization.***
	External Distraction	

	Looking at previous crash or highway incident	***Driver is looking out of the vehicle at a collision or a highway incident that has happened recently.***
	Pedestrian located outside the vehicle	***Driver is looking out of the vehicle at a pedestrian who may or may not pose a safety hazard (generally not in the forward roadway).***
	Animal located outside the vehicle	***Driver is looking out of the vehicle at an animal that may or may not pose a safety hazard (generally not in the forward roadway).***
	Object located outside the vehicle	***Driver is looking out of the vehicle at an object of interest that may or may not pose a safety hazard. Objects may or may not be in the forward roadway.***
	Construction zone	***Driver is looking out of the vehicle at construction equipment that may or may not pose a safety hazard.***
	Personal Hygiene	
	Combing/brushing/fixing hair	***Driver is grooming or styling hair while the vehicle is in gear. Driver may or may not be looking in a mirror.***
	Applying make-up	***Driver is applying makeup while the vehicle is in gear. Driver may or may not be looking in a mirror.***
	Shaving	***Driver is shaving facial hair while the vehicle is in gear. Driver may or may not be looking in a mirror.***
	Brushing/flossing teeth	***Driver is brushing or flossing teeth while the vehicle is in gear. Driver may or may not be looking in a mirror.***
	Biting nails/cuticles	***Driver is biting nails and/or cuticles. Driver may or may not be looking at nails and/or cuticles.***
	Removing/adjusting jewelry	***Driver is removing/adjusting/putting on jewelry while the vehicle is in gear.***
	Removing/inserting contact lenses	***Driver is attempting to remove or insert contact lenses while the vehicle is in gear.***
	Other	***Driver is cleaning/adjusting/altering something on their person while the vehicle is in gear.***
	Driving-related Inattention to Forward Roadway	
	Checking center rear-view mirror	***Driver is observing traffic in rear-view mirror while moving forward or stopped, but the vehicle is in gear (i.e.,***

		stopped at an intersection).
	Looking out left side of windshield (not in direction in motion)	*Driver is looking out the left side of the windshield while the vehicle is either moving forward or stopped, but is in gear. This is not marked if the driver is making a left turn.*
	Looking out right side of windshield (not in direction in motion)	*Driver is looking out the right side of the windshield while the vehicle is either moving forward or stopped, but is in gear. This is not marked if the driver is making a right turn.*
	Checking left rear-view mirror	*Driver is observing traffic in left rear-view mirror while moving forward or stopped, but the vehicle is in gear (i.e., stopped at an intersection).*
	Looking out left window	*Driver is observing traffic in left window while moving forward or stopped, but the vehicle is in gear (i.e., stopped at an intersection).*
	Checking right rear-view mirror	*Driver is observing traffic in right rear-view mirror while moving forward or stopped, but the vehicle is in gear (i.e., stopped at an intersection).*
	Looking out right window	*Driver is observing traffic in right window while moving forward or stopped, but the vehicle is in gear (i.e., stopped at an intersection).*
	Looking at instrument panel	*Driver is checking vehicle speed/temperature/RPMs while vehicle is moving or stopped, but is in gear.*

APPENDIX B: COPY OF QUESTIONNAIRES

DEMOGRAPHIC QUESTIONNAIRE

Subject ID # ___________

Please answer each of the following items.

1. What is your age in years: _________

2. Gender: _____ Male _____ Female

3. What is your highest level of education?
    a. Didn't complete high school
    b. High school graduate
    c. Some college
    d. 2-year college degree/trade school
    e. 4-year college degree
    f. Masters degree
    g. Professional degree
    h. Doctorate degree

4. What is your occupation: ____________________

5. What group do you identify yourself with
    a. Latino/Latina
    b. African-American
    c. Caucasian
    d. Middle Eastern
    e. Pacific Islander
    f. Asian
    g. Other ________________

6. How many years have you been driving? ______________

7. What type of driving do you usually do? (please indicate all that apply)
    a. Around town driving
    b. Commuting on freeways
    c. Commuting on other main roads
    d. Short distance travel (50-200-mile round trip)
    e. Middle distance travel (201-500-mile round trip)
    f. Long distance travel (>500-mile round trip)

DRIVING HISTORY – SUBJECT INTERVIEW

In the past year, how many moving or traffic violations have you had? ___________

What type of violation was it?

(1). ____________________
(2). ____________________
(3). ____________________
(4). ____________________
(5). ____________________

In the past year how many accidents have you been in? ________________

For each accident indicate the severity of the crash (select highest)

a. Injury
b. Tow-away (any vehicle)
c. Police-reported
d. Damage (any), but no police report

Using the diagram indicate each of the following: Category, Configuration, Accident type

	Accident 1	Accident 2	Accident 3	Accident 4	Accident 5
Accident Severity					
Accident Category					
Accident Configuration					
Accident Type					

Comments: ____
____
____
____

HEALTH ASSESSMENT

To the Participant: Please note that your responses to the following questions will in no way affect your ability to participate in the study. Your honest answers are appreciated

1. Do you have a history of any of the following?

a.	Stroke	Y	N
b.	Brain tumor	Y	N
c.	Head injury	Y	N
d.	Epileptic seizures	Y	N
e.	Respiratory disorders	Y	N
f.	Motion sickness	Y	N
g.	Inner ear problems	Y	N
h.	Dizziness, vertigo, or other balance problems	Y	N
i.	Diabetes	Y	N
j.	Migraine, tension headaches	Y	N
k.	Depression	Y	N
l.	Anxiety	Y	N
m.	Other psychiatric disorders	Y	N
n.	Arthritis	Y	N
o.	Auto-immune disorders	Y	N
p.	High blood pressure	Y	N
q.	Heart arrhythmias	Y	N
r.	Chronic fatigue syndrome	Y	N
s.	Chronic stress	Y	N

If yes to any of the above, please explain?

____
____
____
____

2. Are you currently taking any medications on a regular basis? Y N
   If yes, please list them.

____
____
____

3. (Females only) Are you currently pregnant? Y N

4. Height __________

5. Weight __________lbs.

DULA DANGEROUS DRIVING INDEX

Please answer each of the following items as honestly as possible. Please read each item carefully and then circle the answer you choose on the form. If none of the choices seem to be your ideal answer, then select the answer that comes closest. THERE ARE NO RIGHT OR WRONG ANSWERS. Select your answers quickly and do not spend too much time analyzing your answers. If you change an answer, erase the first one well.

1. I drive when I am angry or upset.

   A. Never B. Rarely C. Sometimes D. Often E. Always

2. I lose my temper when driving.

   A. Never B. Rarely C. Sometimes D. Often E. Always

3. I consider the actions of other drivers to be inappropriate or "stupid."

   A. Never B. Rarely C. Sometimes D. Often E. Always

4. I flash my headlights when I am annoyed by another driver.

   A. Never B. Rarely C. Sometimes D. Often E. Always

5. I make rude gestures (e.g., giving "the finger," yelling curse words) toward drivers who annoy me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

6. I verbally insult drivers who annoy me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

7. I deliberately use my car/truck to block drivers who tailgate me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

8. I would tailgate a driver who annoys me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

9. I "drag race" other drivers at stop lights to get out front.

   A. Never B. Rarely C. Sometimes D. Often E. Always

10. I will illegally pass a car/truck that is going too slowly.

   A. Never B. Rarely C. Sometimes D. Often E. Always

11. I feel it is my right to strike back in some way, if I feel another driver has been aggressive toward me.

   A. Never B. Rarely C. Sometimes D. Often E. Always

12. When I get stuck in a traffic jam I get very irritated.

   A. Never B. Rarely C. Sometimes D. Often E. Always

13. I will race a slow moving train to a railroad crossing.

   A. Never B. Rarely C. Sometimes D. Often E. Always

14. I will weave in and out of slower traffic.

A. Never B. Rarely C. Sometimes D. Often E. Always

15. I will drive if I am only mildly intoxicated or buzzed.

A. Never B. Rarely C. Sometimes D. Often E. Always

16. When someone cuts me off, I feel I should punish him/her.

A. Never B. Rarely C. Sometimes D. Often E. Always

17. I get impatient and/or upset when I fall behind schedule when I am driving.

A. Never B. Rarely C. Sometimes D. Often E. Always

18. Passengers in my car/truck tell me to calm down.

A. Never B. Rarely C. Sometimes D. Often E. Always

19. I get irritated when a car/truck in front of me slows down for no reason.

A. Never B. Rarely C. Sometimes D. Often E. Always

20. I will cross double yellow lines to see if I can pass a slow moving car/truck.

A. Never B. Rarely C. Sometimes D. Often E. Always

21. I feel it is my right to get where I need to go as quickly as possible.

A. Never B. Rarely C. Sometimes D. Often E. Always

22. I feel that passive drivers should learn how to drive or stay home.

A. Never B. Rarely C. Sometimes D. Often E. Always

23. I will drive in the shoulder lane or median to get around a traffic jam.

A. Never B. Rarely C. Sometimes D. Often E. Always

24. When passing a car/truck on a 2-lane road, I will barely miss on-coming cars.

A. Never B. Rarely C. Sometimes D. Often E. Always

25. I will drive when I am drunk.

A. Never B. Rarely C. Sometimes D. Often E. Always

26. I feel that I may lose my temper if I have to confront another driver.

A. Never B. Rarely C. Sometimes D. Often E. Always

27. I consider myself to be a risk-taker.

A. Never B. Rarely C. Sometimes D. Often E. Always

28. I feel that most traffic “laws” could be considered as suggestions.

A. Never B. Rarely C. Sometimes D. Often E. Always

SLEEP HYGIENE QUESTIONNAIRE

Using the following rating scale, to what extent do you currently experience the following?

	None				Moderate					Severe
Daytime sleepiness	1	2	3	4	5	6	7	8	9	10
Snoring	1	2	3	4	5	6	7	8	9	10
Difficulty Falling Asleep	1	2	3	4	5	6	7	8	9	10
Difficulty Staying Asleep	1	2	3	4	5	6	7	8	9	10
Difficulty Waking Up	1	2	3	4	5	6	7	8	9	10
Daytime Sleepiness	1	2	3	4	5	6	7	8	9	10
Obtain Too Little Sleep	1	2	3	4	5	6	7	8	9	10

Read through the following questions carefully and answer each as accurately as possible:

1. When you are working:
what time do you go to bed ____:____ a.m./p.m. and wake up ____:____ a.m./p.m.

2. When you are not working:
what time do you go to bed ____:____ a.m./p.m. and wake up ____:____ a.m./p.m.

3. Do you keep a fairly regular sleep schedule? Yes_____ No_____

4. How many hours of actual sleep do you usually get? ________

5. Do you consider yourself a light, normal, or heavy sleeper? ________________

6. Do you feel uncomfortably sleepy during the day? never_____ every day_____
more than once per week_____ once per week _____ a few times a month _____
once a month or less_____

7. Do you ever have an irresistible urge to sleep or find that you fall asleep in unusual/
inappropriate situations? never_____ every day_____ more than once per week_____
once per week _____ a few times a month _____ once a month or less_____

8. Do you usually nap during the day (or between major sleep periods)?
Yes_____ No_____

9. Do you drink caffeinated beverages (coffee, tea, Coca-Cola, Mountain Dew, Jolt Cola)?
Yes_____ No_____

10. If yes, how many cups/glasses per day? __________________

11. How often do you drink alcohol? never_____ every day_____
more than once per week_____ once per week _____ once a month or less_____

12. Do you smoke cigarettes, cigars, pipe or chew or snuff tobacco? Yes_____ No_____

13. If yes, how often? __________________________

PRIMARY SLEEP DISORDERS

14. Have you ever been diagnosed with or suffer from any of the following sleep disorders?

Narcolepsy	Yes	No
Sleep Apnea	Yes	No
Periodic Limb Movement	Yes	No
Restless Leg Syndrome	Yes	No
Insomnia	Yes	No

DRIVER STRESS INVENTORY

Please answer the following questions on the basis of your usual or typical feelings about driving. Each question asks you to answer according to how strongly you agree with one of two alternative answers. Please read each of the two alternatives carefully before answering. To answer, circle the number which expresses your answer most accurately.

Example: Are you a confident driver?

1 2 3 4 5 6 7 8 9 10

Not at all Very Much

1. Does it worry you to drive in bad weather?

   1 2 3 4 5 6 7 8 9 10

   Very Much Not at all

2. I am disturbed by thoughts of having an accident or the car breaking down.

   1 2 3 4 5 6 7 8 9 10

   Very Rarely Very Often

3. Do you lose your temper when another driver does something silly?

   1 2 3 4 5 6 7 8 9 10

   Not at all Very much

4. Do you think you have enough experience and training to deal with risky situations on the road safely?

   1 2 3 4 5 6 7 8 9 10

   Not at all Very much

5. I find myself worrying about my mistakes and the things I do badly when driving.

   1 2 3 4 5 6 7 8 9 10

   Very rarely Very often

6. I would like to risk my life as a racing driver.

1 2 3 4 5 6 7 8 9 10

Not at all Very much

7. My driving would be worse than usual in an unfamiliar rental car.

1 2 3 4 5 6 7 8 9 10

Not at all Very much

8. I sometimes like to frighten myself a little while driving.

1 2 3 4 5 6 7 8 9 10

Very much Not at all

9. I get a real thrill out of driving fast.

1 2 3 4 5 6 7 8 9 10

Very much Not at all

10. I make a point of carefully checking every side road I pass for emerging vehicles.

1 2 3 4 5 6 7 8 9 10

Very Much Not at all

11. Driving brings out the worst in people.

1 2 3 4 5 6 7 8 9 10

Not at all Very much

12. Do you think it is worthwhile taking risks on the road?

1 2 3 4 5 6 7 8 9 10

Very much Not at all

13. At times, I feel like I really dislike other drivers who cause problems for me.

1 2 3 4 5 6 7 8 9 10

Very much Not at all

14. Advice on driving from a passenger is generally:

1	2	3	4	5	6	7	8	9	10

Useful Unnecessary

15. I like to raise my adrenaline levels while driving.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

16. It's important to show other drivers that they can't take advantage of you.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

17. Do you feel confident in your ability to avoid an accident?

1	2	3	4	5	6	7	8	9	10

Not at all Very much

18. Do you usually make an effort to look for potential hazards when driving?

1	2	3	4	5	6	7	8	9	10

Not at all Very much

19. Other drivers are generally to blame for any difficulties I have on the road.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

20. I would enjoy driving a sports car on a road with no speed-limit.

1	2	3	4	5	6	7	8	9	10

Very much Not at all

21. Do you find it difficult to control your temper when driving?

1	2	3	4	5	6	7	8	9	10

Very much Not at all

22. When driving on an unfamiliar road do you become more tense than usual?

1	2	3	4	5	6	7	8	9	10

Very much Not at all

23. I make a special effort to be alert even on roads I know well.

1	2	3	4	5	6	7	8	9	10

Very much Not at all

24. I enjoy the sensation of accelerating rapidly.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

25. If I make a minor mistake when driving, I feel it's something I should be concerned about

1	2	3	4	5	6	7	8	9	10

Very much Not at all

26. I always keep an eye on parked cars in case somebody gets out of them, or there are pedestrians behind them.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

27. I feel more anxious than usual when I have a passenger in the car.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

28. I become annoyed if another car follows very close behind mine for some distance

1	2	3	4	5	6	7	8	9	10

Very much Not at all

29. I make an effort to see what's happening on the road a long way ahead of me.

1 2 3 4 5 6 7 8 9 10

Not at all Very much

30. I try very hard to look out for hazards even when it's not strictly necessary.

1 2 3 4 5 6 7 8 9 10

Not at all Very much

31. Are you usually patient during the rush hour?

1 2 3 4 5 6 7 8 9 10

Very much Not at all

32. When you pass another vehicle do you feel in command of the situation?

1 2 3 4 5 6 7 8 9 10

Not at all Very much

33. When you pass another vehicle do you feel tense or nervous?

1 2 3 4 5 6 7 8 9 10

Not at all Very much

34. Does it annoy you to drive behind a slow moving vehicle?

1 2 3 4 5 6 7 8 9 10

Very much Not at all

35. When you're in a hurry, other drivers usually get in your way.

1 2 3 4 5 6 7 8 9 10

Not at all Very much

36. When I come to negotiate a difficult stretch of road, I am on the alert.

1 2 3 4 5 6 7 8 9 10

Very much Not at all

37. Do you feel more anxious than usual when driving in heavy traffic?

1	2	3	4	5	6	7	8	9	10

Not at all Very much

38. I enjoy cornering at high speeds.

1	2	3	4	5	6	7	8	9	10

Not at all Very much

39. Are you annoyed when the traffic lights change to red when you approach them?

1	2	3	4	5	6	7	8	9	10

Very much Not at all

40. Does driving, <u>usually</u> make you feel aggressive?

1	2	3	4	5	6	7	8	9	10

Very much Not at all

41. Think about how you feel when you have to drive for several hours, with few or no breaks from driving. How do your feelings <u>change</u> during the course of the drive?

a) More uncomfortable physically (e.g., headache or muscle pains)	1	2	3	4	5	6	7	8	9	10	No change
b) More drowsy or sleepy	1	2	3	4	5	6	7	8	9	10	No change
c) Maintain speed of reaction	1	2	3	4	5	6	7	8	9	10	Reactions to other traffic becomes increasingly slower
d) Maintain attention to road-signs	1	2	3	4	5	6	7	8	9	10	Become inattentive to road-signs

e)	Normal vision	1	2	3	4	5	6	7	8	9	10	Vision becomes less clear
f)	Increasingly difficult to judge your speed	1	2	3	4	5	6	7	8	9	10	Normal judgment of speed
g)	Interest in driving does not change	1	2	3	4	5	6	7	8	9	10	Increasingly bored and fed up
h)	Passing becomes increasingly risky and dangerous	1	2	3	4	5	6	7	8	9	10	No change

LIFE STRESS INVENTORY

Please read through the following events carefully. Mark each event which occurred within the past year.

_____ Death of spouse or parent

_____ Divorce

_____ Marital separation or separation from living partner

_____ Jail term

_____ Death of close family member

_____ Personal injury or illness

_____ Fired from job

_____ Marital or relationship reconciliation

_____ Retirement

_____ Change in health of family member

_____ Pregnancy

_____ Sex difficulties

_____ Gain of new family member

_____ Business readjustment

_____ Change in financial state

_____ Death of close friend

_____ Change to different line of work or study

_____ Change in number of arguments with spouse or partner

_____ Mortgage or loan for major purchase (home, etc.)

_____ Foreclosure of mortgage or loan

_____ Change in responsibilities at work

_____ Son or daughter leaves

_____ Trouble with in-laws/partner's family

_____ Outstanding personal achievement

_____ Mate begins or stops work

_____ Change in living conditions

_____ Marriage/establishing life partner

_____ Change in personal habit

_____ Trouble with boss

_____ Change in work hours or conditions

_____ Change in residence

_____ Change in schools

_____ Change in church activities

_____ Change in recreation

_____ Change in social activities

_____ Minor loan (car, TV, etc)

_____ Change in sleeping habits

_____ Change in number of family get-togethers

_____ Change in eating habits

_____ Vacation

_____ Christmas (if approaching)

____ Minor violation of the law

APPENDIX C: DATA REDUCTION VARIABLES

1. Vehicle Number

Comment: Each vehicle will be assigned a vehicle number. Information will originate in the raw data stream.

FORMAT: Integer value.

2. Epoch Number

The Epoch file number is arranged by vehicle identification number, date and time. The first three numbers represent the vehicle identification number, the next two numbers represent the year (Ex. 03 for 2003), the next two numbers represents the month (Ex. 03 for March), the next two numbers represent the day of the month, the next four numbers represent the time in military time. The last six numbers are the epoch ID.

002 03 02 28 1209 000000

Comment: Each valid driving performance trigger will be assigned to an epoch. An epoch will consist of 1 minute of video prior and 30 seconds of video after the initial onset of a trigger. If a second trigger occurs within this 1.5-minute segment, the epoch will extend to include a full one minute prior to the onset of the initial trigger and 30 seconds after the onset of the last trigger.

3. Event Severity – A general term referring to all valid triggered occurrences of an incident, near-crash, or crash that begins at the precipitating event and ends when the evasive maneuver has been completed.

Invalid trigger – Any instance where a trigger appears but no safety-relevant event is present.

Non-subject conflict - Any safety-relevant event captured on video (incident, near-crash, or crash) that does not involve the driver.

Non-conflict - Any event that increases the level of risk associated with driving, but does not result in a crash, near-crash, or incident, as defined below. Examples include: driver control error without proximal hazards being present; driver judgment error such as unsafe tailgating or excessive speed; or cases in which drivers are visually distracted to an unsafe level.

Proximity Event - Any circumstance resulting in extraordinarily close proximity of the subject vehicle to any other vehicle, pedestrian, cyclist, animal, or fixed object where, due to apparent unawareness on the part of the driver(s), pedestrians, cyclists or animals, there is no avoidance maneuver or response. Extraordinarily close proximity is defined as a clear case where the absence of an avoidance maneuver or response is inappropriate for the driving circumstances (including speed, sight distance, etc.).

Crash-Relevant - Any circumstance that requires a crash avoidance response on the part of the subject vehicle. Any other vehicle, pedestrian, cyclist, or animal that is less severe than a rapid evasive maneuver (as defined above), but greater in severity than a "normal maneuver" to avoid a crash. A crash avoidance response can include braking, steering, accelerating, or any combination of control inputs. A "normal maneuver" for the subject vehicle is defined as a control input that falls inside of the 99 percent confidence limit for control input as measured for the same subject.

Near-crash - Any circumstance that requires a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal to avoid a crash. A rapid, evasive maneuver is defined as a steering, braking, accelerating, or any combination of control inputs that approaches the limits of the vehicle capabilities. As a guide: subject vehicle braking greater than 0.5 g, or steering input that results in a lateral acceleration greater than 0.4 g to avoid a crash, constitutes a rapid maneuver.

Crash - Any contact with an object, either moving or fixed, at any speed, in which kinetic energy is measurably transferred or dissipated. Includes other vehicles, roadside barriers, objects on or off the roadway, pedestrians, cyclists or animals.

Comment: Initial coding step. Invalid events result in no further coding. Non-subject and non-conflicts will only result in a brief narrative written, but no other coding. Other coding choices will determine which specific subset of variables that will be coded. Specified at early onset of data reduction software.

4. Trigger Type (C-N-I)
The triggers were specific data signatures that were specified during the sensitivity analysis performed after 10 percent of the data were collected. The specific data signatures that were used to identify valid events are as follows:

Lateral acceleration - Lateral motion equal or greater than 0.7 g.
Longitudinal acceleration - Acceleration or deceleration equal or greater than 0.6 g.
CI button – Activated by the driver upon pressing a button located on the dashboard when an incident occurred that he/she deemed critical.

Forward Time To Collision (FTTC) - Acceleration or deceleration equal to or greater than 0.5 g coupled with a forward TTC of 4 seconds or less.
All longitudinal decelerations between 0.4 g and 0.5 g coupled with a forward TTC value of ≤ 4 seconds and that the corresponding forward range value at the minimum TTC is not greater than 100 feet.
Rear Time To Collision (RTTC) - Any rear TTC trigger value of 2 seconds or less that also has a corresponding rear range distance of ≤ 50 feet AND any rear TTC trigger value where the absolute acceleration of the following vehicle is greater than 0.3 g.
Side object detection – Detects presence of other vehicles/objects in the adjacent lane.
Lane change cut-off – Identifies situations in which the subject vehicle cuts in too close either behind or in front of another vehicle by using closing speed and forward TTC.

Yaw rate – Any value greater than or equal to a plus AND minus 4-degree change in heading (i.e., vehicle must return to the same general direction of travel) within a 3-second window of time.

5. Driver Subject Number (C-N-I-B)
All primary drivers' subject number will be a 3-digit number followed by the letter "A." Any secondary drivers should be given the same 3-digit number followed by the letters "B," "C," and so on.

6. Onset of Precipitating Factor
Using video frame numbers, the reductionists will determine the onset of the precipitating event (i.e., onset of lead-vehicle brake lights for a lead vehicle conflict).

7. Resolution of the Event
Using video frame numbers, the reductionists will determine when the evasive maneuver (or lack thereof) has been executed and the level of danger has returned to normal.

EVENT VARIABLES

1. Event Nature (C-N-I)
This variable specified the type of crash, near-crash, or incident that occurred. The reductionists chose from the following variables that were modified from GES variables "Manner of Collision" and "Most Harmful Event."

1=Conflict with a lead vehicle
2=Conflict with a following vehicle
3=Conflict with an oncoming traffic
4=Conflict with a vehicle in adjacent lane
5=Conflict with a merging vehicle
6=Conflict with a vehicle turning across subject vehicle path (same direction)
7=Conflict with a vehicle turning across subject vehicle path (opposite direction)
8=Conflict with a vehicle turning into subject vehicle path (same direction)
9=Conflict with a vehicle turning into subject vehicle path (opposite direction)
10 =Conflict with a vehicle moving across subject vehicle path (through intersection)
11=Conflict with a parked vehicle
12=Conflict with a pedestrian
13=Conflict with a pedal cyclist
14=Conflict with an animal
15=Conflict with an obstacle/object in roadway
16=Single vehicle conflict
17=Other
18=No known conflict (for RF sensor trigger)
99=Unknown conflict

2. Incident Type (Coded for Crashes and Near-Crashes only)

1 = Rear-end, striking
2 = Rear-end, struck
3 = Road departure (left or right)
4 = Road departure (end)
5 = Sideswipe, same direction (left or right)
6 = Opposite direction (head-on or sideswipe)
7 = Violation of stop sign or signal at intersection
8 = Straight crossing path, not involving sign/signal violation
9 = Turn across path
10 = Turn into path (same direction)
11 = Turn into path (opposite direction)
12 = Backing, fixed object
13 = Backing into traffic
14 = Pedestrian
15 = Pedalcyclist
16 = Animal
17 = Other (specify)
99 = Unknown

3. Pre-Event Maneuver (GES Variable Vehicle 1 Maneuver Prior to Event)
This represents the last action that the subject vehicle driver engaged in just prior to the point that the driver realized impending danger. Note that the variables in italics are those GES variables that were expanded.

1a = Going straight, constant speed
1b = Going straight ahead, accelerating
1c = Going straight, but with unintentional "drifting" within lane or across lanes
2 = Decelerating in traffic lane
3 = Accelerating in traffic lane
4 = Starting in traffic lane
5 = Stopped in traffic lane
6 = Passing or overtaking another vehicle
7 = Disabled or parked in travel lane
8 = Leaving a parked position
9 = Entering a parked position
10 = Turning right
11 = Turning left
12 = Making U-turn
13 = Backing up (other than for parking purposes)
14 = Negotiating a curve
15 = Changing lanes
16 = Merging
17 = Successful corrective action to previous action

18a = Maneuvering to avoid an animal
18b = Maneuvering to avoid a pedestrian/pedalcyclist
18c = Maneuvering to avoid an object
18d = Maneuvering to avoid a vehicle
97 = Other
99 = Unknown

Source/comment: GES Variable V21, Movement Prior to Critical Event. Also, very similar to VA PAR%Variable 19/20.
FORMAT: Integer value as listed above.

4. Judgment of Vehicle 1 Maneuver Prior to Event
This variable provided additional information about the pre-event maneuver as to whether this maneuver was either safe or legal.

1 = Safe and legal
2 = Unsafe but legal
3 = Safe but illegal
4 = Unsafe and illegal
99 = Unknown

5. Precipitating Factor (GES Variable V26, Critical Event)
The driver behavior or state of the environment that begins the event and the subsequent sequence of actions that result in a crash, near-crash, or incident, independent of who caused the event (driver at fault). The precipitating factor occurs outside the vehicle and does not include driver distraction, drowsiness, or disciplining child while driving.

A. This Vehicle Loss of Control Due to:

001 = Blow-out or flat tire
002 = Stalled engine
003 = Disabling vehicle failure (e.g., wheel fell off)
004 = Minor vehicle failure
005 = Poor road conditions (puddle, pothole, ice, etc.)
006 = Excessive speed
007 = Other or unknown reason
008 = Other cause of control loss
009 = Unknown cause of control loss

B. This Vehicle Traveling:

018a = Ahead, stopped on roadway more than 2 seconds
018b = Ahead, decelerated and stopped on roadway 2 seconds or less
021 = Ahead, traveling in same direction and decelerating
022 = Ahead, traveling in same direction with slower constant speed

010 = Over the lane line on the left side of travel lane
011 = Over the lane line on right side of travel lane
012 = Over left edge of roadway
013 = Over right edge of roadway
014 = End departure
015 = Turning left at intersection
016 = Turning right at intersection
017 = Crossing over (passing through) intersection
019 = Unknown travel direction
020a = From adjacent lane (same direction), over left lane line behind lead vehicle, rear-end crash threat
020b = From adjacent lane (same direction), over right lane line behind lead vehicle, rear-end crash threat

C. Other Vehicle in Lane:

050a = Ahead, stopped on roadway more than 2 seconds
050b = Ahead, decelerated and stopped on roadway 2 seconds or less
051 = Ahead, traveling in same direction with slower constant speed
052 = Ahead, traveling in same direction and decelerating
053 = Ahead, traveling in same direction and accelerating
054 = Traveling in opposite direction
055 = In crossover
056 = Backing
059 = Unknown travel direction of the other motor vehicle

Another Vehicle Encroaching into This Vehicle's Lane:

060a = From adjacent lane (same direction), over left lane line in front of this vehicle, rear-end crash threat
060b = From adjacent lane (same direction), over left lane line behind this vehicle, rear-end crash threat
060c = From adjacent lane (same direction), over left lane line, sideswipe threat
060d = From adjacent lane (same direction), over right lane line, sideswipe threat
060e = From adjacent lane (same direction), other
061a = From adjacent lane (same direction), over right lane line in front of this vehicle, rear-end crash threat
061b = From adjacent lane (same direction), over right lane line behind this vehicle, rear-end crash threat
061c = From adjacent lane (same direction), other
062 = From opposite direction over left lane line.
063 = From opposite direction over right lane line
064 = From parallel/diagonal parking lane
065 = Entering intersection—turning in same direction
066 = Entering intersection—straight across path
067 = Entering intersection – turning into opposite direction

068 = Entering intersection—intended path unknown
070 = From driveway, alley access, etc. – turning into same direction
071 = From driveway, alley access, etc. – straight across path
072 = From driveway, alley access, etc. – turning into opposite direction
073 = From driveway, alley access, etc. – intended path unknown
074 = From entrance to limited access highway
078 = Encroaching details unknown

E. Pedestrian, Pedalcyclist, or other Non-Motorist:

080 = Pedestrian in roadway
081 = Pedestrian approaching roadway
082 = Pedestrian in unknown location
083 = Pedalcyclist/other nonmotorist in roadway
084 = Pedalcyclist/other nonmotorist approaching roadway
085 = Pedalcyclist/or other nonmotorist unknown location
086 = Pedestrian/pedalcyclist/other nonmotorist—unknown location

F. Object or Animal:

087 = Animal in roadway
088 = Animal approaching roadway
089 = Animal unknown location
090 = Object in roadway
091 = Object approaching roadway
092 = Object unknown location
099 = Unknown critical event

6. Evasive Maneuver (GES Variable V27 Corrective Action Attempted)
   The subject vehicle driver's reaction to the precipitating factor.

0 = No driver present
1 = No avoidance maneuver
2 = Braking (no lockup)
3 = Braking (lockup)
4 = Braking (lockup unknown)
5 = Releasing brakes
6 = Steered to left
7 = Steered to right
8 = Braked and steered to left
9 = Braked and steered to right
10 = Accelerated
11 = Accelerated and steered to left
12 = Accelerated and steered to right
98 = Other actions
99 = Unknown if driver attempted any corrective action

7. Vehicle Control After Corrective Action (GES Variable V28—Coded only for near-crashes and crashes):

0 = No driver present
1 = Vehicle control maintained after corrective action
2 = Vehicle rotated (yawed) clockwise
3 = Vehicle rotated (yawed) counter-clockwise
4 = Vehicle slid/skid longitudinally – no rotation
5 = Vehicle slid/skid laterally – no rotation
9 = Vehicle rotated (yawed) unknown direction
20 = Combination of 2-9
94 = More than two vehicles involved
98 = Other or unknown type of vehicle control was lost after corrective action
99 = Unknown if vehicle control was lost after corrective action.

Contributing Factors

1. Driver Behavior: Driver 1 Actions/Factors Relating to the Event (VA PAR%Variable 17/18) This variable provides a descriptive label to the driver's actions that may or may not have contributed to the event.

0 = None
1 = Exceeded speed limit
2 = Inattentive or distracted
3 = Exceeded safe speed but not speed limit
4 = Driving slowly: below speed limit
5 = Driving slowly in relation to other traffic: not below speed limit
6 = Illegal passing (i.e., across double line)
7 = Passing on right
8 = Other improper or unsafe passing
9 = Cutting in, too close in front of other vehicle
10 = Cutting in, too close behind other vehicle
11 = Making turn from wrong lane (e.g., across lanes)
12 = Did not see other vehicle during lane change or merge
13 = Driving in other vehicle's blind zone
14 = Aggressive driving, specific, directed menacing actions
15 = Aggressive driving, other, i.e., reckless driving without directed menacing actions
16 = Wrong side of road, not overtaking
17 = Following too close
18 = Failed to signal, or improper signal
19 = Improper turn - wide right turn
20 = Improper turn - cut corner on left turn
21 = Other improper turning
22 = Improper backing, did not see

23 = Improper backing, other
24 = Improper start from parked position
25 = Disregarded officer or watchman
26 = Signal violation, apparently did not see signal
27 = Signal violation, intentionally ran red light
28 = Signal violation, tried to beat signal change
29 = Stop sign violation, apparently did not see stop sign
30 = Stop sign violation, intentionally ran stop sign at speed
31 = Stop sign violation, "rolling stop"
32 = Other sign (e.g., Yield) violation, apparently did not see sign
33 = Other sign (e.g., Yield) violation, intentionally disregarded
34 = Other sign violation
35 = Non-signed crossing violation (e.g., driveway entering roadway)
36 = Right-of-way error in relation to other vehicle or person, apparent recognition failure (e.g., did not see other vehicle)
37 = Right-of-way error in relation to other vehicle or person, apparent decision failure (i.e., did see other vehicle prior to action but misjudged gap)
38 = Right-of-way error in relation to other vehicle or person, other or unknown cause
39 = Sudden or improper stopping on roadway
40 = Parking in improper or dangerous location, e.g., shoulder of Interstate
41 = Failure to signal with other violations or unsafe actions
42 = Failure to signal, without other violations or unsafe actions
43 = Speeding or other unsafe actions in work zone
44 = Failure to dim headlights
45 = Driving without lights or insufficient lights
46 = Avoiding pedestrian
47 = Avoiding other vehicle
48 = Avoiding animal
49 = Apparent unfamiliarity with roadway
50 = Apparent unfamiliarity with vehicle, e.g., displays and controls
51 = Apparent general inexperience driving
52 = Use of cruise control contributed to late braking
53 = Other, specify

2. Driver 1 Physical/Mental Impairment (GES Variable D3: Driver Physical/Mental Condition)

0 = None apparent
1 = Drowsy, sleepy, asleep
2 = Ill, blackout
3a = Angry
3b = Other emotional state
4a = Drugs-medication
4b = Drugs-Alcohol
5 = Other drugs (marijuana, cocaine, etc.)
6 = Restricted to wheelchair

7 = Impaired due to previous injury
8 = Deaf
50 = Hit and run vehicle
97 = Physical/mental impairment – no details
98 = Other physical/mental impairment
99 = Unknown physical/mental condition

Source: GES D3, Driver Physical/Mental Condition. Element 3 expanded to separate anger from other emotions. Element 50 not applicable.
Coded in General State Variables: Driver's General State, Causal/Contributing Factors, and Precipitating Event.
FORMAT: 16-bit encoded value(s) as listed above.

3. Driver 1 Distracted By (GES Variable D7: Driver Distracted By)

This variable was recorded if the reductionists observed the drivers engaging in any of the following secondary tasks 5-10 seconds prior to the onset of the precipitating factor. For a complete definition of these tasks, see Appendix D.

00 = Not Distracted

15 = Cognitive distraction
- 97 = Lost in thought
- 01 = Looked but did not see
- 15a = Reading
- 15b = Talking/singing without obvious passenger
- 15c = Dancing to the radio
- 15d = Reading

03 = Passenger in vehicle
- 3a = Passenger in adjacent seat
- 3b = Passenger in rear seat
- 3c = Child in adjacent seat
- 3d = Child in rear seat

= Object/Animal/Insect in Vehicle
- 4a = Moving object in vehicle (i.e., object fell off seat when driver stopped hard at a traffic light)
- 4b = Insect in vehicle
- 4c = Pet in vehicle
- 4d = Object dropped by driver
- 4e = Reaching for object in vehicle (not cell phone)

5 = Cell phone operations
- 05a = Talking/listening
- 06a = Dialing hand-held cell phone
- 06b = Dialing hand-held cell phone using quick keys

06c = Dialing hands-free cell phone using voice activated software
06d = Locating/reaching/answering cell phone

17 = PDA operations
15a = Locating/reaching PDA
15b = Operating PDA
15c = Viewing PDA

16 = In-vehicle system operations
7 = Adjusting climate control
8a = Adjusting the radio
8b = Inserting/retrieving cassette
8c = Inserting/retrieving CD
9 = Adjusting other devices integral to vehicle (unknown which device)
9a = Adjusting other known in-vehicle devices (text box to specify)

12 = External Distraction
12a = Looking at previous crash or highway incident
12b = Pedestrian located outside the vehicle
12c = Animal located outside the vehicle
12d = Object located outside the vehicle
12e = Construction zone

= Dining
13a = Eating with a utensil
13b = Eating without a utensil
13c = Drinking from a covered container (i.e., straw)
13d = Drinking from an uncovered container

= Smoking
14a = Reaching for cigar/cigarette
14b = Lighting cigar/cigarette
14c = Smoking cigar/cigarette
14d = Extinguishing cigar/cigarette

18. Personal Hygiene
18a = Combing/brushing/fixing hair
18b = Applying make-up
18c = Shaving
18d = Brushing/flossing teeth
18e = Biting nails/cuticles
18f = Removing/adjusting jewelry
18g = Removing/inserting contact lenses
18h = Other

19. Inattention to the Forward Roadway

19a = Left window
19b = Left rear-view mirror
19c = Center rear-view mirror
19d = Right rear-view mirror
19e = Right passenger window

3a. Time Distraction Began
Reductionists entered the video frame number corresponding to the time at which the driver became distracted or began to engage in the distracting task.

3b. Time Distraction Ended
Reductionists entered the video frame number corresponding to the time at which the driver disengaged from the distracting task or the driver's attention returned to the forward roadway.

3c. Outcome (of Incident) Impacted
Reductionists also marked whether they believed that the secondary task that was present at the onset of the precipitating factor impacted the severity or the outcome of the event. Note that all distraction analyses conducted in this report only used those secondary tasks that were marked 'yes' or 'not able to determine'.

1 = Yes
2 = No
3 = Not able to determine
99 = Unknown

4. Willful Behavior
Reductionists marked this variable when they believed that the driver was aware or cognizant of their poor behavior. There were 3 options, written in sequential order of increasingly willful or aggressive behavior.

1 = Aggressive driving
2 = Purposeful violation of traffic laws
3 = Use of vehicle for improper purposes (Intimidation/weapon)
99 = Unknown

Source/comment: This variable came from the Light/Heavy Vehicle Interaction Study Taxonomy.

5. Driver Proficiency
Reductionists marked this variable when it was believed that the driver was generally unaware of their poor driving behavior. There are 4 options, written in order of decreasing levels of proficiency (the last is the most drastic measure of poor driving proficiency).

1 = Violation of traffic laws
2 = Driving techniques (incompetent to safely perform driving maneuver)
3 = Vehicle kinematics (incompetent handling the vehicle)

4 = Driver capabilities (incompetent on what maneuvers are safe and
appropriate)

Source/comment: This variable came from the Light/Heavy Vehicle Interaction Study Taxonomy.

6. Driver 1 Drowsiness Rating (Coded for Crashes and Near-Crashes only)
An observer rating of drowsiness will be assigned for the 30 seconds prior to the event based on review of driver videos. For drowsiness levels above a criterion level of and ORD of 60 or above, a manual calculation of PERCLOS will be measured by the analyst. This variable will be coded for all crashes and near-crashes (Wierwille and Ellsworth, 1994).

7. Driver 1 Vision Obscured by (GES Variable D4: Vision Obscured by)
Reductionists will ascertain to the best of their ability whether the driver's vision was obscured by any of the following:

0 = No obstruction
1 = Rain, snow, fog, smoke, sand, dust
2a = Reflected glare
2b = Sunlight
2c = Headlights
3 = Curve or hill
4 = Building, billboard, or other design features (includes signs,
embankment)
5 = Trees, crops, vegetation
6 = Moving vehicle (including load)
7 = Parked vehicle
8 = Splash or spray of passing vehicle [any other vehicle]
9 = Inadequate defrost or defog system
10 = Inadequate lighting system
11 = Obstruction interior to vehicle
12 = Mirrors
13 = Head restraints
14 = Broken or improperly cleaned windshield
15 = Fog
50 = Hit-and-run vehicle
95 = No driver present
96 = Not reported
97 = Vision obscured – no details
98 = Other obstruction
99 = Unknown whether vision was obstructed

8. Vehicle Contributing Factors (GES Variable V12, Vehicle contributing factors)
Reductionists will determine if any of the following contributed to the severity or the presence of an event.

0 = None
1 = Tires
2 = Brake system
3 = Steering system
4 = Suspension
5 = Power train
6 = Exhaust system
7 = Headlights
8 = Signal lights
9 = Other lights
10 = Wipers
11 = Wheels
12 = Mirrors
13 = Driver seating and controls
14 = Body, doors
15 = Trailer hitch
50 = Hit and run vehicle
97 = Vehicle contributing factors, no details
98 = Other vehicle contributing factors
99 = Unknown if vehicle had contributing factors

Environmental Factors: Driving Environment

1. Weather (GES Variable A20I, Atmospheric condition and VA PAR%Variable 4)
Reductionists will determine the type of weather using the video and record as part of the data reduction process.

1 = Clear
2 = Cloudy
3 = Fog
4 = Mist
5 = Raining
6 = Snowing
7 = Sleeting
8 = Smoke dust
9 = Other
99 = Unknown

2. Light (GES Variable A19I, Light Condition and VA PAR% Variable 7)
Reductionists will determine the type of ambient light conditions are present using the video and record as part of the data reduction process.

1 = Dawn
2 = Daylight
3 = Dusk
4 = Darkness, lighted

5 = Darkness, not lighted
99 = Unknown

3. Windshield Wiper Activation
Analysts will determine the windshield wiper activation through video reduction.

0 = Off
1 - On
99 = Unknown

4. Surface Condition (VA PAR%Variable 5)
Reductionists will determine the type of surface condition at the onset of the precipitating factor and record as part of the data reduction process.

1 = Dry
2 = Wet
3 = Snowy
4 = Icy
5 = Muddy
6 = Oily
7 = Other
99 = Unknown

5. Traffic Density (Level of Service)
Reductionists will determine the level of traffic density at the time of the precipitating factor and record as part of the data reduction process.

1 = LOS A: free flow
2 = LOS B: Flow with some restrictions
3 = LOS C: Stable flow, maneuverability and speed are more restricted
4 = LOS D: Unstable flow – temporary restrictions substantially slow driver
5 = LOS E: Flow is unstable, vehicles are unable to pass, temporary stoppages, etc.
6 = LOS F: Forced traffic flow condition with low speeds and traffic volumes that are below capacity. Queues forming in particular locations.
99 = Unknown

Driving Environment: Infrastructure
1. Kind of Locality (VA PAR%Variable 8)
Reductionists will determine the kind of locality at the onset of the precipitating factor and record as part of the data reduction process.

1 = School
2 = Church

3 = Playground
4 = Open Country
5 = Business/industrial
6 = Residential
7 = Interstate
8 = Other
9= Construction Zone (Added)
99 = Unknown

2. Relation to Junction (GES Variable A9)
Reductionists will determine the whether the precipitating factor occurred near a roadway junction and record as part of the data reduction process.

Non-Interchange Area
00 = Non-Junction
01 = Intersection
02 = Intersection-related
03 = Driveway, alley access, etc.
04 = Entrance/exit ramp
05 = Rail grade crossing
06 = On a bridge
07 = Crossover related
08 = Other, non-interchange area
09 = Unknown, non-interchange
20 = Parking lot [Added]

FORMAT: Integer value as listed above.

Interchange Area
10 = Non-Junction
11 = Intersection
12 = Intersection-related
13 = Driveway, alley access, etc.
14 = Entrance/exit ramp
16 = On a bridge
17 = Crossover related
18 = Other location in interchange area
19 = Unknown, interchange area
99 = Unknown if interchange

3. Trafficway Flow (GES Variable A11)
Reductionists will determine the whether the roadway was divided at the time of the precipitating factor and record as part of the data reduction process.

1 = Not divided
2 = Divided (median strip or barrier)

3 = One-way traffic
99 = Unknown

4. Number of Travel Lanes (GES Variable A12)
Reductionists will determine the number of travel lanes at the time of the precipitating factor and record as part of the data reduction process.

1 = 1
2 = 2
3a = 3 lanes in direction of travel (divided or one-way trafficway)
3b = Undivided highway, 3 lanes total, 2 in direction of travel
3c = Undivided highway, 3 lanes total, 1 in direction of travel
4 = 4
5 = 5
6 = 6
7 = 7+
99 = Unknown

5. Traffic Control (VA PAR%Variable 1)
Reductionists will determine whether there was a traffic control device present and record as part of the data reduction process.

1 = No traffic control
2 = Officer or watchman
3 = Traffic signal
4 = Stop sign
5 = Slow or warning sign
6 = Traffic lanes marked
7 = No passing signs
8 = Yield sign
9 = One way road or street
10 = Railroad crossing with markings or signs
11 = Railroad crossing with signals
12 = Railroad crossing with gate and signals
13 = Other
99 = Unknown

Source: VA PAR%Variable 1.
Coded in General State Variables: Road/Traffic Variables.
FORMAT: Integer value as listed above.

6. Alignment (VA PAR%Variable 3)
Reductionists will determine whether there what the road alignment was at the onset of the precipitating factor and record as part of the data reduction process.

1 = Straight level

2 = Curve level
3 = Grade straight
4 = Grade curve
5 = Hillcrest straight
6 = Hillcrest curve
7 = Dip straight
8 = Up curve
9 = Other
99 = Unknown

DRIVER STATE VARIABLES

1. Driver 1 Hands on Wheel (C-N-I-B)
Reductionists will the number of hands the driver had on the steering wheel at the time of the precipitating factor and record as part of the data reduction process.

0 = None
1 = Left hand only
2 = Both hands
3 = Right hand only
99 = Unknown

2. Occupant Safety Belt Usage (C)
Reductionists will determine whether the driver had a seatbelt fastened at the time of the precipitating factor and record as part of the data reduction process.

1 = Lap/shoulder belt
2 = Lap belt only
3 = Shoulder belt only
5 = None used
99 = Unknown if used.

3. Driver 1 Alcohol Use (GES Variable V92)
Reductionists will determine whether drivers were using alcohol or under the influence of alcohol at the time of the precipitating factor and record as part of the data reduction process.

1a = Use observed in vehicle without overt effects on driving
1b = Use observed in vehicle with overt effects on driving
1c = Use not observed but reported by police
1d = Use not observed or reported, but suspected based on driver behavior.
2 = None known
99 = Unknown

4. Fault Assignment
1 = Driver 1 (subject vehicle)
2 = Driver 2

3 = Driver 3
4 = Driver 4
5 = Driver 5
6 = Driver 6
7 = Driver 7
8 = Driver 8
9 = Driver 9
10 = Driver 10
11 = Other (textbox)
99 = Unknown

5. Observer Rating of Drowsiness (ORD)

For crashes and near-crashes, reductionists rated the driver’s drowsiness on a scale of 0-100. The procedure for measuring ORD was developed and first used by Wierwille and Ellsworth (1994). This scale is broken down as is shown in Figure C-1.

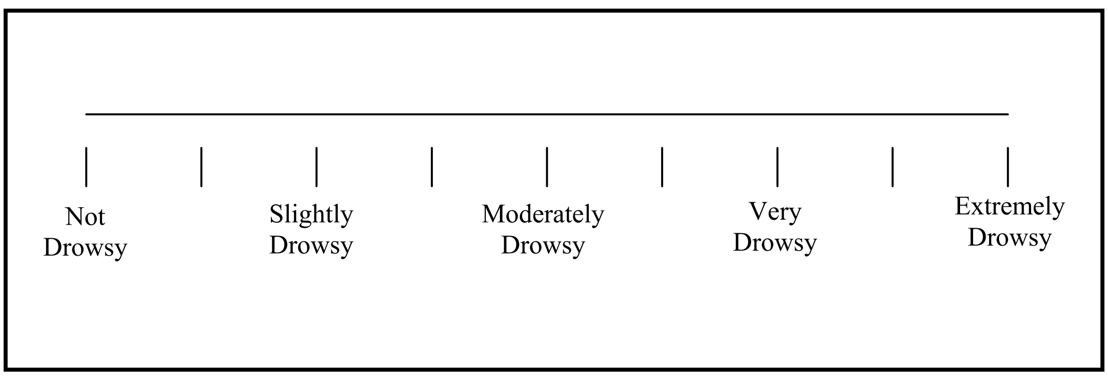

Figure C-1. The observer rating of drowsiness scale where not drowsy is equal to 0 and extremely drowsy is equal to 100.

Reductionists were instructed to watch the driver’s face and body language for a period of time prior to the trigger. As described by Wierwille and Ellsworth (1994), signs indicative of drowsiness include rubbing face or eyes, facial contortions, moving restlessly in the seat, and slow eyelid closures. Reductionists were trained to look for these signs of drowsiness and make a subjective but specific assessment of the level of drowsiness. After watching the video data, reductionists employed a rating scale to record an ORD level. Please note that for a driver to be considered ‘”drowsy” in all of the analyses in this report, the ORD rating needed to be 60 or higher. The specific drowsy behaviors that reductionists used to rate a driver’s drowsiness level were as follows:

- **Not Drowsy:** A driver who is not drowsy while driving will exhibit behaviors such that the appearance of alertness will be present. For example, normal facial tone, normal fast eye blinks, and short ordinary glances may be observed. Occasional body movements and gestures may occur.

- **Slightly Drowsy:** A driver who is slightly drowsy while driving may not look as sharp or alert as a driver who is not drowsy. Glances may be a little longer and eye blinks may not be as fast. Nevertheless, the driver is still sufficiently alert to be able to drive.

- **Moderately Drowsy:** As a driver becomes moderately drowsy, various behaviors may be exhibited. These behaviors, called mannerisms, may include rubbing the face or eyes, scratching, facial contortions, and moving restlessly in the seat, among others. These actions can be thought of as countermeasures to drowsiness. They occur during the intermediate stages of drowsiness. Not all individuals exhibit mannerisms during intermediate stages. Some individuals appear more subdued, they may have slower closures, their facial tone may decrease, they may have a glassy-eyed appearance, and they may stare at a fixed position.

- **Very Drowsy:** As a driver becomes very drowsy eyelid closures of 2 to 3 seconds or longer usually occur. This is often accompanied by a rolling upward or sideways movement of the eyes themselves. The individual may also appear not to be focusing the eyes properly, or may exhibit a cross-eyed (lack of proper vergence) look. Facial tone will probably have decreased. Very drowsy drivers may also exhibit a lack of apparent activity and there may be large isolated (or punctuating) movements, such as providing a large correction to steering or reorienting the head from a leaning or tilted position.

- **Extremely Drowsy:** Drivers who are extremely drowsy are falling asleep and usually exhibit prolonged eyelid closures (4 seconds or more) and similar prolonged periods of lack of activity. There may be large punctuated movements as they transition in and out of intervals of dozing.

6. Average PERCLOS (Percentage Eyes Closed) (C, N)
For crashes and near-crashes where the driver's observer rating of drowsiness is above a criterion level an ORD of 60, the average PERCLOS value for the 30 seconds pre-event period will be obtained through video reduction.

7. Driver 1 Eyeglance Reconstruction (C-N)
Eyeglances for the previous 30 seconds will be classified using the following categories and described as a timed, narrative sequence of the following numbers:
1 = Center forward
2 = Left forward
3 = Right forward
4 = Left mirror
5 = Right mirror
6 = Left window
7 = Right window
8 = Instrument panel
9 = Passenger
10 = Object
11 = Cell Phone
12 = Other

Comment: The analysis will include a recording of time the driver's eyes were not "on the road," i.e., straight ahead, forward right, or forward left. When possible, eyeglances will be characterized in greater detail than the general directions and areas listed above, e.g., when known, the specific object of regard will be noted in the narrative. For the instrument panel, for example, specific components such as the radio/CD will be noted in the narrative. When applicable and possible, the eyeglance reconstruction will also include an assessment of driver reaction time to a stimulus, e.g., braking reaction time following a potential crash-precipitating event.

Driver/Vehicle 2

1. Number of other Vehicle/Person (s)
Reductionists will identify the number of vehicles in the immediate environment and then record the following variables.

2. Location of other Vehicle/Persons
Reductionists will identify the location of vehicles in the immediate environment with respect to the subject vehicle and then record the following variables.

A = In front of subject vehicle
B = In front and to the immediate right of the subject vehicle
C = On the right side of the subject vehicle, closer to front seat of the vehicle.
D = On the right side of the subject vehicle, closer to rear seat of the vehicle.
E = Behind and to the immediate right of the subject vehicle.
F = Behind the subject vehicle
G = Behind and to the immediate left of the subject vehicle.
H = On the left side of the subject vehicle, closer to the rear seat of the vehicle.
I = On the left side of the subject vehicle, closer to the front seat of the vehicle.
J = In front and to the immediate left of the subject vehicle.

3. Vehicle/Person 2 Type (Modified version of GES Variable V5, Body Type)
Data reductionists will record what type of vehicles that are in the subject vehicle's immediate surroundings.

1 = Automobile
14 = Sport Utility Vehicles
20 = Van-based truck (minivan or standard van)
30 = Pickup truck
50 = School bus
58a = Transit bus
58b = Greyhound bus
58c = Conversion bus
64a = Single-unit straight truck: Multistop/step van
64b = Single-unit straight truck: Box
64c = Single-unit straight truck: Dump
64d = Single-unit straight truck: Garbage/recycling
64e = Single-unit straight truck: Concrete mixer
64f = Single-unit straight truck: Beverage
64g =Single-unit straight truck: Flatbed

64h =Single-unit straight truck: Tow truck
64i = Single-unit straight truck: Other
64j = Single-unit straight truck: Unknown
64k = Straight Truck + Trailer
66 = Tractor only
66a = Tractor-trailer: Enclosed box
66b = Tractor-trailer: Flatbed
66c = Tractor-trailer: Tank
66d = Tractor-trailer: Car carrier
66e = Tractor-trailer: Livestock
66f = Tractor-trailer: Lowboy trailer
66g = Tractor-trailer: Dump trailer
66h = Tractor-trailer: Multiple trailers/enclosed box
66i = Tractor-trailer: Multiple trailers/grain
66e = Tractor-trailer: Other
93 = Other Large Construction Equipment
8 = Motorcycle or moped
9a = Ambulance
9b = Fire truck
9c = Police
10 = Other vehicle type
11 = Pedestrian
12 = Cyclist
13 = Animal
99 = Unknown vehicle type
4. Vehicle 2 Maneuver (GES Variable V21, Movement Prior to Critical Event)
Reductionists will record what the other vehicle's actions were just prior to the onset of the precipitating factor.

1 = Going straight ahead
2 = Making right turn
3 = Making left turn
4 = Making U-turn
5 = Slowing or stopping
6 = Starting in traffic lane
7 = Starting from parked position
8 = Stopped in traffic lane]
9 = Ran off road right
10 = Ran off road left
11 = Parked
12 = Backing
13 = Passing
14 = Changing lanes
15 = Other
16 = Accelerating in traffic lane
17 = Entering a parked position

18 = Negotiating a curve
19 = Merging
99 = Unknown

5. Driver/Vehicle 2 Corrective Action Attempted (GES V27, Corrective Action Attempted)
Reductionists will record the corrective action attempted for each vehicle immediately surrounding the subject vehicle.

0 = No driver present
1 = No avoidance maneuver
2 = Braking (no lockup)
3 = Braking (lockup)
4 = Braking (lockup unknown)
5 = Releasing brakes
6 = Steered to left
7 = Steered to right
8 = Braked and steered to left
9 = Braked and steered to right
10 = Accelerated
11 = Accelerated and steered to left
12 = Accelerated and steered to right
98 = Other actions
99 = Unknown if driver attempted any corrective action

Coded: From PAR%and/or video.
Source: GES V27, Corrective Action Attempted.
Coded in General State Variables: Driver/Vehicle 2.
FORMAT: Integer value as listed above.

6. Driver/Vehicle 2 Physical/Mental Impairment (GES D3, Driver Physical/Mental Condition)
Reductionists will mark only for those crashes that a police accident report form is collected from the subject.

0 = None apparent
1 = Drowsy, sleepy, asleep
2 = Ill, blackout
3a = Angry
3b = Other emotional state
4 = Drugs and medication
5 = Other drugs (marijuana, cocaine, etc.)
6 = Restricted to wheelchair
7 = Impaired due to previous injury
8 = Deaf
50 = Hit-and-run vehicle
97 = Physical/mental impairment – no details
98 = Other physical/mental impairment

99 = Unknown physical/mental condition

7. Driver 2 Actions/Factors Relating to Crash/Incident (VA PAR%Variable 17/18)
Reductionists will code this for crashes and near-crashes only for each vehicle immediately surrounding the subject vehicle.

0 = None
1 = Exceeded speed limit
2 = Inattentive or distracted (coded in previous variable)
3 = Exceeded safe speed but not speed limit
4 = Driving slowly: below speed limit
5 = Driving slowly in relation to other traffic: not below speed limit
6 = Illegal passing (i.e., across double line)
7 = Passing on right
8 = Other improper or unsafe passing
9 = Cutting in, too close in front of other vehicle
10 = Cutting in, too close behind other vehicle
11 = Making turn from wrong lane (e.g., across lanes)
12 = Did not see other vehicle during lane change or merge
13 = Driving in other vehicle's blind zone
14 = Aggressive driving, specific, directed menacing actions
15 = Aggressive driving, other, i.e., reckless driving without directed menacing actions
16 = Wrong side of road, not overtaking
17 = Following too close
18 = Failed to signal, or improper signal
19 = Improper turn: wide right turn
20 = Improper turn: cut corner on left turn
21 = Other improper turning
22 = Improper backing, did not see
23 = Improper backing, other
24 = Improper start from parked position
25 = Disregarded officer or watchman
26 = Signal violation, apparently did not see signal
27 = Signal violation, intentionally ran red light
28 = Signal violation, tried to beat signal change
29 = Stop sign violation, apparently did not see stop sign
30 = Stop sign violation, intentionally ran stop sign at speed
31 = Stop sign violation, "rolling stop"
32 = Other sign (e.g., Yield) violation, apparently did not see sign
33 = Other sign (e.g., Yield) violation, intentionally disregarded
34 = Other sign violation
35 = Non-signed crossing violation (e.g., driveway entering roadway)
36 = Right-of-way error in relation to other vehicle or person, apparent recognition failure (e.g., did not see other vehicle)
37 = Right-of-way error in relation to other vehicle or person, apparent

decision failure (i.e., did see other vehicle prior to action but misjudged gap)

38 = Right-of-way error in relation to other vehicle or person, other or unknown cause
39 = Sudden or improper stopping on roadway
40 = Parking in improper or dangerous location, e.g., shoulder of Interstate
41 = Failure to signal with other violations or unsafe actions
42 = Failure to signal, without other violations or unsafe actions
43 = Speeding or other unsafe actions in work zone
44 = Failure to dim headlights
45 = Driving without lights or insufficient lights
46 = Avoiding pedestrian
47 = Avoiding other vehicle
48 = Avoiding animal
49 = Apparent unfamiliarity with roadway
50 = Apparent unfamiliarity with vehicle, e.g., displays and controls
51 = Apparent general inexperience driving
52 = Use of cruise control contributed to late braking
53 = Other, specify

APPENDIX D: ANOVA TABLES

Table D-1. T-test summary table for Driver Attentiveness (Driver Age).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Age					
Attention Category	1	1371.7638	1371.764	7.07	0.0091

Table D-2. T-test summary table for Driver Attentiveness (Male Driver's Age).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Age/Male					
Attention Category	1	294.02362	294.0236	1.63	0.2066

Table D-3. T-test summary table for Driver Attentiveness (Female Driver's Age).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Age/Female					
Attention Category	1	1031.7459	1031.746	4.9	0.0328

Table D-4. T-test summary table for Driver Attentiveness (Years of Driving Experience).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Experience					
Attention Category	1	1482.5217	1482.522	7.6	0.0069

Table D-5. T-test summary table for Driver Attentiveness (Number of Traffic Violations).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Violations					
Attention Category	1	18.324647	18.32465	4.9	0.029

Table D-6. T-test summary table for Driver Attentiveness (Number of Accidents).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Accidents					
Attention Category	1	0.1762382	0.176238	0.08	0.7764

Table D-7. T-test summary table for Driver Attentiveness (Number of Illnesses).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Illness					
Attention Category	1	0.2442525	0.244252	0.12	0.7337

Table D-8. T-test summary table for Driver Attentiveness (Daytime Sleepiness Rating).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Daytime Sleepiness Rating					
Attention Category	1	16.615563	16.61556	3.61	0.0602

Table D-9. T-test summary table for Driver Attentiveness (Number of Hours of Sleep).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Number of Hours of Sleep					
Attention Category	1	0.0491863	0.049186	0.05	0.8157

Table D-10. T-test summary table for Driver Attentiveness (Life Stress Score).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Life Stress Score					
Attention Category	1	9824.6815	9824.682	0.8	0.3754

Table D-11. T-test summary table for driver attentiveness for Driver Behavior Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Aggression					
Attention Category	1	123.64634	123.6463	0.57	0.4526

Table D-12. T-test summary table for driver attentiveness Driver Behavior Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Dislike of Driving					
Attention Category	1	32.855265	32.85527	0.31	0.5785

Table D-13. T-test summary table for driver attentiveness Driver Behavior Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Hazard Monitoring					
Attention Category	1	362.16148	362.1615	2.66	0.1057

Table D-14. T-test summary table for driver attentiveness for Driver Behavior Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Thrill-seeking					
Attention Category	1	262.34811	262.3481	0.98	0.325

Table D-15. T-test summary table for driver attentiveness for Driver Behavior Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Drowsiness Proneness					
Attention Category	1	202.42993	202.4299	1.15	0.2868

Table D-16. T-test summary table for driver attentiveness and the Dula Dangerous Driving Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: DDDI					
Attention Category	1	117.71573	117.7157	0.94	0.3344

Table D-17. T-test summary table for driver attentiveness the Dula Dangerous Driving Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Negative Emotion					
Attention Category	1	15.387279	15.38728	0.66	0.4181

Table D-18. T-test summary table for driver attentiveness the Dula Dangerous Driving Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Aggressive Driving					
Attention Category	1	2.8125107	2.812511	0.19	0.6652

Table D-19. T-test summary table for driver attentiveness the Dula Dangerous Driving Questionnaire.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Risky Driving					
Attention Category	1	24.275174	24.27517	1.29	0.2587

Table D-20. T-test summary table for driver attentiveness for the NEO Five-Factor Personality Inventory.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Neuroticism					
Attention Category	1	734.107	734.107	2.75	0.1004

Table D-21. T-test summary table for driver attentiveness for the NEO Five-Factor Personality Inventory.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Extroversion					
Attention Category	1	976.01176	976.0118	7.03	0.0093

Table D-22. T-test summary table for driver attentiveness for the NEO Five-Factor Personality Inventory.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Openness					
Attention Category	1	537.18718	537.1872	4.03	0.0473

Table D-23. T-test summary table for driver attentiveness for the NEO Five-Factor Personality Inventory.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Agreeableness					
Attention Category	1	941.01129	941.0113	8.26	0.0049

Table D-24. T-test summary table for driver attentiveness for the NEO Five-Factor Personality Inventory.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Conscientiousness					
Attention Category	1	554.77672	554.7767	6.62	0.0115

Table D-25. T-test summary table for Driver Attentiveness.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Channel Capacity					
Attention Category	1	0.4384058	0.438406	0.1	0.7526

Table D-26. T-test summary table for driver attentiveness for the Waypoint Performance-Based Test.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Preventable Near-Crash/Crash Risk					
Attention Category	1	1.0471015	1.047101	2.05	0.1555

Table D-27. T-test summary table for driver attentiveness for the Waypoint Performance-Based Test.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Expected # of Moving Violations in the Next 5 Years					
Attention Category	1	0.0036232	0.003623	0.01	0.9299

Table D-28. T-test summary table for driver attentiveness for the Waypoint Performance-Based Test.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Expected Seat Belt Use					
Attention Category	1	0.0664504	0.06645	0.57	0.4539

Table D-29. T-test summary table for driver attentiveness for the Useful Field of View Performance-Based Test.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: UFOV					
Attention Category	1	5.9753086	5.975309	1.39	0.2404

Analysis of Variance Tables for Driver Attentiveness

Table D-30. ANOVA summary table for Driver Attentiveness (Driver Age).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Age					
Attention Category	2	2538.22963	1269.11481	6.77	0.0017

Table D-31. ANOVA summary table for Driver Attentiveness (Years of Driving Experience).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Experience					
Attention Category	2	2858.6439	1429.322	7.69	0.0008

Table D-32. ANOVA summary table for Driver Attentiveness (Number of Traffic Violations).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Violations					
Attention Category	2	38.949862	19.47493	5.54	0.0052

Table D-33. ANOVA summary table for Driver Attentiveness (Number of Accidents).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Accidents					
Attention Category	2	19.292393	9.646197	4.88	0.0094

Table D-34. ANOVA summary table for Driver Attentiveness (Daytime Sleepiness Rating).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Daytime Sleepiness Rating					
Attention Category	2	35.005781	17.50289	3.8	0.0255

Table D-35. ANOVA summary table for Driver Attentiveness (Hours of Sleep).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Hours of Sleep					
Attention Category	2	1.1631296	0.581565	0.65	0.5258

Table D-36. ANOVA summary table for driver attentiveness for Driver Behavior Questionnaire (Aggression).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Aggression					
Attention Category	2	123.14055	61.57028	0.29	0.7522

Table D-37. ANOVA summary table for driver attentiveness for Driver Behavior Questionnaire (Dislike).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Dislike of Driving					
Attention Category	2	37.498264	18.74913	0.17	0.8405

Table D-38. ANOVA summary table for driver attentiveness for Driver Behavior Questionnaire (Hazard).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Hazard Monitoring					
Attention Category	2	791.19383	395.5969	2.9	0.0594

Table D-39. ANOVA summary table for driver attentiveness for Driver Behavior Questionnaire (Thrill-seeking).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Thrill-seeking					
Attention Category	2	224.13074	112.0654	0.41	0.6661

Table D-40. ANOVA summary table for Driver Attentiveness Driver Behavior Questionnaire (Drowsiness).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Drowsiness Proneness					
Attention Category	2	63.21934	31.60967	0.18	0.8377

Table D-41. ANOVA summary table for driver attentiveness for the Dula Dangerous Driving Inventory (DDDI).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: DDDI					
Attention Category	2	368.34603	184.173	1.52	0.2238

Table D-42. ANOVA summary table for driver attentiveness for the Dula Dangerous Driving Inventory (NE).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Negative Emotional					
Attention Category	2	116.1119	58.05595	2.64	0.0762

Table D-43. ANOVA summary table for driver attentiveness for the Dula Dangerous Driving Inventory (AD).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Aggressive Driving					
Attention Category	2	4.8314514	2.415726	0.16	0.8501

Table D-44. ANOVA summary table for driver attentiveness for the Dula Dangerous Driving Inventory (RD).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Risky Driving					
Attention Category	2	46.012434	23.00622	1.21	0.3033

Table D-45. ANOVA summary table for driver attentiveness for the Useful Field of View.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: UFOV					
Attention Category	1	23.945798	11.9729	2.47	0.0887

Table D-46. ANOVA summary table for driver attentiveness for the NEO Five-Factor Personality Inventory (N).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Neuroticism					
Attention Category	2	544.88275	272.4414	1.05	0.3549

Table D-47. ANOVA summary table for driver attentiveness for the NEO Five-Factor Personality Inventory (E).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Extroversion					
Attention Category	2	531.03909	265.5195	1.96	0.1461

Table D-48. ANOVA summary table for driver attentiveness for the NEO Five-Factor Personality Inventory (O).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Openness					
Attention Category	2	258.81916	129.4096	0.96	0.3853

Table D-49. ANOVA summary table for driver attentiveness for the NEO Five-Factor Personality Inventory (A).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Agreeableness					
Attention Category	2	819.18283	409.5914	3.77	0.0261

Table D-50. ANOVA summary table for driver attentiveness for the NEO Five-Factor Personality Inventory (C).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Consciousness					
Attention Category	2	486.96632	243.4832	3.05	0.0512

Table D-51. ANOVA summary table for driver attentiveness for the waypoint performance-based test (channel 1).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Channel Capacity					
Attention Category	2	6.0800916	3.040046	0.7	0.4968

Table D-52. ANOVA summary table for driver attentiveness for the waypoint performance-based test (pcr).

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Preventable Near-Crash/Crash Risk					
Attention Category	2	0.7911188	0.395559	0.79	0.4588

Table D-53. ANOVA summary table for driver attentiveness for the waypoint performance-based test (mvr).

Source of Variation	**df**	**SS**	**MS**	**F value**	***p* value***
Dependant Variable: Expected # of Moving Violations in the Next 5 Years					
Attention Category	2	0.0735243	0.036762	0.08	0.9262

Table D-54. ANOVA summary table for driver attentiveness for the waypoint performance-based test (seatbelt).

Source of Variation	**df**	**SS**	**MS**	**F value**	***p* value***
Dependant Variable: Expected Seat Belt Use					
Attention Category	2	0.1220738	0.061037	0.54	0.5835

Analysis of Variance Tables for Chapter 6

Table D-55. ANOVA summary table for eyeglance for total time eyes off the forward roadway.

Source of Variation	**df**	**SS**	**MS**	**F value**	***p* value***
Dependant Variable: Total Time					
Severity	3	175.797	58.599	33.36	<.0001

Table D-56. ANOVA summary table for eyeglance for number of eyeglances.

Source of Variation	**df**	**SS**	**MS**	**F value**	***p* value***
Dependant Variable: Number of Glances					
Severity	3	127.34777	42.44926	22.02	<.0001

Table D-57. ANOVA summary table for eyeglance for length of longest glance.

Source of Variation	df	SS	MS	F value	*p* value*
Dependant Variable: Length of Longest Glance					
Severity	3	134.75325	44.91775	34.94	<.0001

DOT HS 810 594
April 2006

U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

www.nhtsa.dot.gov
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people saving people

CITY OF KYLE, TEXAS

Presentation Central Texas Clean Air Coalition

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Presentation regarding the newly proposed U.S. EPA regulations for ozone. ~ *Fred Blood, Air Quality Program Specialist, Central Texas Clean Air Coalition*

Other Information:

Legal Notes:

Budget Information:

Viewing Attachments Requires Adobe Acrobat. Click here to download.

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Presentaion

Central Texas Air Quality

Kyle City Council

July, 2015

CAPITAL AREA COUNCIL OF GOVERNMENTS

CAPCOG – Regional Planning Commission in Statute; More often called a COG.

- Emergency Communications 9-1-1
- Area Agency on Aging
- Homeland Security Planning & Training
- Regional Law Enforcement Academy
- Air Quality Planning
- Economic Development Analysis & Tech Assist
- Solid Waste Planning

Ten-County service area; State of Texas planning region 12

7/24/2015 Capital Area Council of Governments Be Air Aware 3

CAPCOG Executive Committee

Council Member
Eileen Altmiller
City of Buda

Judge
Brett Bray
Blanco County

Judge
Bert Cobb
Hays County

Mayor
Jeff Coleman
City of Pflugerville

Commissioner
Will Conley
Hays County

Judge
Mary Cunningham
Llano County

Commissioner
Gerald Daugherty
Travis County

Commissioner
Joe Don Dockery
Burnet County

Judge
Sarah Eckhardt
Travis County

Judge
Dan A. Gattis
Williamson County

Mayor
Daniel Guerrero
City of San Marcos

Mayor
Debbie Holland
City of Hutto

Mayor
Marc Holm
City of Elgin

Judge
Ed Janecka
Fayette County

Commissioner
Cynthia Long
Williamson County

Council Member
Kirsten Lynch
City of Leander

Mayor
Alan McGraw
City of Round Rock

Mayor
Caroline Murphy
City of Bee Cave

Judge
James Oakley
Burnet County

Judge
Paul Pape
Bastrop County

Commissioner
Maurice Pitts
Lee County

Judge
Ken Schawe
Caldwell County

Council Member
Ellen Troxclair
City of Austin

Council Member
Donald Tracy
City of Cedar Park

Mayor
Lew White
City of Lockhart

State Representative
Jason Isaac

State Representative
Paul Workman

State Representative
Eddie Rodriguez

Senator
Judith Zaffirini

7/24/2015 Capital Area Council of Governments Be Air Aware 4

Status of Central Texas Air Quality

- In compliance with all National Ambient Air Quality Standards (NAAQS)
  - Ozone Levels: 92% of NAAQS
  - Annual $PM_{2.5}$ Levels: 68% of NAAQS
  - Daily $PM_{2.5}$ Levels: 58% of NAAQS
- "Good" Air Quality on 70% of days in 2014
  - 88 "Moderate" PM days
  - 31 "Moderate" Ozone Days
- No Expected Adverse Impacts to Health or Environment from Ambient Air Toxics Levels

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EPA's Proposed Ozone Standards

- Proposes to lower the level from 75 parts per billion (ppb) to a range of 65-70 ppb
- Intended to increase protections for public health and vegetation
- Central Texas Levels 2012-2014: 69 ppb
- Court order to finalize by October 1, 2015
- 2014-2016 Ozone data will likely be key

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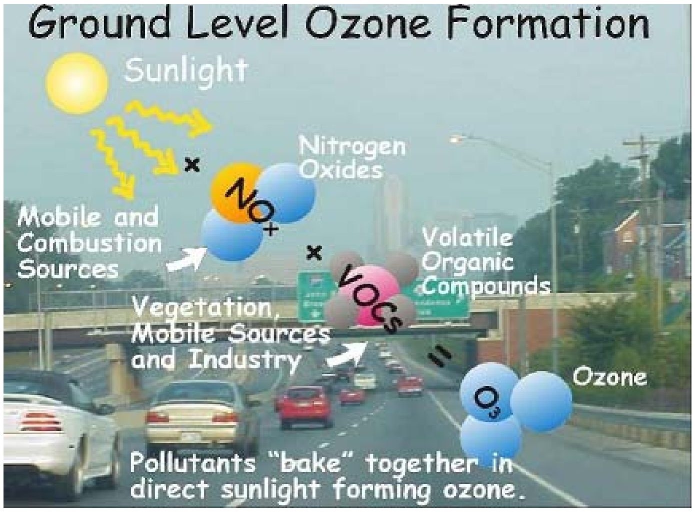
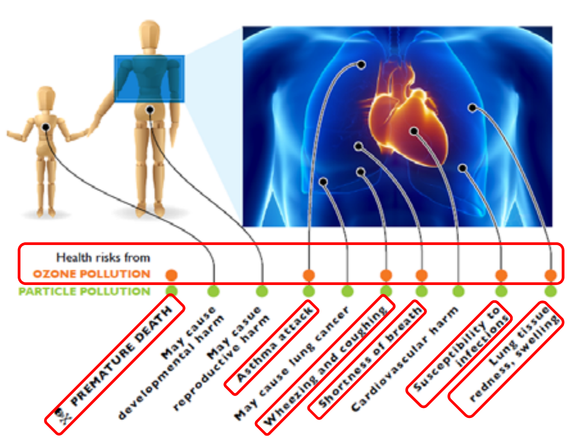
What Is Ground-Level Ozone?



7/24/2015 | Capital Area Council of Governments
Be Air Aware | 7

Review of Ozone Health Impacts

Air pollution remains a major danger to the health of children and adults.



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Be Air Aware | 8

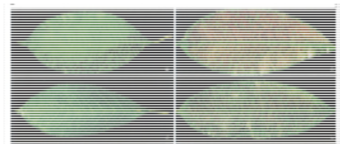
Impacts of Ozone Exposure

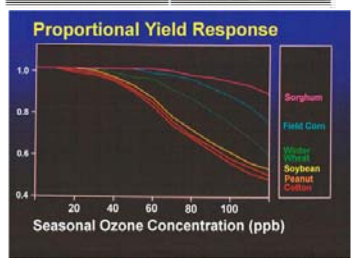
Respiratory Effects on Humans

# of Deaths in 2007 Associated with Peak Summertime Ozone Levels			
County	Smith et. al Study	Zanobetti Study	Jerrett et. al Study
Bastrop	2-4	2-4	4-8
Caldwell	1-2	1-2	4-8
Hays	2-4	2-4	8-16
Travis	16-32	16-32	>64
Williamson	8-16	8-16	16-32

Source: Health and Risk Exposure Assessment, Figures 8-2, 8-3, and 8-4
http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_2008_rea.html

Damage to Vegetation And Reduced Crop Yields



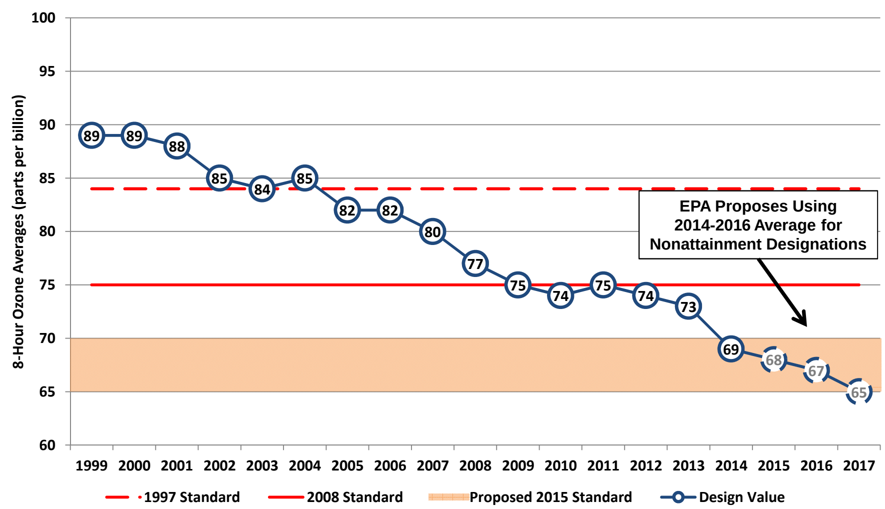


California 10-yr Children's Health Study

- Air pollution harms children's lungs for life. Children had significantly lower lung function at age 18, and lung function deficits are unlikely to be reversed.
- Children living in high ozone communities who actively participated in several sports were more likely to develop asthma.
- Days with higher ozone levels resulted in significantly higher school absences due to respiratory illness.
- Children with asthma who were exposed to higher concentrations of particulate matter were much more likely to develop bronchitis

Compliance with Ozone NAAQS

CAPCOG



Source for 1999-2014 data: TCEQ https://www.tceq.texas.gov/cgi-bin/compliance/monops/8hr_attainment.pl

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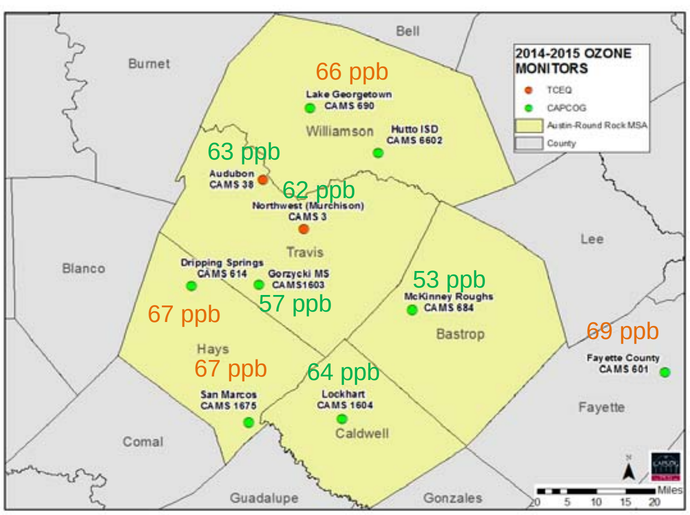
2014 Ozone Levels Around the Region

CAPCOG



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Impacts of O_3 Nonattainment Designation

- More difficult to build new roads
- Industrial growth is limited
- Federal approvals become more difficult
- No “back-sliding”

Central Texas Clean Air Coalition

- County and City Elected Officials
- Adopts Air Quality Plans
- Policies and Strategies to Guide Member Jurisdictions
- Won 2014 Clean Air Excellence Award from EPA

Cities Participating in the CAC

Area Name	Population (2014)
Austin	**879,500**
Round Rock	**108,900**
Cedar Park	**59,200**
Pflugerville	**54,300**
Georgetown	**52,700**
San Marcos	**52,200**
Kyle	33,100
Leander	27,900
Hutto	**18,200**
Taylor	**17,400**
Lockhart	**13,000**
Lakeway	12,800
Buda	**8,800**
Elgin	**8,300**
Bastrop	**7,300**
Lago Vista	6,900
Luling	**5,600**
Manor	5,500

Regional Air Quality Goals

1. Stay in attainment of the 2008 eight-hour ozone National Ambient Air Quality Standards (NAAQS) of 75 parts per billion (ppb);
2. Continue reducing the region's 8-hour ozone design value to avoid being designated nonattainment for a new ozone NAAQS;
3. Put the region in the best possible position to bring the area into attainment of an ozone standard expeditiously if it is does violate an ozone standard or gets designated nonattainment;
4. Reduce the exposure of vulnerable populations to air pollution when the region experiences high ozone levels, and
5. Minimize the costs to the region of any potential future nonattainment designation.

What Can be Done?

- Ensure Existing Voluntary Commitments Are Fully Implemented
- Recruit New Participants in the Ozone Advance Program Action Plan
  - Commute reduction programs
  - Ozone action day programs
  - Replace older vehicles and equipment
  - Conserve electricity, gas, and water
  - Encourage contractors to reduce emissions

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Questions?

7/24/2015 Capital Area Council of Governments Be Air Aware 18

THANK YOU!

Capital Area Council of Governments

Air Quality Program

http://www.capcog.org/airquality

Fred Blood

Air Quality Program Specialist

fblood@capcog.org

(512) 916-6036

7/24/2015 Capital Area Council of Governments Be Air Aware 19

CITY OF KYLE, TEXAS

Presentation Catalyst Commercial

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Discussion of land use, policies and effective strategies for attracting quality development on the I-35 Corridor and quarterly report. ~ *Jason Claunch, President*

Other Information:

Legal Notes:

Budget Information:

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- Catalyst Commercial Quarterly Report

Cover Memo

August 1st, 2015
Diana Blank- Torres, Director Economic Development
City of Kyle
100 West Center Street
Kyle, Texas 78640

Dear Mrs. Blank- Torres,

Catalyst Commercial, Inc. (Catalyst) was retained by the City of Kyle to conduct a market analysis with the purpose of identifying retail demand and potential tenants for the City of Kyle. The following is a brief summarization of the work we performed according to the tasks identified in the contract per the scopes of our work:

- Monthly Conference Call with the City of Kyle
- Additional Research/Marketing Collateral Updates- Last update May 2015
- Secured & attended strategic meetings at the ICSC Las Vegas RECon Convention May 17th- 20th, 2015

Catalyst is currently in the Implementation Phase of this project. Progress is as follows:

- Catalyst tracking "Top 10" Retail Targets and track leads & activity on monthly progress reports
- Catalyst scheduled confirmed strategic meetings at the ICSC RECon Convention 2015 & sent follow up recap memo with the details of these meetings & follow up necessary
- Catalyst is hosting ENGAGE Retail Event August 19th, 2105
- Catalyst will attend the Retail Live Austin August 20th, 2015
- Catalyst will attend & schedule meetings for the City of Kyle at the ICSC Dallas November 4th- 6th, 2015

Should you have any questions or concerns, or require additional information, please feel free to contact me at the phone number or email below.

Jason Claunch
Catalyst
972-999-0081 x101
jason@catalystcommercial.net

CITY OF KYLE, TEXAS

MNT & S Development (Sonic) - Zoning

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation:

(*Second Reading*) An ordinance amending Chapter 53 (Zoning) of the City of Kyle, Texas, for the purpose of assigning original zoning to approximately 5.125 acres of land from Agriculture "AG" to Retail Service District "RS", on property located at 400 E. RR 150, in Hays County, Texas. (MNT & S Development, LTD, Z-15-006). ~ *Howard J. Koontz, AICP, Director of Planning and Community Development*

Planning and Zoning Commission voted 6-0 to recommend approval of the request.

Other Information:

The site is located at 400 RR 150 E, which is directly south of the intersection of Hill Street and RR 150 E. The property, comprising 5.125 acres, is currently zoned AG (Agriculture), and is vacant. The lot in question is located on the southwest side of both RR 150 E and Hill Street. The adjacent lot to the northwest is zoned C-2 (Commercial – General Business) and is developed with a convenience store with gas pumps; the lots to the northeast, across RR 150 are zoned both R/S and AG, and are both as yet undeveloped. The properties to the southeast and southwest, across a small creek, are zoned AG, and house the PAWS animal shelter of Central Texas and the Kyle Correctional Center, respectively. The applicant seeks to rezone the subject property to R/S, a retail services zoning category for "the retail sale of goods and products to which value has been added on site, including sales of goods and services outside of the primary structure".

Conditions of the Zoning Ordinance

§53-1205 – Amendments …

(d) Referral of amendment to planning and zoning commission. Upon its own motion, a request by the planning and zoning commission, or the receipt of an administratively complete petition and application to zone or rezone a lot, tract or parcel of land, which petition and application has been examined and approved as to form by the city manager, shall be referred to the planning and zoning commission for consideration, public hearing, and recommendation to the city council. The council may not enact a rezoning amendment until the planning and zoning commission has held a public hearing and made its recommendation to the city council, or has made a final vote on the matter without obtaining a majority, on the zoning or rezoning of the property.

(e) Action by the planning and zoning commission. The planning and zoning commission shall cause such study and review to be made as advisable and required, shall give public notice and hold a public hearing as provided by state law, and shall recommend to the council such action as the planning and zoning commission deems proper…

Comprehensive Plan Text

The subject site is located in a 'Regional Node' character area. In the Regional Node, it is recommended that R/S be approved conditionally.

Regional Node "Character": "Regional Nodes should have regional scale retail and commercial activity complemented by regional scale residential uses. These Nodes should represent the character and identity of Kyle, and signal these traits to the surrounding community. Regional Nodes have a radius of approximately 1/3 of a mile so that they are walkable, but are able to contain a greater range of uses at a larger scale than those found in Local Nodes. Appropriate uses may include grocery stores, retail shopping centers, multi-family housing, and municipal services, such as libraries and recreation centers."

Regional Node "Intent": "The primary goal of the Regional Nodes is to capture commercial opportunities necessary to close Kyle's tax gap. To achieve this goal, these Nodes should draw upon anticipated regional growth and aggregate density to enhance value and activity levels in a concentrated and visible location. Regional Nodes should provide a mixture of uses that complements regional commercial activity, as well as encourage high intensity residential development. These Nodes should respond to other regional areas of growth, specifically along I-35 and FM 1626, and to growth toward Hwy 21, SH 45 and SH 130. The anchor of each Regional Node should be regional commercial uses, and Regional Nodes should have a high level of development intensity."

Recommendation

Establishing R/S zoning on this parcel is completely appropriate for this area of the city, especially in the context of "…draw[ing] upon anticipated regional growth and aggregate density to enhance value and activity levels in a concentrated and visible location." Staff recommends that this request should be considered favorably.

Planning Commission

At their regular July 14, 2015 meeting, the Planning Commission heard and considered this item at a Public Hearing. Following limited discussion, the Commission recommended approval of the request to assign R/S zoning to the property, 6-0 (Wilson absent).

	Attachments · Application · Letter of intent · Overhead map of the subject vicinity
Legal Notes:	N/A
Budget Information:	N/A

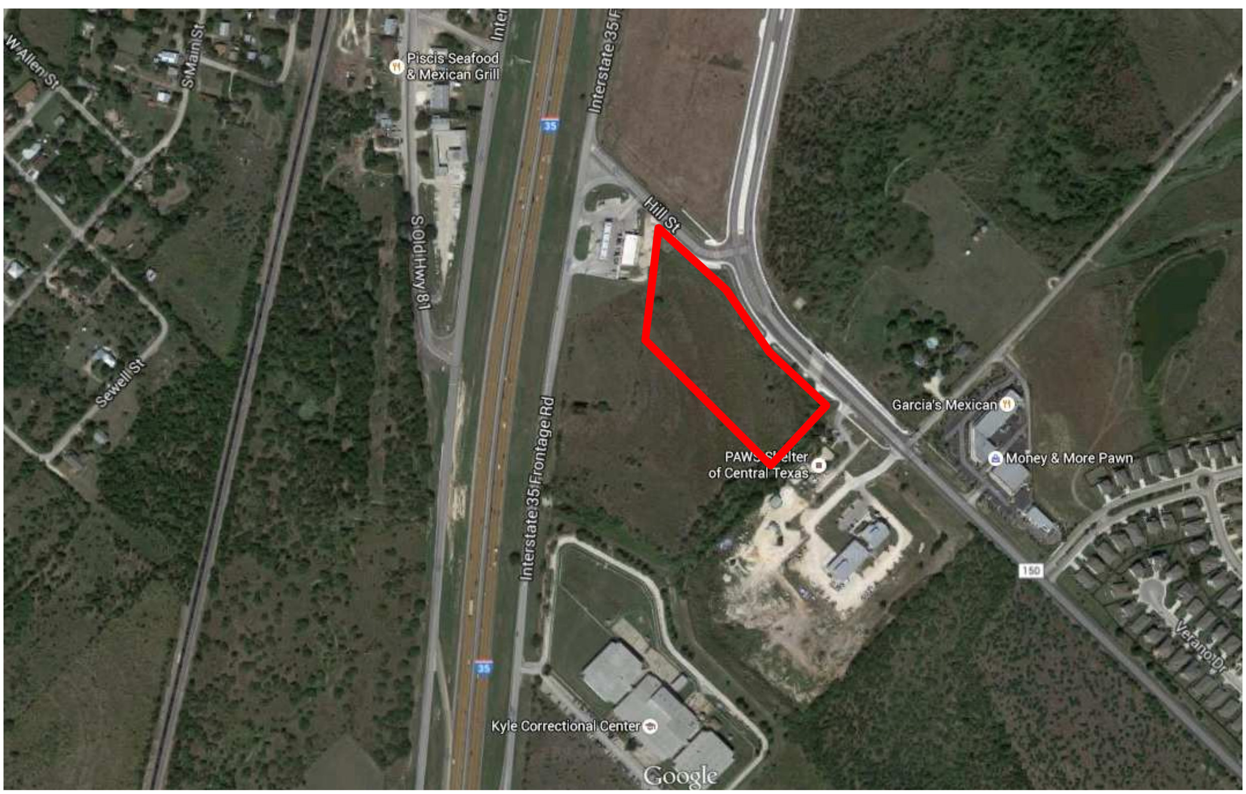
Viewing Attachments Requires Adobe Acrobat. Click here to download.

Attachments / click to download

- Location Map
- Ordinance with Exhibits A & B
- Application Packet
- Staff Memo

Property Location	**400 RR 150 E**
Petitioner	**John F. Patton, Director of Development** **MGCC Texas Enterprises, LLC** **P.O. Box 17788** **Austin, Texas 78760**
Owner	**MNT & S Development, LTD** **1508 West 5th Street, Suite 100** **Austin, Texas 78703**
Request	**Rezone 5.125 acres from AG (Agriculture) to R/S (Retail/Service)**

Vicinity Map



The site is located at 400 RR 150 E, which is directly south of the intersection of Hill Street and RR 150 E. The property, comprising 5.125 acres, is currently zoned AG (Agriculture), and is vacant. The lot in question is located on the southwest side of both RR 150 E and Hill Street. The adjacent lot to the northwest is zoned C-2 (Commercial – General Business) and is developed with a convenience store with gas pumps; the lots to the northeast, across RR 150 are zoned both R/S and AG, and are both as yet undeveloped. The properties to the southeast and southwest, across a small creek, are zoned AG, and house the PAWS animal shelter of Central Texas and the Kyle Correctional Center, respectively. The applicant seeks to rezone the subject property to R/S, a retail services zoning category for “the retail sale of goods and products to which value has been added on site, including sales of goods and services outside of the primary structure”.

Conditions of the Zoning Ordinance

§53-1205 – Amendments

…

(d) Referral of amendment to planning and zoning commission. Upon its own motion, a request by the planning and zoning commission, or the receipt of an administratively complete petition and application to zone or rezone a lot, tract or parcel of land, which petition and application has been examined and approved as to form by the city manager, shall be referred to the planning and zoning commission for consideration, public hearing, and recommendation to the city council. The council may not enact a rezoning amendment until the planning and zoning commission has held a public hearing and made its recommendation to the city council, or has made a final vote on the matter without obtaining a majority, on the zoning or rezoning of the property.

(e) Action by the planning and zoning commission. The planning and zoning commission shall cause such study and review to be made as advisable and required, shall give public notice and hold a public hearing as provided by state law, and shall recommend to the council such action as the planning and zoning commission deems proper…

Comprehensive Plan Text

The subject site is located in a ‘Regional Node’ character area. In the Regional Node, it is recommended that R/S be approved conditionally.

Regional Node “Character”: “Regional Nodes should have regional scale retail and commercial activity complemented by regional scale residential uses. These Nodes should represent the character and identity of Kyle, and signal these traits to the surrounding community. Regional Nodes have a radius of approximately 1/3 of a mile so that they are walkable, but are able to contain a greater range of uses at a larger scale than those found in Local Nodes. Appropriate uses may include grocery stores, retail shopping centers, multi-family housing, and municipal services, such as libraries and recreation centers.”

Regional Node “Intent”: “The primary goal of the Regional Nodes is to capture commercial opportunities necessary to close Kyle’s tax gap. To achieve this goal, these Nodes should draw upon anticipated regional growth and aggregate density to enhance value and activity levels in a concentrated and visible location. Regional Nodes should provide a mixture of uses that complements regional commercial activity, as well as encourage high intensity residential development. These Nodes should respond to other regional areas of growth, specifically along I-35 and FM 1626, and to growth toward Hwy 21, SH 45 and SH 130. The anchor of each Regional Node should be regional commercial uses, and Regional Nodes should have a high level of development intensity."

Recommendation

Establishing R/S zoning on this parcel is completely appropriate for this area of the city, especially in the context of "…draw[ing] upon anticipated regional growth and aggregate density to enhance value and activity levels *in a concentrated and visible location*." Staff recommends that this request should be considered favorably.

Planning Commission

At their regular July 14, 2015 meeting, the Planning Commission heard and considered this item at a Public Hearing. Following limited discussion, the Commission recommended approval of the request to assign R/S zoning to the property, 6-0 (Wilson absent).

Attachments

- Application
- Letter of intent
- Overhead map of the subject vicinity

ORDINANCE NO. ________

AN ORDINANCE AMENDING CHAPTER 53 (ZONING) OF THE CITY OF KYLE, TEXAS, FOR THE PURPOSE OF ASSIGNING ORIGINAL ZONING TO APPROXIMATELY 5.125 ACRES OF LAND FROM AGRICULTURE 'AG' TO RETAIL SERVICE DISTRICT 'RS', ON PROPERTY LOCATED AT 400 E. RR 150, IN HAYS COUNTY, TEXAS. (MNT & S DEVELOPMENT, LTD., Z-15-006); AUTHORIZING THE CITY SECRETARY TO AMEND THE ZONING MAP OF THE CITY OF KYLE SO AS TO REFLECT THIS CHANGE; PROVIDING FOR PUBLICATION AND EFFECTIVE DATE; PROVIDING FOR SEVERABILITY; AND ORDAINING OTHER PROVISIONS RELATED TO THE SUBJECT MATTER HEREOF; FINDING AND DETERMINING THAT THE MEETING AT WHICH THIS ORDINANCE WAS PASSED WAS OPEN TO THE PUBLIC AS REQUIRED BY LAW.

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF KYLE, TEXAS, THAT:

SECTION 1. That the zoning district map of the City of Kyle adopted in Chapter 53 (Zoning) be and the same is hereby amended to assign original zoning to approximately 5.125 acres from Agriculture 'AG' to Retail Service District 'RS', on property located at 400 E. RR 150, and the property location map labeled Exhibit B.

SECTION 2. That the City Secretary is hereby authorized and directed to designate the tract of land zoned herein as such on the zoning district map of the City of Kyle and by proper endorsement indicate the authority for said notation.

SECTION 3. If any provision, section, sentence, clause, or phrase of this Ordinance, or the application of same to any person or set of circumstances is for any reason held to be unconstitutional, void or invalid (or for any reason unenforceable), the validity of the remaining portions of this Ordinance or the application to such other persons or sets of circumstances shall not be affected hereby, it being the intent of the City Council of the City of Kyle in adopting this Ordinance, that no portion hereof or provision contained herein shall become inoperative or fail by reason of any unconstitutionality or invalidity of any other portion or provision.

SECTION 4. This Ordinance shall be published according to law and shall be and remain in full force and effect from and after the date of publication.

SECTION 5. It is hereby officially found and determined that the meeting at which this ordinance was passed was open to the public as required by law.

READ, CONSIDERED, PASSED AND APPROVED ON FIRST READING by the City Council of Kyle at a regular meeting on the ___ day of_______, 2015, at which a quorum was present and for which due notice was given pursuant to Section 551.001, et. Seq. of the Government Code.

READ, CONSIDERED, PASSED AND APPROVED ON SECOND AND FINAL READING by the City Council of Kyle at a regular meeting on the ______ day of ______, 2015, at which a quorum was present and for which due notice was given pursuant to Section 551.001, et. Seq. of the Government Code.

APPROVED this _________ day of ____________, 2015.

____
R. Todd Webster, Mayor

ATTEST:

____
Amelia Sanchez, City Secretary

EXHIBIT A

EXHIBIT A
Page 1 of 4

5.125 ac.
Z. Hinton Sur. No. 12 A-220
Hays County, Texas

Project No. 03-748
Fieldbook 335 Jan 14

A DESCRIPTION OF A CERTAIN 5.125 ACRE TRACT OF LAND SITUATED IN THE Z. HINTON SURVEY NO. 12, ABSTRACT 200, IN HAYS COUNTY, TEXAS;

SAID 5.125 ACRE TRACT HERE DESCRIBED BEING A PART OF THAT CERTAIN 12.13 ACRE TRACT OF LAND CONVEYED BY ADOLPH HILL AND WIFE, EMMA HILL, TO MAX GARRETT BY WARRANTY DEED DATED MARCH 19, 1974 RECORDED IN VOLUME 266 AT PAGE 297 OF THE HAYS COUNTY DEED RECORDS;

AND SAID 5.125 ACRE TRACT BEING MORE PARTICULARLY DESCRIBED BY METES AND BOUNDS FROM A SURVEY PERFORMED UPON THE GROUND UNDER THE DIRECTION OF KENT NEAL MCMILLAN, REGISTERED PROFESSIONAL LAND SURVEYOR, 2104 PARAMOUNT AVENUE, AUSTIN, TEXAS, AS FOLLOWS:

Bearings of lines in the following description refer to Grid North of the Texas Coordinate System (South Central Zone, NAD83) as computed from GPS vectors. At the POINT OF BEGINNING described below, True Azimuth = Grid Azimuth + 0°33'13".

Distances in the following description (unless otherwise noted) are **Horizontal Surface Distances** in units of US Survey Feet computed using an average project Combined Grid Factor of 0.999899 (Surface Distance = Grid Distance / 0.999899);

Coordinates noted in the following description are in **US Survey Feet** and refer to the **Texas Coordinate System** (South Central Zone; NAD83) as determined by survey from NGS Horizontal Control Point "AUSTIN RRP CORS L1 PHASE CENTER", taking the same to have a position of 30°18'42.08789", 97°45'22.71327", NAD83 (CORS, 1996.0) as published by the National Geodetic Survey;

In the following description, **"Standard Rod and Cap"** denotes a Punchmark on a 2 in. Aluminum Cap stamped "KENT MCMILLAN, SURVEYOR, RPLS 4341" (and numbered as noted) on a 5/8 in. Iron Rod;

"Standard Spike and Washer" denotes a 3/8 in. Steel Spike with a 2 in. Aluminum Washer stamped "KENT MCMILLAN, SURVEYOR, RPLS 4341" (and numbered as noted)

-oOo-

BEGINNING at an old 3/4 in. Iron Rod (Y=13906178.412, X=2326255.175) found on the Southwest line of the 80 ft. wide right-of-way of F.M. Highway 150 marking the East corner of that certain 12.13 acre tract of land conveyed by Adolph Hill et ux to Max Garrett by Warranty Deed dated March 19, 1974 recorded in Volume 266 at Page 297 of the Hays County Deed Records (HCDR), same marking the North corner of that certain 0.40 ac. strip of land designated as Tract 3 conveyed by Adoph Hill et al to Barbara Humble, Trustee, by Warranty Deed dated March 7, 1984 recorded in Volume 427 at Page 673 HCDR and marking also the North corner of that certain 1.10 acre tract of land conveyed by McCoy Corporation to Public for Animal Welfare, Inc.by Special Warranty Deed dated December 18, 1990 recorded in Volume 856 at Page 106 of the Hays County Official Public Records (HCOPR), noting that from said old 3/4 in. Iron Rod found:

- a Small Hole drilled in the Top Center of a Concrete Right-of-Way Marker (Y=13905530.799, X=2326945.885) found on the Southwest line of F.M. 150

(opposite Engineer's Centerline Station 29+45.2) bears N43°08'32"E, 40.00 ft.; S46°51'28"E, 947.01 ft.; and S43°15'57"W, 40.22 ft.;

- a Small Hole drilled in the Top Center of a Concrete Right-of-Way Marker (Y=13905589.371, X=2327001.015) found on the Northeast line of F.M. 150 (opposite Engineer's Centerline Station 29+45.2) bears N43°08'32"E, 40.00 ft.; S46°51'28"E, 947.01 ft.; and N43°15'57"E, 40.22 ft.;

- a Standard Spike and Washer No. 61 (Y=13907325.904, X=2325030.754) set in the Center of the base of a broken Concrete Right-of-Way Marker found on the Southwest line of F.M. 150 (opposite Engineer's Centerline Station 3+18.4) bears N43°08'32"E, 40.00 ft.; N46°51'28"W, 1678.25 ft.; and S43°08'32"W, 40.00 ft., same point being on the West line of the right-of-way of Interstate Highway 35 opposite Engineer's Centerline Station 457+68.6 as shown upon the Texas Highway Department Right-of-way Map for Interstate Highway No. 35 dated April, 1958)

- the Top Center of a Concrete Right-of-Way Marker (Y=13907459.564, X=2324973.620) found on the North east line of F.M. 150 (opposite Engineer's Centerline Station 1+95.8) bears N43°08'32"E, 40.00 ft.; N46°51'28"W, 1740.09 ft.; N65°14'28"W, 61.80 ft.; and N24°45'32"E, 40.00 ft.;

- a Standard Spike and Washer No. 50 (Y=13906880.177, X=2325498.369, set in the base of a broken Concrete Right-of-Way Marker found opposite Engineer's Centerline Station 461+35.87 for Interstate Highway 35 (using the above mentioned Right-of-Way Marker found at 457+68.6 as the basis of stationing), 307.87 ft. distant in an Easterly direction from said Centerline as located by this resurvey) bears N43°08'32"E, 40.00 ft.; N46°51'28"W, 1032.19 ft.; and S43°08'32"W, 45.46 ft., (noting that this Marker does not actually lie upon the Southwest line of F.M. 150 as conveyed to the State of Texas by Adolph Hill et ux by Right-of-Way Deed dated February 18, 1947 recorded in Volume 137 at Page 298 HCDR);

- a Standard Rod and Cap No. 220 (Y=13906160.172, X=2326238.082) set to mark the recognized North corner of that certain 14.937 ac. tract of land conveyed to the City of Kyle as described in Judgment entered September 25, 1970 in Cause No. 2182, City of Kyle, Texas v. Adolph Hill, et al, Proceedings in Eminent Domain in the County Court of Hays County, Texas, and recorded in Volume "G" at Page 318 of the Minutes of the County Court, bears S43°08'32"W, 25.00 ft.;

- a Standard Rod and Cap No. 221 (Y=13905576.504, X=2325691.088) set in the bottom of a Drainage Channel to mark the West corner of said 14.937 ac. City of Kyle tract bears S43°08'32"W, 825.00 ft.;

- an old 1/2 in. Iron Rod (Y=13905616.526, X=2325729.754) found and taken as marking the South corner of the 12.13 ac. Max Garrett tract as described in Deed recorded in Volume 266 at Page 297 HCDR bears S43°08'32"W, 769.57 ft. and S61°34'07"E, 0.87 ft.;

- an old 1/2 in. Iron Pipe (Y=13905859.639, X=2325280.715) found 0.77 ft. distant in an Easterly direction from the curving East line of Interstate Highway 35, but taken as marking the Southwest corner of the said 12.13 ac. Max Garrett tract as described in the Deed to Garrett, bears S43°08'32"W, 769.57 ft. and N61°34'07"W, 509.80 ft., said Iron Pipe marking also the North corner of that certain 39.13 acre tract of land designated as "Tract 1"conveyed by Adoph Hill et al to Barbara Humble, Trustee by Deed dated March 12, 1984 recorded in Volume 427 at Page 673 of the Hays County Real Property Records (HCRPR) and also the

North corner of Lot 1 of KYLE T.D.C. PRE-RELEASE FACILITIES SUBDIVISION NO. 1, according to the Plat recorded in Book 5 at Page 39 of the Hays County Plat Records;

- a Standard Rod and Cap No. 222 (Y=13905616.942, X=2325728.986) set on the Northwest line of the above mentioned 14.937 ac. City of Kyle tract to mark the true South corner of the 12.13 ac. Max Garrett tract bears S43°08'32"W, 769.57 ft.;

- a 5/8 in. Iron Rod found (Y=13905604.508, X=2325719.226) by a Fence Post and taken as marking an Angle Point on the Northeast line of Lot 1 of KYLE T.D.C. PRE-RELEASE FACILITIES SUBDIVISION NO. 1, as shown upon the Plat of said subdivision bears S43°08'32"W, 785.64 ft. and S59°48'31"E 1.42 ft.;

- the above-mentioned 1/2 in. Iron Pipe marking the North corner of said Lot 1 bears S43°08'32"W, 785.64 ft. and N59°48'31"W, 505.96 ft.;

- a Standard Rod and Cap No. 217 (Y=13905605.221, X=2325718.001) set to mark the point at which the Northeast line of said Lot 1 as platted intersects the Northwest line of the 14.937 acre City of Kyle tract bears S43°08'32"W, 785.64 ft.;

- a 1/2 in. Iron Rod found with yellow plastic cap imprinted "BYRN SURVEY" bears S47°00'09"E, 149.98 ft., said Rod and Cap being taken as marking the North corner of that certain 0.31 acre strip of land conveyed by McCoy Corporation to the City of Kyle by Warranty Deed dated September 29, 1987 recorded in Volume 698 at Page 676 HCDR

- a 1/2 in. Iron Rod found and taken as marking the West corner of that certain 1.01 acre tract of land conveyed by the City of Kyle to McCoy Corporation as described in Warranty Deed dated September 30, 1987 recorded in Volume 698 at Page 679 HCRPR bears S43°08'32"W, 319.90 ft. and S46°48'47"E, 4.78 ft.

- a Standard Rod and Cap No. 228 (Y=13905945.015, X=2326036.443) set on the Northwest line of the 14.937 acre City of Kyle tract bears S43°08'32"W, 319.90 ft.

1) **THENCE** along the Northwest line of the 14.937 acre tract of land conveyed to the City of Kyle as described in Judgment entered September 25, 1970 in Cause No. 2182, City of Kyle, Texas v. Adolph Hill, et al, Proceedings in Eminent Domain in the County Court of Hays County, Texas, and recorded in Volume "G" at Page 318 of the Minutes of the County Court, same being the true Southeast line of the 12.13 acre Max Garrett tract, **S43°08'32"W, 303.80 ft.** to a Standard Rod and Cap No. 226 (Y=13905956.764, X=2326047.454) set to mark the South corner of the 5.125 acre tract here described;

2) **THENCE** into the interior of the 12.13 acre Max Garrett tract, **N46°51'28"W, 339.22 ft.** to a Standard Rod and Cap No. 234 (Y=13906188.706, X=2325799.961) set;

3) **THENCE N46°51'28"W, 291.08 ft.** to a Standard Rod and Cap No. 225 (Y=13906387.733, X=2325587.589) set on the West line of the 12.13 acre Max Garrett tract to mark the West corner of the 5.125 acre tract here described, noting that from said Rod and Cap set:

- an old 3/4 in. Iron Pipe found marking the re-entrant corner on the West line of the 12.13 acre Max Garrett tract bears S8°36'23"W, 277.12 ft. said Pipe marking also the South corner of that certain 3.989 acre parcel designated as "Tract Two" conveyed by Adolph Hill et al. to Cromwell Company, James B. Hobbs, and Dillo, Inc. as described in Warranty Deed dated October 24, 1980 recorded in Volume 349 at Page 235 HCDR, said 3.989 acre parcel having been subsequently platted as WARREN SUBDIVISION according to the Plat recorded in Volume 7 at Page 12 HCPR,

- a 1-1/4 in. Iron Pipe found in Concrete marking the East corner of Lot 1 of WARREN SUBDIVISION (although found to actually lie within the 80 ft. wide Right-of-Way of F.M. Highway 150) bears N8°36'23"E, 369.36 ft., and

- a 1/2 in. Iron Rod found in Concrete marking an Angle Point on the Northeast line of said Lot 1 bears N8°36'23"E, 369.36 ft. and N46°58'15"W, 83.49 ft.

4) **THENCE** along the Northwest line of the 12.13 acre Max Garrett tract, **N8°36'23"E,**

- at 167.34 ft. passing a 1" Iron Pipe (Y=13906553.174, X=2325612.629) found in Concrete marking the East common corner of Lots 1 and 2 of WARREN SUBDIVISION (noting that from said Pipe a 1 in. Iron Pipe found marking the West common corner of Lots 1 and 2, bears N80°49'07"W, 246.01 ft.),

in all for a total distance of **368.79 ft.** to a Standard Rod and Cap No. 224 (Y=13906752.334, X=2325642.772) set at the intersection of the true Southwest line of F.M. 150, same being the Southwest line of that certain 3.26 acre strip of land conveyed by Adolph Hill et ux to the State of Texas by Right-of-Way Deed dated February 18, 1947 recorded in Volume 137 at Page 298 HCDR, and being 40.00 ft. distant from the Engineer's Centerline for F.M. 150;

5) **THENCE** along the Southwest line of F.M. 150, parallel with the Engineer's Centerline as located by this resurvey, **S46°51'28"E, 839.38 ft.** to the **POINT OF BEGINNING;**

CONTAINING in all 5.125 acres of land within the above described metes.

I, Kent Neal McMillan, a Registered Professional Land Surveyor, hereby certify that the above is a true and correct representation of the results of an actual survey performed upon the ground under my direction, completed January 23, 2003.

Witness my hand and seal of registration
January 27, 2002.

Kent Neal McMillan

Kent Neal McMillan
Registered Professional Land Surveyor
No. 4341
2104 Paramount Avenue, Austin TX 78704
Telephone (512) 445-5441

EXHIBIT "B"

(Permitted Exceptions)

1. Electric transmission lines and systems easement granted to Texas Power & Light Company, by instrument dated October 28, 1927, recorded in Volume 94, Page 481 of the Deed Records of Hays County, Texas.

2. Floodwater retarding structure easement granted to Plum Creek Conservation District of Lockhart, Texas, by instrument dated February 27, 1967, recorded in Volume 216, Page 59 of the Deed Records of Hays County, Texas.

3. An undivided one-sixteenth (1/16th) royalty interest in all oil, gas and other minerals reserved by The Federal Land Bank of Houston in instrument recorded in Volume 117, Page 152 of the Deed Records of Hays County, Texas.

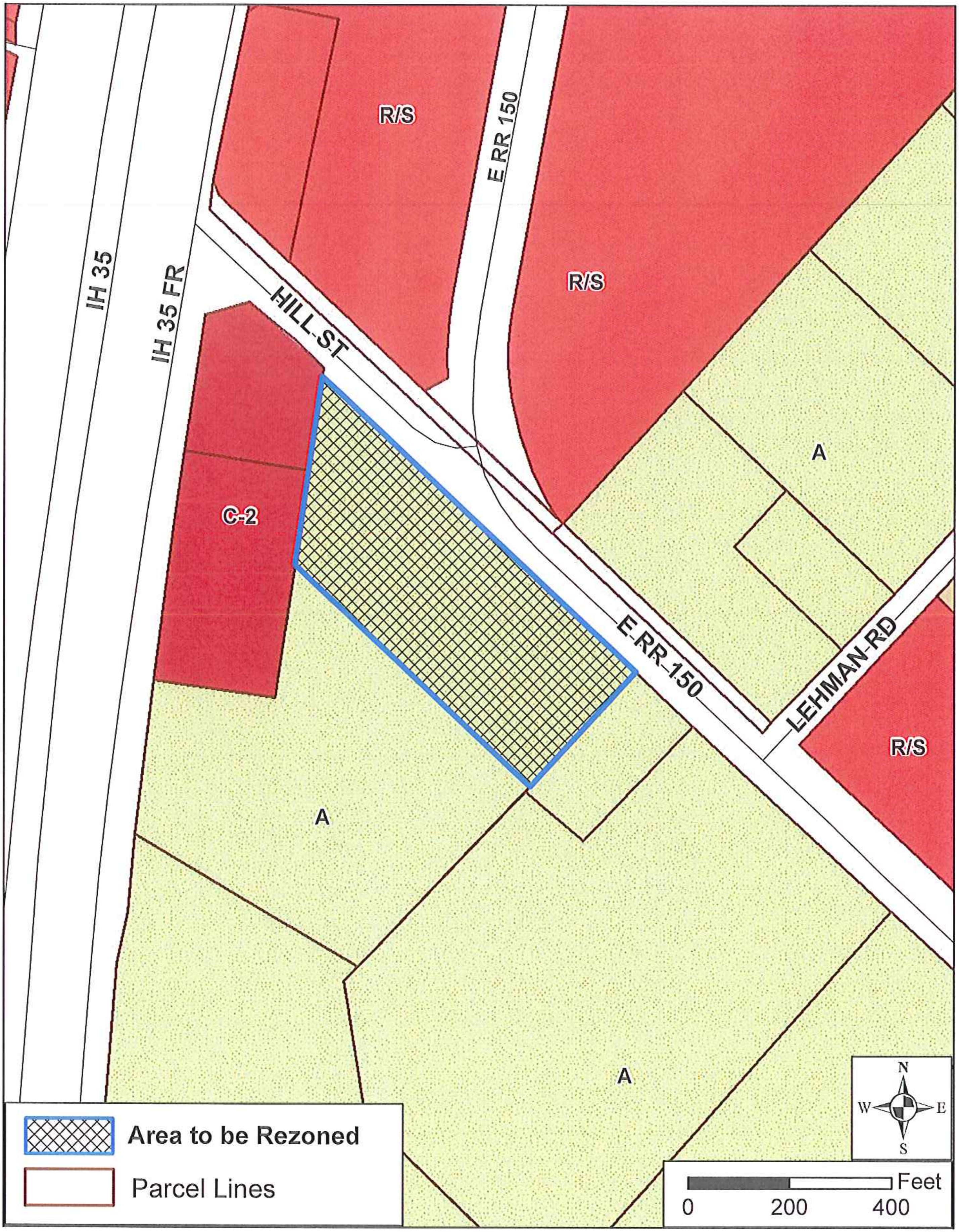
4. Sewer line easement granted in Decree entered in Cause No. 2182, in the County Court of Hays County, Texas styled, "City of Kyle vs. Adolph Hill, et al" as set out in Volume G, Page 318 of the Minutes of the County Court of Hays County, Texas.

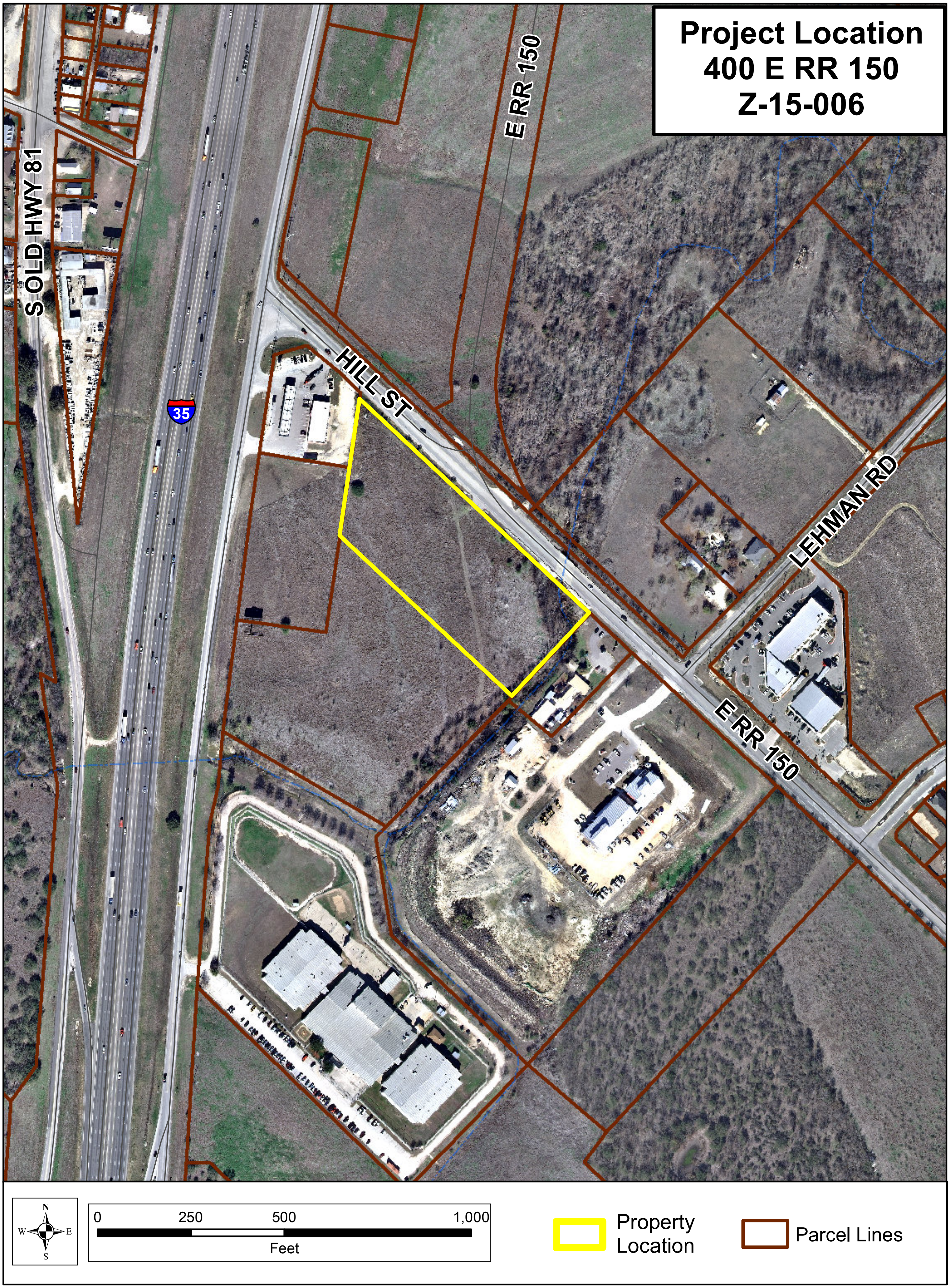
5. Surface Damage Release and Drill Site Easement dated October 29, 1997 as evidenced by survey dated January 23, 2003, prepared by Kent Neal McMillan, Registered Professional Land Surveyor No. 4341 (the "Survey").

6. Fence lies inside the southeasterly property line as shown on survey dated January 23, 2003, prepared by Kent Neal McMillan, Registered Professional Land Surveyor No. 4341 (the "Survey").

7. Easement rights, if any, implied by location of the sewer lines lying outside of the dedicated sewer line easement described in Permitted Exception 4 above.

Exhibit B Z-15-006





Project Location
400 E RR 150
Z-15-006
E RR 150
S OLD HWY 81
35
HILL ST
LEHMAN RD
E RR 150
N
W
E
S
0
250
500
1,000
Feet
Property Location
Parcel Lines

APPLICATION & CHECKLIST – ZONING CHANGE

CITY OF KYLE

Zoning: MNT & S Development LTD (Name of Owner) 06/11/15 (Submittal Date)

JUN 16 2015

PLANNING DEPARTMENT

INSTRUCTIONS: Z-15-004

- Fill out the following application and checklist completely prior to submission.
- Place a check mark on each line when you have complied with that item.
- Use the most current application from the City's website at www.cityofkyle.com or at City Hall. City ordinances can be obtained from the City of Kyle.

REQUIRED ITEMS FOR SUBMITTAL PACKAGE:

The following items are required to be submitted to the Planning Department in order for the Zoning Application to be accepted.

✓ 1. Completed application form with owner's original signature.

✓ 2. Letter explaining the reason for the request.

✓ 3. Application *fee*: $428.06, plus $3.62 per acre or portion thereof.

Newspaper Publication Fee: $190.21

Total Fee: $428.06 + (3.62 x 5.125ac = 18.55) + 190.21 = $636.82

✓ 4. A map or plat showing the area being proposed for rezoning.

✓ 5. A clear and legible copy of field notes (metes and bounds) describing the tract (when not a subdivided lot).

✓ 6. Certified Tax certificates: County __ School __ City __

✓ 7. Copy of Deed showing current ownership.

**** A submittal meeting is required. Please contact Debbie Guerra at (512) 262-3959 to schedule an appointment.*

1. Zoning Request:

Current Zoning Classification: A - Agriculture

Proposed Zoning Classification: R/S - Retail Service

Proposed Use of the Property: Sonic Drive-In & Future Other Retail Services

Acreage/Sq. Ft. of Zoning Change: 5.125ac.

2. Address and Legal Description:

Provide certified field notes describing the property being proposed for rezoning.
Provide complete information on the location of the property being proposed for rezoning.

Street Address: 400 FM 150 E

Subdivision Name/Lot & Block Nos.: ________

Property Recording Information: ☑ Hays County
Volume/Cabinet No. VL-3555 Page/Slide No. PG-547 to PG-554

3. Ownership Information:

Name of Property Owner(s): MNT & S Development LTD

(If property ownership is in the name of a partnership, corporation, joint venture, trust or other entity, please list the official name of the entity and the name of the managing partner.)

Address of Owner: 1508 West 5th Street; Suite 100
Austin TX 78703

Phone Number: 512-322-2008, Ext. 802

Fax Number:

Email Number: mark@primusre.com

I hereby request that my property, as described above, be considered for rezoning:

Signed: Mark Shields

Date: 6/15/2015

4. Agent Information:

If an agent is representing the owner of the property, please complete the following information:

Agent's Name: John F Patton; Director of Development, MGCC Texas Enterprises LLC

Agent's Address: P.O.Box 17788 Austin TX 78760

Agent's Phone Number: 512-923-0529

Agent's Fax Number:

Agent's Mobile Number: 512-923-0529

Agent's Email Number: jpatton@austinsonics.com

I hereby authorize the person named above to act as my agent in processing this application before the Planning and Zoning Commission and City Council of the City of Kyle:

Owner's Signature: Mark Shields

Date: 6/15/2015

Do Not Write Below This Line
Staff Will Complete

Tax Certificates: ☑ County ☑ School ☑ City

Certified List of Property Owners Within 200" ☑

All Fees Paid: ☑ Filing/Application ☑ Mail Out Costs

Attached Map of Subject Property ☑

Accepted for Processing By: Debbie A. Guerra Date: ________

CITY OF KYLE
JUN 16 2015
PLANNING DEPARTMENT

Date of Public Notification in Newspaper: 6/24/15

Date of Public Hearing Before Planning and Zoning Commission: 7/14/15

Date of Public Hearing Before City Council: 7/21/15 & 8/4/15

Licensed Franchise of Sonic Inc.
Austin Partners, L.L.P.
PO Box 17788 • Austin, TX 78760
Tel: (512) 462-0393 • Fax (512) 462-3639

June 11, 2015

Ms. Debbie Guerra
City of Kyle Texas
Planning Department
By Hand Delivery

Debbie,

Our Sonic Drive-In development entity MGCC Texas Enterprises LLC has contracted to purchase the eastern 40thousand+ square feet out of the 5.125ac tract on FM 150 E currently owned by MNT & S Development LTD; so MNT & S Development LTD and we wish to initiate a Zoning Change on the 5.125ac tract from its current A-Agriculture classification to R/S-Retail Services.

A completed Zoning Change Application Form with required Checklist items accompanies this Letter of Explanation.

We/MGCC Texas Enterprises LLC will follow up the Zoning Change on this 5.125ac with Preliminary Plat, Final Plat, Site Plan, and Building Plan submissions for a new Sonic Drive-In to be constructed on the tract.

Sincerely,

John F Patton

John F Patton
Director of Development
MGCC Enterprises LLC

S Old Highway 81
Ih 35
Ih 35
Ih 35
Ih 35
Ih 35
Ih 35
Ih 35
35
FM-150
FM-150
150
150
LOT 2
LOT 1
SONIC
Lehman Rd
SONIC DRIVE-IN RM 150
KYLE, TX
Mountain City
Kyle
PROJECT SITE
1 inch = 200 feet
N
MOELLER & ASSOCIATES
bing
Nokia © AND © 2015
Microsoft Corporation

70 2008 80039407

Hays County
Linda C. Fritsche
County Clerk
San Marcos, Texas 78666

Instrument Number: 2008-80039407

As

Recorded On: December 16, 2008 **OPR RECORDINGS**

Parties: REILLY BUTTE DEVELOPMENT LLC **Billable Pages: 7**

To **MNT & S DEVELOPMENT LTD** **Number of Pages: 8**

Comment:

(Parties listed above are for Clerks reference only)

**** Examined and Charged as Follows: ****

OPR RECORDINGS	40.00
Total Recording:	40.00

**************** DO NOT REMOVE. THIS PAGE IS PART OF THE INSTRUMENT ****************

Any provision herein which restricts the Sale, Rental or use of the described REAL PROPERTY because of color or race is invalid and unenforceable under federal law.

File Information:

Document Number: 2008-80039407
Receipt Number: 208613
Recorded Date/Time: December 16, 2008 10:53:04A
Book-Vol/Pg: BK-OPR VL-3555 PG-547
User / Station: O Martinez - Cashering #2

Record and Return To:

HERITAGE TITLE
401 CONGRESS AVE STE 1500
AUSTIN TX 78701

COUNTY COURT OF HAYS COUNTY, TEXAS

State of Texas |
County of Hays

I hereby certify that this instrument was filed for record in my office on the date and time stamped hereon and was recorded on the volume and page of the named records of Hays County, Texas

Linda C. Fritsche

Linda C. Fritsche, County Clerk

80350

Bk Vol Pg
80039407 OPR 3555 548

NOTICE OF CONFIDENTIALLY RIGHTS; IF YOU ARE A NATURAL PERSON, YOU MAY REMOVE OR STRIKE ANY OR ALL OF THE FOLLOWING INFORMATION FROM ANY INSTRUMENT THAT TRANSFERS AN INTEREST IN REAL PROPERTY BEFORE IT IS FILED FOR RECORD IN THE PUBLIC RECORDS: YOUR SOCIAL SECURITY NUMBER OR YOUR DRIVER'S LICENSE NUMBER."

GENERAL WARRANTY DEED
[Re-conveyance Instrument]

THE STATE OF TEXAS §
§ KNOW ALL PERSONS BY THESE PRESENTS:
COUNTY OF HAYS §

That Reilly Butte Development, LLC ("**Grantor**"), whose address is 1567 SW Chandler, Ste. 101, Bend, OR 97702, is an Exchange Accommodation Titleholder in a Qualified Exchange Accommodation Arrangement for MNT & S Development, Ltd., a Texas limited partnership ("**Grantee**"), whose address is 1508 West 5th Street, Ste. 100, Austin, TX 78703. As such, Grantor acquired the property herein conveyed from Craig Fuller((the "**Original Grantor**") pursuant to a general warranty deed dated October 1, 2003 and filed of record on October 2, 2003 in Volume 2326, Page 206 (Document number 03031962) of the Official Public Records of Hays County, Texas, as the replacement property in a reverse exchange under Section 1031 of the Internal Revenue Code and Internal Revenue Procedure 2000-37 (Reverse Exchanges).

The proposed reverse exchange failed to occur within the time frame allowed under Section 1031 of the Internal Revenue Code and Internal Revenue Procedure 2000-37 (Reverse Exchanges). This deed is therefore being made and delivered to re-convey to Grantee the property described below, with the effect being the same as if the transfer from Original Grantor pursuant to the deed referenced above had been made to Grantee in place of Grantor.

Now, Therefore, Grantor as an Exchange Accommodation Title Holder in the above referenced Qualified Exchange Accommodation Arrangement for Grantee in a reverse exchange under Section 1031 of the Internal Revenue Code and Internal Revenue Procedure 2000-37 (Reverse Exchanges), for and in consideration of the sum of TEN AND NO/100 DOLLARS and other valuable consideration to the undersigned paid by the Grantee herein named, the receipt of which is hereby acknowledged, have GRANTED, SOLD AND CONVEYED, and by these presents do GRANT, SELL AND CONVEY unto Grantee, all of the following described real property (the "Property") in Hays County, Texas, to-wit:

> 5.125 acres of land, more or less, in the Z. Hinton Survey No 12, Abstract No. 200, in Hays County, Texas as more fully described in as more fully identified in the attached **Exhibit "A"** attached hereto and incorporated by this reference for all purposes.

The obligation to pay current ad valorem taxes on the Property herein described, as well as any and all so called "roll back taxes" are assumed by Grantee. This conveyance is made subject to the liens securing payment of ad valorem taxes for the current and subsequent calendar years, as well as all easements now of record in Hays County, Texas, or visible or apparent on the ground, and all reservations, covenants, conditions and restrictions, which are applicable to the Property hereby conveyed, and Grantee, by the acceptance of delivery of this General Warranty Deed does hereby assume and agree to perform all of the obligations of Grantor under the aforesaid easements, reservations, covenants and restrictions.

TO HAVE AND TO HOLD the above described Property, together with all and singular the rights and appurtenances thereto in anywise belonging, unto to said Grantee, its successors and assigns forever; and Grantor does hereby bind Grantor, its successors and assigns to WARRANT AND FOREVER DEFEND all and singular the said Property unto the said Grantee, its successors and assigns against every person whomsoever lawfully claiming or to claim the same or any part thereof.

EXECUTED on December 15, 2008 to be effective as of and retroactive to October 2, 2003.

Grantor: REILLY BUTTE DEVELOPMENT, LLC
By: Three Sisters Development Co., Inc., Sole Member

By: ______________________
Doug Ruby, Vice President

THE STATE OF TEXAS §
COUNTY OF TRAVIS §

This instrument was acknowledged before me on December 15, 2008, by Doug Ruby, Vice President of Three Sisters Development Co., Inc., as the Sole Member of REILLY BUTTE DEVELOPMENT, LLC

____
Notary Public, State of Texas

AFTER RECORDING, RETURN TO:
Craig A. Dunagan P.C.
2004 Lakeshore Drive
Austin, Texas 78746

SOPHIE C. GAMWELL
Notary Public, State of Texas
My Commission Expires
March 13, 2010

5.125 ac.
Z. Hinton Sur. No. 12 A-220
Hays County, Texas

Project No. 03-748
Fieldbook 335 Jan 14

A DESCRIPTION OF A CERTAIN 5.125 ACRE TRACT OF LAND SITUATED IN THE Z. HINTON SURVEY NO. 12, ABSTRACT 200, IN HAYS COUNTY, TEXAS;

SAID 5.125 ACRE TRACT HERE DESCRIBED BEING A PART OF THAT CERTAIN 12.13 ACRE TRACT OF LAND CONVEYED BY ADOLPH HILL AND WIFE, EMMA HILL, TO MAX GARRETT BY WARRANTY DEED DATED MARCH 19, 1974 RECORDED IN VOLUME 266 AT PAGE 297 OF THE HAYS COUNTY DEED RECORDS;

AND SAID 5.125 ACRE TRACT BEING MORE PARTICULARLY DESCRIBED BY METES AND BOUNDS FROM A SURVEY PERFORMED UPON THE GROUND UNDER THE DIRECTION OF KENT NEAL MCMILLAN, REGISTERED PROFESSIONAL LAND SURVEYOR, 2104 PARAMOUNT AVENUE, AUSTIN, TEXAS, AS FOLLOWS:

Bearings of lines in the following description refer to Grid North of the Texas Coordinate System (South Central Zone, NAD83) as computed from GPS vectors. At the POINT OF BEGINNING described below, True Azimuth = Grid Azimuth + 0°33'13".

Distances in the following description (unless otherwise noted) are **Horizontal Surface Distances** in units of US Survey Feet computed using an average project Combined Grid Factor of 0.999899 (Surface Distance = Grid Distance / 0.999899);

Coordinates noted in the following description are in **US Survey Feet** and refer to the **Texas Coordinate System** (South Central Zone; NAD83) as determined by survey from NGS Horizontal Control Point "AUSTIN RRP CORS L1 PHASE CENTER", taking the same to have a position of 30°18'42.08789", 97°45'22.71327", NAD83 (CORS, 1996.0) as published by the National Geodetic Survey;

In the following description, **"Standard Rod and Cap"** denotes a Punchmark on a 2 in. Aluminum Cap stamped "KENT MCMILLAN, SURVEYOR, RPLS 4341" (and numbered as noted) on a 5/8 in. Iron Rod;

"Standard Spike and Washer" denotes a 3/8 in. Steel Spike with a 2 in. Aluminum Washer stamped "KENT MCMILLAN, SURVEYOR, RPLS 4341" (and numbered as noted)

-oOo-

BEGINNING at an old 3/4 in. Iron Rod (Y=13906178.412, X=2326255.175) found on the Southwest line of the 80 ft. wide right-of-way of F.M. Highway 150 marking the East corner of that certain 12.13 acre tract of land conveyed by Adolph Hill et ux to Max Garrett by Warranty Deed dated March 19, 1974 recorded in Volume 266 at Page 297 of the Hays County Deed Records (HCDR), same marking the North corner of that certain 0.40 ac. strip of land designated as Tract 3 conveyed by Adoph Hill et al to Barbara Humble, Trustee, by Warranty Deed dated March 7, 1984 recorded in Volume 427 at Page 673 HCDR and marking also the North corner of that certain 1.10 acre tract of land conveyed by McCoy Corporation to Public for Animal Welfare, Inc.by Special Warranty Deed dated December 18, 1990 recorded in Volume 856 at Page 106 of the Hays County Official Public Records (HCOPR), noting that from said old 3/4 in. Iron Rod found:

- a Small Hole drilled in the Top Center of a Concrete Right-of-Way Marker (Y=13905530.799, X=2326945.885) found on the Southwest line of F.M. 150

(opposite Engineer's Centerline Station 29+45.2) bears N43°08'32"E, 40.00 ft.; S46°51'28"E, 947.01 ft.; and S43°15'57"W, 40.22 ft.;

- a Small Hole drilled in the Top Center of a Concrete Right-of-Way Marker (Y=13905589.371, X=2327001.015) found on the Northeast line of F.M. 150 (opposite Engineer's Centerline Station 29+45.2) bears N43°08'32"E, 40.00 ft.; S46°51'28"E, 947.01 ft.; and N43°15'57"E, 40.22 ft.;

- a Standard Spike and Washer No. 61 (Y=13907325.904, X=2325030.754) set in the Center of the base of a broken Concrete Right-of-Way Marker found on the Southwest line of F.M. 150 (opposite Engineer's Centerline Station 3+18.4) bears N43°08'32"E, 40.00 ft.; N46°51'28"W, 1678.25 ft.; and S43°08'32"W, 40.00 ft., same point being on the West line of the right-of-way of Interstate Highway 35 opposite Engineer's Centerline Station 457+68.6 as shown upon the Texas Highway Department Right-of-way Map for Interstate Highway No. 35 dated April, 1958)

- the Top Center of a Concrete Right-of-Way Marker (Y=13907459.564, X=2324973.620) found on the North east line of F.M. 150 (opposite Engineer's Centerline Station 1+95.8) bears N43°08'32"E, 40.00 ft.; N46°51'28"W, 1740.09 ft.; N65°14'28"W, 61.80 ft.; and N24°45'32"E, 40.00 ft.;

- a Standard Spike and Washer No. 50 (Y=13906880.177, X=2325498.369, set in the base of a broken Concrete Right-of-Way Marker found opposite Engineer's Centerline Station 461+35.87 for Interstate Highway 35 (using the above mentioned Right-of-Way Marker found at 457+68.6 as the basis of stationing), 307.87 ft. distant in an Easterly direction from said Centerline as located by this resurvey) bears N43°08'32"E, 40.00 ft.; N46°51'28"W, 1032.19 ft.; and S43°08'32"W, 45.46 ft., (noting that this Marker does not actually lie upon the Southwest line of F.M. 150 as conveyed to the State of Texas by Adolph Hill et ux by Right-of-Way Deed dated February 18, 1947 recorded in Volume 137 at Page 298 HCDR);

- a Standard Rod and Cap No. 220 (Y=13906160.172, X=2326238.082) set to mark the recognized North corner of that certain 14.937 ac. tract of land conveyed to the City of Kyle as described in Judgment entered September 25, 1970 in Cause No. 2182, City of Kyle, Texas v. Adolph Hill, et al, Proceedings in Eminent Domain in the County Court of Hays County, Texas, and recorded in Volume "G" at Page 318 of the Minutes of the County Court, bears S43°08'32"W, 25.00 ft.;

- a Standard Rod and Cap No. 221 (Y=13905576.504, X=2325691.088) set in the bottom of a Drainage Channel to mark the West corner of said 14.937 ac. City of Kyle tract bears S43°08'32"W, 825.00 ft.;

- an old 1/2 in. Iron Rod (Y=13905616.526, X=2325729.754) found and taken as marking the South corner of the 12.13 ac. Max Garrett tract as described in Deed recorded in Volume 266 at Page 297 HCDR bears S43°08'32"W, 769.57 ft. and S61°34'07"E, 0.87 ft.;

- an old 1/2 in. Iron Pipe (Y=13905859.639, X=2325280.715) found 0.77 ft. distant in an Easterly direction from the curving East line of Interstate Highway 35, but taken as marking the Southwest corner of the said 12.13 ac. Max Garrett tract as described in the Deed to Garrett, bears S43°08'32"W, 769.57 ft. and N61°34'07"W, 509.80 ft., said Iron Pipe marking also the North corner of that certain 39.13 acre tract of land designated as "Tract 1"conveyed by Adoph Hill et al to Barbara Humble, Trustee by Deed dated March 12, 1984 recorded in Volume 427 at Page 673 of the Hays County Real Property Records (HCRPR) and also the

North corner of Lot 1 of KYLE T.D.C. PRE-RELEASE FACILITIES SUBDIVISION NO. 1, according to the Plat recorded in Book 5 at Page 39 of the Hays County Plat Records;

- a Standard Rod and Cap No. 222 (Y=13905616.942, X=2325728.986) set on the Northwest line of the above mentioned 14.937 ac. City of Kyle tract to mark the true South corner of the 12.13 ac. Max Garrett tract bears S43°08'32"W, 769.57 ft.;

- a 5/8 in. Iron Rod found (Y=13905604.508, X=2325719.226) by a Fence Post and taken as marking an Angle Point on the Northeast line of Lot 1 of KYLE T.D.C. PRE-RELEASE FACILITIES SUBDIVISION NO. 1, as shown upon the Plat of said subdivision bears S43°08'32"W, 785.64 ft. and S59°48'31"E 1.42 ft.;

- the above-mentioned 1/2 in. Iron Pipe marking the North corner of said Lot 1 bears S43°08'32"W, 785.64 ft. and N59°48'31"W, 505.96 ft.;

- a Standard Rod and Cap No. 217 (Y=13905605.221, X=2325718.001) set to mark the point at which the Northeast line of said Lot 1 as platted intersects the Northwest line of the 14.937 acre City of Kyle tract bears S43°08'32"W, 785.64 ft.;

- a 1/2 in. Iron Rod found with yellow plastic cap imprinted "BYRN SURVEY" bears S47°00'09"E, 149.98 ft., said Rod and Cap being taken as marking the North corner of that certain 0.31 acre strip of land conveyed by McCoy Corporation to the City of Kyle by Warranty Deed dated September 29, 1987 recorded in Volume 698 at Page 676 HCDR

- a 1/2 in. Iron Rod found and taken as marking the West corner of that certain 1.01 acre tract of land conveyed by the City of Kyle to McCoy Corporation as described in Warranty Deed dated September 30, 1987 recorded in Volume 698 at Page 679 HCRPR bears S43°08'32"W, 319.90 ft. and S46°48'47"E, 4.78 ft.

- a Standard Rod and Cap No. 228 (Y=13905945.015, X=2326036.443) set on the Northwest line of the 14.937 acre City of Kyle tract bears S43°08'32"W, 319.90 ft.

1) **THENCE** along the Northwest line of the 14.937 acre tract of land conveyed to the City of Kyle as described in Judgment entered September 25, 1970 in Cause No. 2182, City of Kyle, Texas v. Adolph Hill, et al, Proceedings in Eminent Domain in the County Court of Hays County, Texas, and recorded in Volume "G" at Page 318 of the Minutes of the County Court, same being the true Southeast line of the 12.13 acre Max Garrett tract, **S43°08'32"W, 303.80 ft.** to a Standard Rod and Cap No. 226 (Y=13905956.764, X=2326047.454) set to mark the South corner of the 5.125 acre tract here described;

2) **THENCE** into the interior of the 12.13 acre Max Garrett tract, **N46°51'28"W, 339.22 ft.** to a Standard Rod and Cap No. 234 (Y=13906188.706, X=2325799.961) set;

3) **THENCE N46°51'28"W, 291.08 ft.** to a Standard Rod and Cap No. 225 (Y=13906387.733, X=2325587.589) set on the West line of the 12.13 acre Max Garrett tract to mark the West corner of the 5.125 acre tract here described, noting that from said Rod and Cap set:

   - an old 3/4 in. Iron Pipe found marking the re-entrant corner on the West line of the 12.13 acre Max Garrett tract bears S8°36'23"W, 277.12 ft. said Pipe marking also the South corner of that certain 3.989 acre parcel designated as "Tract Two" conveyed by Adolph Hill et al. to Cromwell Company, James B. Hobbs, and Dillo, Inc. as described in Warranty Deed dated October 24, 1980 recorded in Volume 349 at Page 235 HCDR, said 3.989 acre parcel having been subsequently platted as WARREN SUBDIVISION according to the Plat recorded in Volume 7 at Page 12 HCPR,

- a 1-1/4 in. Iron Pipe found in Concrete marking the East corner of Lot 1 of WARREN SUBDIVISION (although found to actually lie within the 80 ft. wide Right-of-Way of F.M. Highway 150) bears N8°36'23"E, 369.36 ft., and

- a 1/2 in. Iron Rod found in Concrete marking an Angle Point on the Northeast line of said Lot 1 bears N8°36'23"E, 369.36 ft. and N46°58'15"W, 83.49 ft.

4) **THENCE** along the Northwest line of the 12.13 acre Max Garrett tract, **N8°36'23"E,**

- at 167.34 ft. passing a 1" Iron Pipe (Y=13906553.174, X=2325612.629) found in Concrete marking the East common corner of Lots 1 and 2 of WARREN SUBDIVISION (noting that from said Pipe a 1 in. Iron Pipe found marking the West common corner of Lots 1 and 2, bears N80°49'07"W, 246.01 ft.),

in all for a total distance of **368.79 ft.** to a Standard Rod and Cap No. 224 (Y=13906752.334, X=2325642.772) set at the intersection of the true Southwest line of F.M. 150, same being the Southwest line of that certain 3.26 acre strip of land conveyed by Adolph Hill et ux to the State of Texas by Right-of-Way Deed dated February 18, 1947 recorded in Volume 137 at Page 298 HCDR, and being 40.00 ft. distant from the Engineer's Centerline for F.M. 150;

5) **THENCE** along the Southwest line of F.M. 150, parallel with the Engineer's Centerline as located by this resurvey, **S46°51'28"E, 839.38 ft.** to the **POINT OF BEGINNING;**

CONTAINING in all 5.125 acres of land within the above described metes.

I, Kent Neal McMillan, a Registered Professional Land Surveyor, hereby certify that the above is a true and correct representation of the results of an actual survey performed upon the ground under my direction, completed January 23, 2003.

Witness my hand and seal of registration
January 27, 2002.

Kent Neal McMillan
Registered Professional Land Surveyor
No. 4341
2104 Paramount Avenue, Austin TX 78704
Telephone (512) 445-5441

EXHIBIT "B"

(Permitted Exceptions)

1. Electric transmission lines and systems easement granted to Texas Power & Light Company, by instrument dated October 28, 1927, recorded in Volume 94, Page 481 of the Deed Records of Hays County, Texas.

2. Floodwater retarding structure easement granted to Plum Creek Conservation District of Lockhart, Texas, by instrument dated February 27, 1967, recorded in Volume 216, Page 59 of the Deed Records of Hays County, Texas.

3. An undivided one-sixteenth (1/16th) royalty interest in all oil, gas and other minerals reserved by The Federal Land Bank of Houston in instrument recorded in Volume 117, Page 152 of the Deed Records of Hays County, Texas.

4. Sewer line easement granted in Decree entered in Cause No. 2182, in the County Court of Hays County, Texas styled, "City of Kyle vs. Adolph Hill, et al" as set out in Volume G, Page 318 of the Minutes of the County Court of Hays County, Texas.

5. Surface Damage Release and Drill Site Easement dated October 29, 1997 as evidenced by survey dated January 23, 2003, prepared by Kent Neal McMillan, Registered Professional Land Surveyor No. 4341 (the "Survey").

6. Fence lies inside the southeasterly property line as shown on survey dated January 23, 2003, prepared by Kent Neal McMillan, Registered Professional Land Surveyor No. 4341 (the "Survey").

7. Easement rights, if any, implied by location of the sewer lines lying outside of the dedicated sewer line easement described in Permitted Exception 4 above.

Issue Date : 6/18/2015

TAX CERTIFICATE

Luanne Caraway Tax Assessor-Collector, Hays County
712 S. Stagecoach Trail
San Marcos, TX 78666
Ph: 512-393-5545 Fax: 512-393-5517

This certificate includes tax years up to 2014

Entities to which this certificate applies:

SHA - Hays Consolidated ISD
WPC - Plum Creek Groundwater District
FHA - Hays Co ESD #5
ACCD - AUSTIN COMMUNITY COLLEGE DISTRICT
PCC - Plum Creek Conservation District
RSP - Special Road Dist
GHA - Hays County
CKY - City Of Kyle

Property Information

Property ID : 10-0220-0066-00001-2
Quick-Ref ID : R106974

E IH 35/FM 150 KYLE, TX 78640

A0220 Z HINTON SURVEY, ACRES 4.835

Value Information

Land HS	:	$0.00
Land NHS	:	$170,050.00
Imp HS	:	$0.00
Imp NHS	:	$0.00
Ag Mkt	:	$0.00
Ag Use	:	$0.00
Tim Mkt	:	$0.00
Tim Use	:	$0.00
HS Cap Adj	:	$0.00
Assessed	:	$170,050.00

Owner Information

Owner ID : O0092082

MNT & S DEVELOPMENT LTD
2630 EXPOSITION BLVD
STE G-05
AUSTIN, TX 78703

Ownership: 100.00%

Suit Information: 06-1079

This Document is to certify that after a careful check of the Tax Records of this Office, the following Current or Delinquent Taxes, Penalties, and Interest are due on the Property for the Taxing Entities described above:

Entity	Year	Tax	Discount	P&I	Atty Fee	TOTAL
PCC	2014	37.41	0.00	0.00	0.00	0.00
SHA	2014	2,614.86	0.00	0.00	0.00	0.00
RSP	2014	74.48	0.00	0.00	0.00	0.00
WPC	2014	37.41	0.00	0.00	0.00	0.00
GHA	2014	723.05	0.00	0.00	0.00	0.00
FHA	2014	170.05	0.00	0.00	0.00	0.00
CKY	2014	915.38	0.00	0.00	0.00	0.00
ACCD	2014	160.18	0.00	0.00	0.00	0.00

Total for current bills if paid by 6/30/2015 : $0.00
Total due on all bills 6/30/2015 : $0.00
2014 taxes paid for entity PCC $37.41
2014 taxes paid for entity SHA $2,614.86
2014 taxes paid for entity RSP $74.48
2014 taxes paid for entity WPC $37.41
2014 taxes paid for entity GHA $723.05
2014 taxes paid for entity FHA $170.05
2014 taxes paid for entity CKY $915.38
2014 taxes paid for entity ACCD $160.18

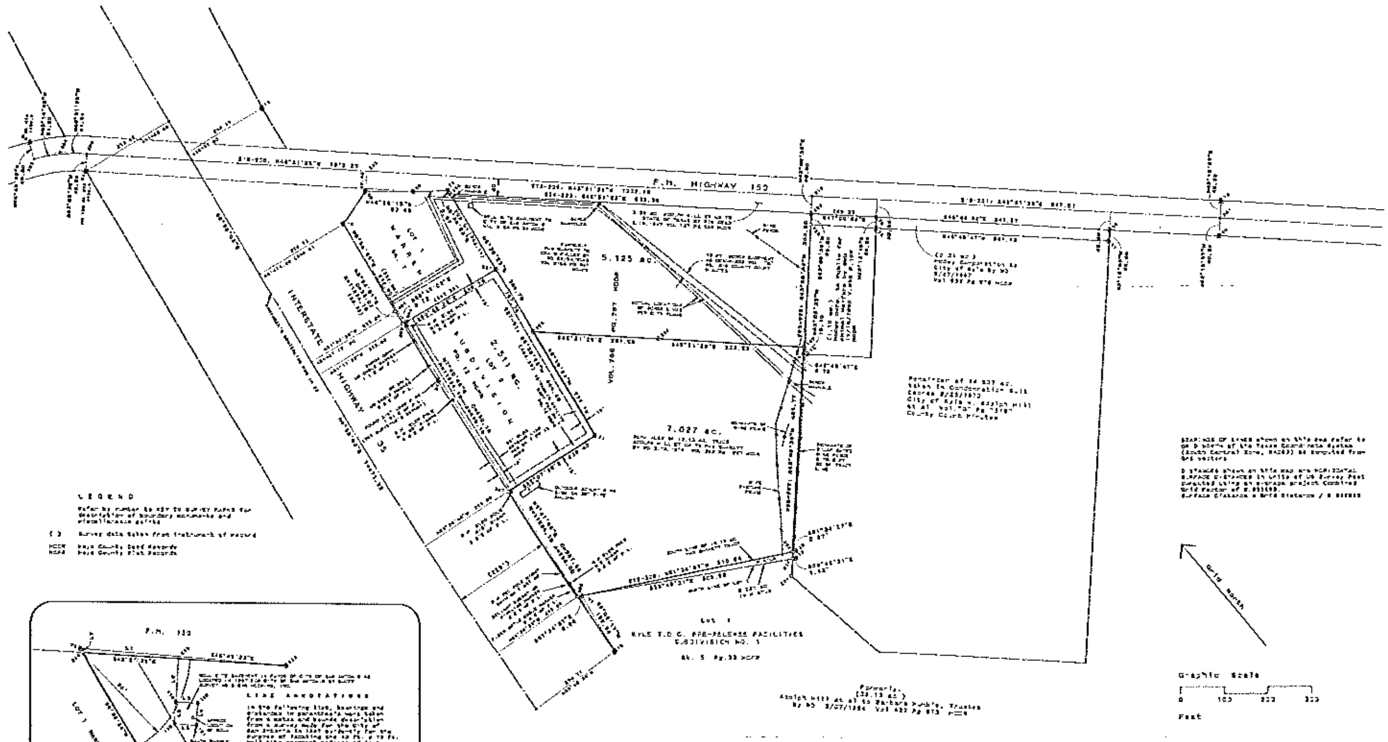
2014 Total Taxes Paid : $4,732.82

Date of Last Payment : 01/09/15

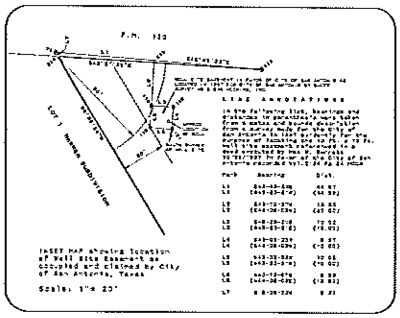
If applicable, the above-described property is receiving special valuation based on its use. Additional rollback taxes that may become due based on the provisions of the special valuation are not indicated in this document.

This certificate does not clear abuse of granted exemptions as defined in Section 11.43, Paragraph (i) of the Texas Property Tax Code.

Signature of Authorized Officer of the Tax Office	Date of Issue : 06/18/2015 Requestor : MNT & S DEVELOPMENT LTD Receipt : SM-2015-826439 Fee Paid : $10.00 Payer : JOHN PATTON



L E G E N D

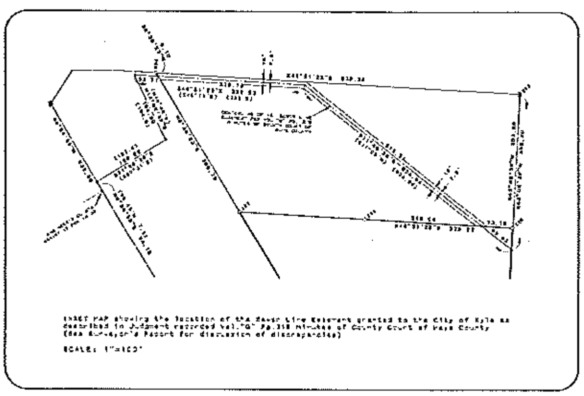


INSET MAP showing location of Well Site Easement as occupied and claimed by City of San Antonio, Texas

Scale: 1"= 20'

L E G E N D

N O T E S



INSET MAP showing the location of the Power Line Easement granted to the City of Kyle as described in Judgment recorded Vol."G" Pg.318 Minutes of County Court of Hays County (See Surveyor's Report for discussion of discrepancies)

SCALE: 1"=100'

K E Y T O S U R V E Y M A R K S

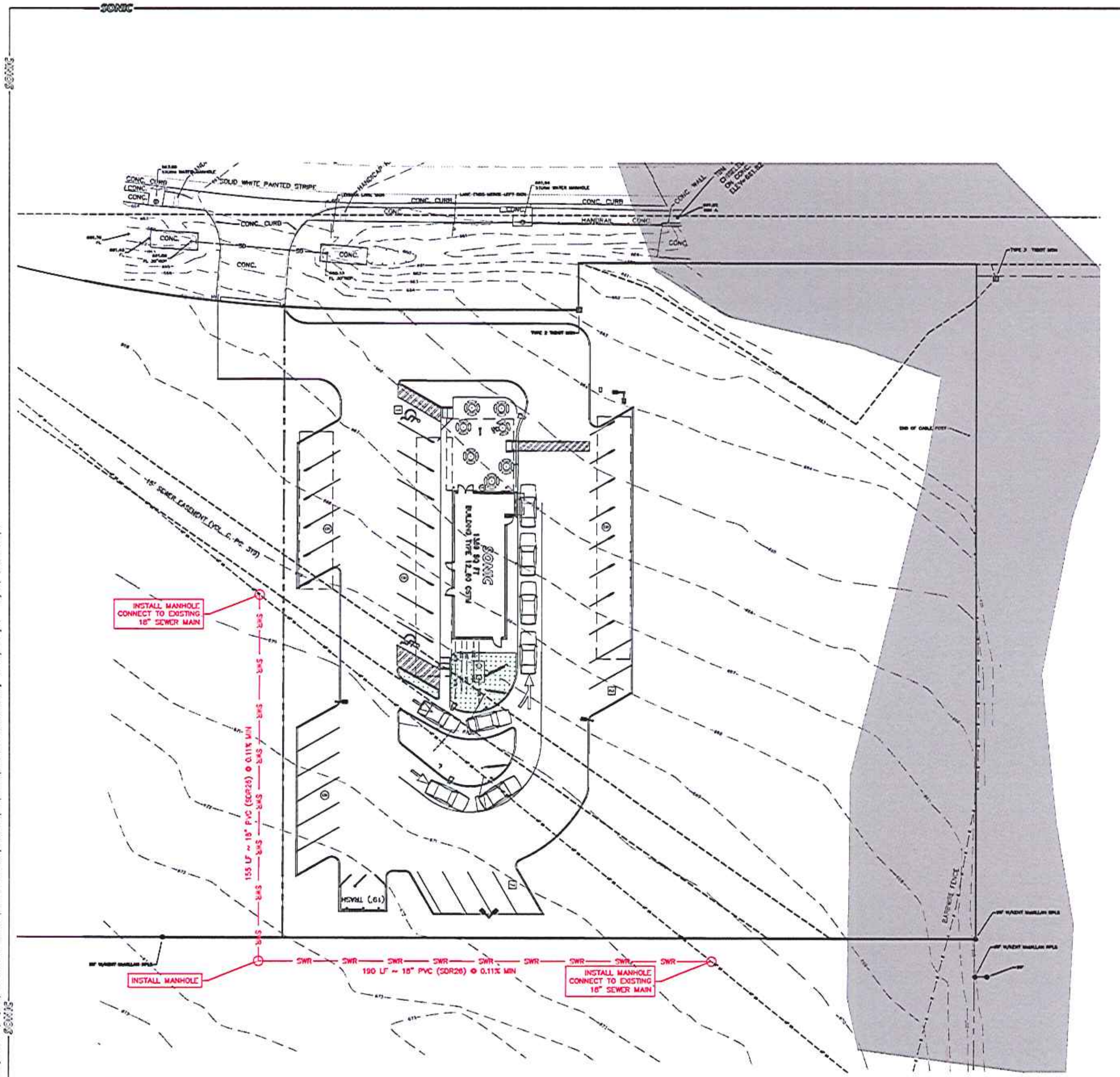
C O O R D I N A T E L I S T

M A P O F S U R V E Y

Of a Certain 7.027 Acre Tract of Land Situated in the Z. Hinton Survey No. 12, A-200, in Hays County, Texas

Being the remainder of that certain 12.13 acre tract of land conveyed by Adolph Hill et ux to Max Garrett by WD March 19, 1974 recorded Vol.265 at Pg.237 HCDR

Made by
Kent McMillan, Land Surveyor
2104 Paramount Avenue



MOELLER & ASSOCIATES *Engineering Solutions*

Sonic Drive-In, FM 150, Kyle, Texas
Offsite Sewer Re-Alignment
Engineer's Opinion of Probable Costs
Pre-Design
5-26-2015

On-Site Sewer Items					
Item Number	Description	Quantity	Unit	Unit Price	Total Price
	New Manhole 4' dia	3	EACH	$5,800.00	$17,400.00
	Extra Depth Manhole 4' dia	3	VF	$300.00	$900.00
	Trench Protection	345	LF	$1.50	$517.50
	Pipe, 18" Dia (PVC SDR-26) (0-8') Including Excavation and Backfill	345	LF	$65.00	$22,425.00
Sewer Subtotal					$41,242.50

This document is released for the purpose for interim review under the authority of James Ingalls, P.E. 107416, on this date May 26, 2015. It is to be used for review purposes only, and is not to be used for permitting, bidding, or construction.

Sub-Total	$41,242.50
Engineering/Coord	$4,000.00
Contingency (15%)	$6,186.38
Total	$51,428.88

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF JAMES I. INGALLS, PE 107416 ON May 26, 2015. IT IS TO BE USED FOR BIDDING AND PERMITTING PURPOSES ONLY. NOT TO BE USED FOR CONSTRUCTION.

NO	DATE	REVISIONS

MOELLER & ASSOCIATES *Engineering Solutions*
1040 N. WALNUT AVE. STE B, NEW BRAUNFELS, TX 78130
PH: 830-358-7127 www.ma-tx.com
TBPE FIRM F-13351

SONIC CORPORATION
300 JOHNNY BENCH DRIVE
OKLAHOMA CITY, OK 73104
OFFICE: 405-225-5000

MASON HARRISON RATLIFF ENTERPRISES, LLC
5139 NORTHWEST 23RD ST
OKLAHOMA CITY, OKLAHOMA 73142

SONIC DRIVE-IN — SONIC TYPE: 10 CSTM.
FM 150 — KYLE, TEXAS
LEGAL DESCRIPTION:
OFFSITE SEWER EXHIBIT

SHEET
EX

DATE: 05/26/15

CITY OF KYLE, TEXAS

Interlocal Agreement with City of San Marcos

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Authorize execution of an interlocal agreement between the City of Kyle, and the City of San Marcos to establish the terms in the installation of gateway monument signs in each city's jurisdiction. ~ *J. Scott Sellers, City Manager*

Other Information:

Legal Notes:

Budget Information:

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Attachments / click to download

Kyle-San Marcos Sign Agreement

INTERLOCAL AGREEMENT

This Interlocal Agreement (the "Agreement") is entered into effective as of September 1, 2015 (the "Effective Date") between the City of Kyle, Texas, a municipal corporation ("Kyle") and the City of San Marcos, Texas, a municipal corporation ("San Marcos") under the authority of the Texas Interlocal Cooperation Act, Chapter 791 of the Texas Government Code.

I. Recitals

1.01. The cities of Kyle and San Marcos share a common boundary line along IH-35 near the Yarrington Road overpass.

1.02. The Texas Department of Transportation ("TXDOT") has authorized funding to assist both cities install gateway monument signs within TXDOT right-of-way north and south of Yarrington Road.

1.03. San Marcos wishes to place its sign within the city limits of Kyle to welcome visitors approaching San Marcos from the north, while Kyle wishes to place its sign within the city limits of San Marcos to welcome visitors approaching Kyle from the south.

1.04. Before TXDOT will allow such gateway monument sign installations, it requires the mutual consent of each city to allow the placement of the other's sign within its city limits.

1.05. The purpose of this Agreement is to delineate the rights and responsibilities of the parties with regard to the installation of said gateway monument signs. The activities of the parties under this Agreement are governmental as defined in §791.003 of the Texas Government Code.

1.06. In consideration of the foregoing and the following mutual promises, covenants, benefits and agreements contained herein, San Marcos and Kyle enter into this Agreement.

II. Sign Installation

Section 2.01. Consent to Signs. Kyle and San Marcos each consent to the other's installation of a gateway monument sign within its city limits.

Section 2.02. Sign Types and Locations. The signs installed by the parties shall comply with the standards under TXDOT's Gateway Monument Program Guidelines, attached hereto as Exhibit "A," and made a part hereof for all purposes, and shall be subject to approval by TXDOT. Each sign will be located within the areas of TXDOT right-of-way as shown on Exhibit "C, attached hereto and made a part hereof for all purposes.

Section 2.03. Maintenance. The parties shall maintain their respective signs in good, clean and safe repair and condition, free of graffiti and obstructions. Each party hereby grants permission to the other to enter into its city limits within the areas shown in Exhibit "B," in order to conduct necessary sign maintenance and repairs.

Section 2.04. Subject to TXDOT Rules. Notwithstanding any of the provisions in this Agreement, including the duration of this Agreement under Section 3.01, the installation of signs under this Agreement shall be subject to any applicable rules, regulations and guidelines as established by TXDOT, including the Gateway Monument Program Guidelines, which shall control in the event of any conflict.

III. Term, Default and Termination

Section 3.01. Term; Termination. The initial term of this Agreement is ten years commencing on the Effective Date and ending on August 31, 2025. This Agreement will renew automatically for successive one-year terms unless either party elects to terminate the Agreement by providing written notice of termination to the other party. Upon termination of this Agreement, each patty shall be responsible for removing its sign from the other's city limits within a reasonable time, but in no event, longer than 180 days after the date of termination.

IV. Miscellaneous Provisions

Section 4.01. Compliance with Laws. The obligations of Kyle and San Marcos under this Agreement are subject to all applicable federal, state and local laws and regulations currently in effect and as amended or modified from time to time, including any and all changes to the municipal boundaries of either Kyle or San Marcos over the course of the Agreement.

Section 4.02. Independent Contractors. Nothing in this Agreement will be construed as creating any form of partnership or joint venture relationship between the parties. The parties are independent contractors with respect to each other.

Section 4.03. Assignment. This Agreement will inure to the benefit of, and be binding upon, the successors and permitted assigns of the parties. Except as provided elsewhere herein, neither party may assign any of its rights or duties under this Agreement without the written consent of the other party.

Section 4.04. Amendments. This Agreement may be amended only through a written amendment executed by the parties.

Section 4.05. Governing Law and Venue. This Agreement is governed by the laws of the State of Texas. Venue for any dispute shall be in the appropriate state courts of Hays County, Texas.

Section 4.06. Severability. If any the provision of this Agreement is held to be invalid or unenforceable by a court of proper jurisdiction, the holding will not affect any other provisions of this Agreement if the Agreement can be given effect without the invalid provision.

Section 4.07. Remedies; No Waivers. It is not intended hereby to specify, and this Agreement shall not be considered as specifying, an exclusive remedy for any default, but all such other remedies existing at law or in equity may be availed of by either party and shall be cumulative. No waiver or waivers of any breach or default, or any breaches or defaults, made by a party hereto of any term, covenant, condition or liability hereunder or the performance by the other party of any duty or obligation hereunder shall be deemed or construed to be a waiver of subsequent breaches or defaults of any kind.

Section 4.08. Notices. All notices given under this Agreement will be delivered personally, by certified mail, return receipt requested, or by confirmed fax transmission, by overnight mail or by courier, to the following address for the respective party:

To San Marcos: San Marcos City Manager
City of San Marcos
630 East Hopkins Street
San Marcos, TX 78666
Fax No. (512) 396-4656

To Kyle: Kyle City Manager
City of Kyle
100 West Center Street
Kyle, Texas 78640
Fax: (512) 262-3800

EXECUTED to be effective as of the Effective Date first stated above.

City of San Marcos:

By: ______________________________
Jared Miller, City Manager

Date: ______________________________

City of Kyle:

By: ______________________________
Scott Sellers, City Manager

Date: ______________________________

[EXHIBITS NEED TO BE ATTACHED]

CITY OF KYLE, TEXAS

Marketplace Extension Adjustment Svcs and Fees

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Approve Supplement No. 1 to engineering services agreement with K FRIESE & ASSOCIATES, INC., Austin, Texas, in order to reduce the contract amount by $44,840.00 and related scope of work for engineering and environmental services associated with the Marketplace Avenue improvement project. ~ *Leon Barba, P.E., City Engineer*

Other Information: The consultant was able to use environmental and surveying information provided by the developer. The cost for the environmental services was $14,348.00 and the cost for the surveying was $30,492.00. The total amount of the reduction is $44,840.00.

Legal Notes:

Budget Information: A Fiscal Note is not required. This City Council action, if approved, will increase the amount of available funds by $44,480.00.

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Attachments / click to download

- Marketplace Extension Letter

K·FRIESE + ASSOCIATES
PUBLIC PROJECT ENGINEERING

1120 S. Capital of Texas Highway
CityView 2, Suite 100
Austin, Texas 78746
TBPE Firm #6535
P - 512.338.1704 F - 512.338.1784
kfriese.com

Wednesday, June 17, 2015

Ms. Jo Ann Garcia, PE
City of Kyle
100 W Center St
Kyle, TX 78640

Sent Via: Email

Re: Marketplace Avenue – Scope Modifications

Dear Ms. Garcia:

Attached please find the following proposed modifications to the Marketplace Avenue design scope.

1.) McGray & McGray proposal for parcel notes and sketches for Marketplace. $3500/parcel x 4 parcels. The 5th parcel (Parker Family Trust) that fronts along Burleson was already part of their Burleson project work.

2.) Proposed Updated fee schedule, reflecting changes to the project scope. In summary, we:

a. Eliminated all Geotech work
b. Suspended the schematic phase at the 95% level, as requested.
c. Reduced environmental investigations to $14,568 - This was, and remains an hourly/NTE task. To date, we have not used any of this task.
d. Added lump sum survey task $14,000 for roadway easement survey & descriptions
e. Added time for additional survey easements & coordination ($16,492) – I propose this task be hourly/NTE, as well
f. Added waterline design along Burleson Road and preliminary WW layout tasks.

The overall contract total has been reduced from $364,134 to $325,662 with $44,840 in Hourly/NTE tasks.

Sincerely,

Joseph Skidmore

Joseph Skidmore, PE

Enclosure: McGray & McGray Fee Proposal, Update Marketplace fee schedule

February 24, 2015

McGRAY & McGRAY
LAND SURVEYORS, INC.

B. Ryan Bell, P.E.
K. Friese + Associates
1120 S Capital of Texas Highway
Cityview 2, Ste. 100
Austin, TX 78746
(512) 338-1704

VIA EMAIL
rbell@kfriese.com

RE: Proposal for Boundary Surveying Services for the Marketplace Avenue Extension Project, City of Kyle, Texas

Dear Mr. Bell:

We appreciate the opportunity to present you with this proposal for boundary surveying services for the above referenced project. The following represents our understanding of the area to survey, scope of services, and our fee proposal.

Scope of Services:

- Provide 4 plats and metes and bounds descriptions for proposed Right-of-Way acquisitions. (see attached sketch)
- Recover the corner or angle point monuments pertinent to the proposed ROW of Marketplace Avenue on the front and side lines of each of the properties to be acquired.
- Utilizing the boundary surveys and the proposed ROW line location provided by client, we will compute the boundaries of the right-of-way parcels for each of the subject properties.
- Draft plats for each of the ROW parcels. The plats will be prepared on 8 1/2" x 11" pages at a scale not smaller than 1 inch equals 100 feet. A closure computation will be prepared for each of the plats.
- Prepare a metes and bounds description for each of the ROW parcels. A closure computation will be prepared for each of the descriptions. Metes and bounds descriptions will indicate parent tract areas based on recorded information only.
- Plats, metes and bounds descriptions, and closure computations will be submitted to client for review. Upon the completion of review of all ROW survey documents, Surveyor will make revisions as needed and address review comments. Revised documents will be returned to client in final format.
- Set property corners using 1/2 inch rebar with caps. Corners will be placed at property line intersections with the new ROW, and at P.C.'s, P.T.'s and angle points on new ROW within each of the acquisition parcels. No monumentation will be placed on existing ROW in those areas where no additional ROW is being acquired.

- Provide two legal descriptions for each parcel (original signed and sealed).
- Provide two individual plats for each parcel (original signed and sealed).
- Provide area computation sheets for plats and metes and bounds descriptions for all acquisition parcels.
- Provide engineer with a MicroStation V8i, drawing file showing boundary lines with an ASCII point file.

Fees:
These surveying services will be provided on a per parcel basis of $3,500.00, not to exceed the fee of $14,000.00 plus 8.25% sales tax of $1,155.00, for a total of **$15,155.00**. Since this project includes taxable services, we will need to receive a Texas Sales and Use Tax Resale Certificate for those services prior to starting the project. If one is not available, sales tax will be charged.

We will proceed as soon as we receive notice to proceed. We estimate it will take approximately 4 to 6 weeks (weekends and holidays excluded) from notice to proceed to complete this project, weather and circumstances beyond our control permitting. Please let us know if we need to accelerate this schedule.

Thank you for including us on this project. We look forward to the opportunity to work with you. If you think we have omitted any service you require or misinterpreted your request, please let me or Chris Conrad know.

Sincerely,

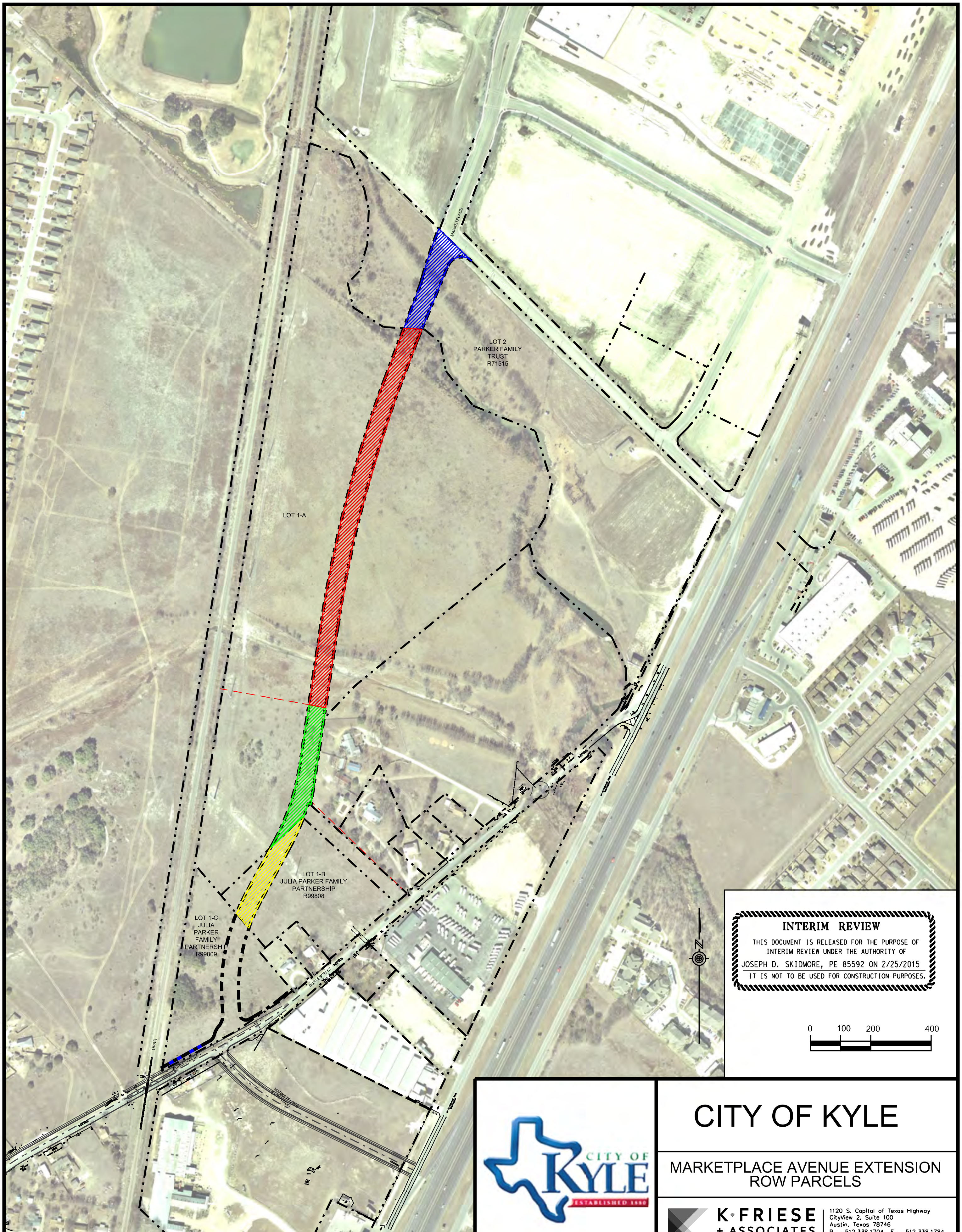
Judith J. McGray, RPLS
President
TBPLS Firm #10095500

Authorized to Proceed by:

Signature Date

Print Name Title

JJM:CIC:klr
Encl.



INTERIM REVIEW

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF JOSEPH D. SKIDMORE, PE 85592 ON 2/25/2015

IT IS NOT TO BE USED FOR CONSTRUCTION PURPOSES.

CITY OF KYLE

MARKETPLACE AVENUE EXTENSION ROW PARCELS

K•FRIESE + ASSOCIATES
PUBLIC PROJECT ENGINEERING

1120 S. Capital of Texas Highway
CityView 2, Suite 100
Austin, Texas 78746
P – 512.338.1704 F – 512.338.1784
TBPE Firm Number 6535
www.kfriese.com

X:\Projects\0351-Kyle_Marketplace\DGN\Exhibits\0351_Exhibit_ROW Parcels.dgn modified by rbell on 2/25/2015 - 2:07:26 PM

City of Kyle - Marketplace Avenue
Exhibit "C"

Market Place Avenue (N. Burleson St. to City Lights Drive)

Compensation Summary

Project Phase	Work Task	Compensation Type	Amount
Schematic and Environmental	Geotechnical Investigation & Pavement Design	Lump Sum	$ -
	Schematic Design	Lump Sum	$ 35,411.82
	Environmental Documentation	Hourly/NTE	$ 14,568.00
	Survey (Roadway Easement Parcels)	Per Parcel	$ 14,000.00
	Additional Easments & Coordination	Hourly/NTE	$ 16,492.00
Design	30% PSE Submittal	Lump Sum	$ -
	60% PSE Submittal	Lump Sum	$ 86,500.00
	90% PSE Submittal	Lump Sum	$ 62,765.18
	100% PSE Submittal	Lump Sum	$ 26,537.00
	Waterline Design	Lump Sum	$ 27,168.00
Bidding	Bidding Phase Services	Lump Sum	$ 10,310.00
Construction	Construction Administration and Close Out	Lump Sum	$ 31,910.00
Total Compensation			$ 325,662.00

City of Kyle - Marketplace Avenue
Exhibit "C"

TASK	COMPENSATION TYPE	KFA	ACI	McGray & McGray	KHA	HVJ	Total Labor Cost
PROJECT MANAGEMENT							
1. Overall Project Management	LS	$ 10,184.00	$ -	$ -	$ 945.00	$ -	$ 11,129.00
2. Meetings	LS	$ 10,184.00	$ -	$ -	$ 1,950.00	$ -	$ 12,134.00
PHASE I - PRELIMINARY ENGINEERING PHASE							
1. Kick-Off Meeting & Site Reconnaissance	LS	$ 2,932.00	$ -	$ -	$ -	$ -	$ 2,932.00
2. Data Gathering	LS	$ 778.00	$ -	$ -	$ -	$ -	$ 778.00
3. North Burleson Coordination	LS	$ 4,372.00	$ -	$ -	$ -	$ -	$ 4,372.00
4. Environmental Documentation							
Task 1 - Environmental Background Studies & Review	Hourly/NTE	$ 2,988.00	$ 11,360.00	$ -	$ -	$ -	$ 14,348.00
5a. Survey - Boundary Survey & Roadway Easement Parcel Notes & Sketches	PER PARCEL	$ -	$ -	$ 14,000.00	$ -	$ -	$ 14,000.00
5b. Survey/Property - Additional Easement Coordination & Easment Sketches	Hourly/NTE	$ 6,236.00	$ -	$ 10,256.00	$ -	$ -	$ 16,492.00
6. Geotechnical Investigation and Pavement Design Coordination	LS	$ -	$ -	$ -	$ -	$ -	$ -
7. Utility Investigations & Coordination, Preliminary WW layout	LS	$ 3,256.00	$ -	$ -	$ -	$ -	$ 3,256.00
8. Preliminary Engineering & Roadway Schematic	LS	$ 19,176.00	$ -	$ -	$ -	$ -	$ 19,176.00
PHASE II - DESIGN & BID PHASE							
1. Construction Plans							
a. 1. TITLE SHEET	LS	$ 1,167.00	$ -	$ -	$ -	$ -	$ 1,167.00
a.2. INDEX OF SHEETS	LS	$ 651.00	$ -	$ -	$ -	$ -	$ 651.00
a.3. QUANTITY/SUMMARY SHEETS	LS	$ 6,294.00	$ -	$ -	$ -	$ -	$ 6,294.00
a.4. GENERAL NOTES	LS	$ 2,670.00	$ -	$ -	$ -	$ -	$ 2,670.00
a.5. HORIZONTAL ALIGNMENT DATA	LS	$ 849.00	$ -	$ -	$ -	$ -	$ 849.00
b.1. TYPICAL SECTIONS	LS	$ 2,886.00	$ -	$ -	$ -	$ -	$ 2,886.00
b.2. ROADWAY PLAN & PROFILES	LS	$ 8,548.00	$ -	$ -	$ -	$ -	$ 8,548.00
c.1. CROSS-SECTIONS	LS	$ 7,378.00	$ -	$ -	$ -	$ -	$ 7,378.00
c.2. INTERSECTION DETAIL SHEETS	LS	$ 3,398.00	$ -	$ -	$ -	$ -	$ 3,398.00
c.3. ROADWAY STANDARDS	LS	$ 1,826.00	$ -	$ -	$ -	$ -	$ 1,826.00
d.1. OVERALL DRAINAGE AREA MAPS & RUNOFF COMPUTATIONS	LS	$ 3,762.00	$ -	$ -	$ -	$ -	$ 3,762.00
d.2. BRIDGE HYDRAULIC CALCULATIONS	LS	$ 8,540.00	$ -	$ -	$ -	$ -	$ 8,540.00
d.3. BRIDGE SCOUR DATA SHEETS	LS	$ 2,902.00	$ -	$ -	$ -	$ -	$ 2,902.00
d.4. STORM SEWER PLAN & PROFILES	LS	$ 6,056.00	$ -	$ -	$ -	$ -	$ 6,056.00
d.5. STORM SEWER & INLET HYDRAULIC CALCULATIONS	LS	$ 3,746.00	$ -	$ -	$ -	$ -	$ 3,746.00
d.6. DRAINAGE STANDARDS	LS	$ 1,486.00	$ -	$ -	$ -	$ -	$ 1,486.00
e.1. BRIDGE QUANTITIES AND BEARING SEAT ELEVATIONS	LS	$ -	$ -	$ -	$ 5,410.00	$ -	$ 5,410.00
e.2. BRIDGE LAYOUTS	LS	$ 4,812.00	$ -	$ -	$ 2,100.00	$ -	$ 6,912.00
e.3. ABUTMENT DETAILS	LS	$ -	$ -	$ -	$ 21,560.00	$ -	$ 21,560.00
e.4. BENT DETAILS	LS	$ -	$ -	$ -	$ -	$ -	$ -
e.5. SPAN DETAILS	LS	$ -	$ -	$ -	$ 12,710.00	$ -	$ 12,710.00
e.6. BRIDGE STANDARDS	LS	$ -	$ -	$ -	$ 1,495.00	$ -	$ 1,495.00
f.1. SEQUENCE OF CONSTRUCTION NARRATIVE	LS	$ 849.00	$ -	$ -	$ -	$ -	$ 849.00
f.2. TRAFFIC CONTROL PLANS	LS	$ 1,689.00	$ -	$ -	$ -	$ -	$ 1,689.00
f.3. TRAFFIC CONTROL STANDARDS	LS	$ 651.00	$ -	$ -	$ -	$ -	$ 651.00
g.1. SIGNING AND PAVEMENT MARKING PLANS	LS	$ 2,616.00	$ -	$ -	$ -	$ -	$ 2,616.00
g.2. SIGNING AND PAVEMENT MARKING STANDARDS	LS	$ 1,302.00	$ -	$ -	$ -	$ -	$ 1,302.00
h.1. STORMWATER POLLUTION PREVENTION PLAN	LS	$ 714.00	$ -	$ -	$ -	$ -	$ 714.00
h.2. EROSION CONTROL PLANS	LS	$ 2,553.00	$ -	$ -	$ -	$ -	$ 2,553.00
h.3. EROSION CONTROL STANDARDS	LS	$ 1,428.00	$ -	$ -	$ -	$ -	$ 1,428.00
i.1. ILLUMINATION PLANS	LS	$ -	$ -	$ -	$ 19,620.00	$ -	$ 19,620.00
i.2. ELECTRICAL CIRCUIT DIAGRAMS	LS	$ -	$ -	$ -	$ -	$ -	$ -
i.3. STREET LIGHT BASE DETAIL	LS	$ -	$ -	$ -	$ -	$ -	$ -
i.4. ILLUMINATION STANDARDS	LS	$ -	$ -	$ -	$ -	$ -	$ -
j.1. WATERLINE PLAN AND PROFILE SHEETS	LS	$ 24,408.00	$ -	$ -	$ -	$ -	$ 24,408.00
j.2. WATERLINE STANDARDS	LS	$ 2,760.00	$ -	$ -	$ -	$ -	$ 2,760.00
2. Opinion of Probable Construction Cost	LS	$ 1,412.00	$ -	$ -	$ -	$ -	$ 1,412.00
3. Construction Duration Estimate	LS	$ 1,132.00	$ -	$ -	$ -	$ -	$ 1,132.00
4. Contract Documents	LS	$ 3,364.00	$ -	$ -	$ -	$ -	$ 3,364.00
5. Permitting	LS						
a. TCEQ Chapter 290 Review	LS	$ 382.00	$ -	$ -	$ -	$ -	$ 382.00
b. TCEQ NPDES	LS	$ 382.00	$ -	$ -	$ -	$ -	$ 382.00
c. TDLR Review Submittal	LS	$ 1,410.00	$ -	$ -	$ -	$ -	$ 1,410.00
6. FEMA Conditional Letter of Map Revision Coordination	LS	$ 4,640.00	$ -	$ -	$ -	$ -	$ 4,640.00
7. Bid and Award Phase Services							
a. Bid Solicitation	LS	$ 1,636.00	$ -	$ -	$ -	$ -	$ 1,636.00
b. Bid Document Distribution	LS	$ 844.00	$ -	$ -	$ -	$ -	$ 844.00
c. Pre-Bid Conference	LS	$ 1,116.00	$ -	$ -	$ -	$ -	$ 1,116.00
d. Addenda Preparation	LS	$ 2,552.00	$ -	$ -	$ -	$ -	$ 2,552.00
e. Bid Opening and Review	LS	$ 1,440.00	$ -	$ -	$ -	$ -	$ 1,440.00
f. Contract Award	LS	$ 1,448.00	$ -	$ -	$ -	$ -	$ 1,448.00
g. Conforming Documents	LS	$ 1,274.00	$ -	$ -	$ -	$ -	$ 1,274.00
PHASE III - CONSTRUCTION PHASE							
1. Construction Phase Services							
a. Pre-Construction Conference	LS	$ 1,484.00	$ -	$ -	$ -	$ -	$ 1,484.00
b. Progress Meetings and Site Visits (16)	LS	$ 5,988.00	$ -	$ -	$ -	$ -	$ 5,988.00
c. Submittal Review	LS	$ 6,006.00	$ -	$ -	$ 7,380.00	$ -	$ 13,386.00
d. Pay Estimate Review	LS	$ 1,286.00	$ -	$ -	$ -	$ -	$ 1,286.00
e. Preparation of Change Orders	LS	$ 3,144.00	$ -	$ -	$ -	$ -	$ 3,144.00
f. RFI Response	LS	$ 1,388.00	$ -	$ -	$ -	$ -	$ 1,388.00
g. Contract Closeout	LS	$ 2,150.00	$ -	$ -	$ -	$ -	$ 2,150.00
h. Record Drawings	LS	$ 3,084.00	$ -	$ -	$ -	$ -	$ 3,084.00
LABOR COST		**$ 213,609.00**	**$ 11,360.00**	**$ 24,256.00**	**$ 73,170.00**	**$ -**	**$ 322,395.00**
DIRECT NON-LABOR EXPENSES		**$ 2,785.00**	**$ 220.00**	**$ -**	**$ 262.00**	**$ -**	**$ 3,267.00**
TOTAL PROJECT COST		**$ 216,394.00**	**$ 11,580.00**	**$ 24,256.00**	**$ 73,432.00**	**$ -**	**$ 325,662.00**

City of Kyle - Marketplace Avenue
Exhibit "C"

TASK	Total LS Cost	Total Hourly/NTE Cost
PROJECT MANAGEMENT		
1. Overall Project Management	$ 11,129.00	$ -
2. Meetings	$ 12,134.00	$ -
PHASE I - PRELIMINARY ENGINEERING PHASE		
1. Kick-Off Meeting & Site Reconnaissance	$ 2,932.00	$ -
2. Data Gathering	$ 778.00	$ -
3. North Burleson Coordination	$ 4,372.00	$ -
4. Environmental Documentation	$ -	$ -
Task 1 - Environmental Background Studies & Review	$ -	$ 14,348.00
5a. Survey - Boundary Survey & Roadway Easement Parcel Notes & Sketches	$ -	$ 14,000.00
5b. Survey/Property - Additional Easement Coordination & Easment Sketches	$ -	$ 16,492.00
6. Geotechnical Investigation and Pavement Design Coordination	$ -	$ -
7. Utility Investigations & Coordination, Preliminary WW layout	$ 3,256.00	$ -
8. Preliminary Engineering & Roadway Schematic	$ 19,176.00	$ -
PHASE II - DESIGN & BID PHASE		
1. Construction Plans		
a. 1. TITLE SHEET	$ 1,167.00	$ -
a.2. INDEX OF SHEETS	$ 651.00	$ -
a.3. QUANTITY/SUMMARY SHEETS	$ 6,294.00	$ -
a.4. GENERAL NOTES	$ 2,670.00	$ -
a.5. HORIZONTAL ALIGNMENT DATA	$ 849.00	$ -
b.1. TYPICAL SECTIONS	$ 2,886.00	$ -
b.2. ROADWAY PLAN & PROFILES	$ 8,548.00	$ -
c.1. CROSS-SECTIONS	$ 7,378.00	$ -
c.2. INTERSECTION DETAIL SHEETS	$ 3,398.00	$ -
c.3. ROADWAY STANDARDS	$ 1,826.00	$ -
d.1. OVERALL DRAINAGE AREA MAPS & RUNOFF COMPUTATIONS	$ 3,762.00	$ -
d.2. BRIDGE HYDRAULIC CALCULATIONS	$ 8,540.00	$ -
d.3. BRIDGE SCOUR DATA SHEETS	$ 2,902.00	$ -
d.4. STORM SEWER PLAN & PROFILES	$ 6,056.00	$ -
d.5. STORM SEWER & INLET HYDRAULIC CALCULATIONS	$ 3,746.00	$ -
d.6. DRAINAGE STANDARDS	$ 1,486.00	$ -
e.1. BRIDGE QUANTITIES AND BEARING SEAT ELEVATIONS	$ 5,410.00	$ -
e.2. BRIDGE LAYOUTS	$ 6,912.00	$ -
e.3. ABUTMENT DETAILS	$ 21,560.00	$ -
e.4. BENT DETAILS	$ -	$ -
e.5. SPAN DETAILS	$ 12,710.00	$ -
e.6. BRIDGE STANDARDS	$ 1,495.00	$ -
f.1. SEQUENCE OF CONSTRUCTION NARRATIVE	$ 849.00	$ -
f.2. TRAFFIC CONTROL PLANS	$ 1,689.00	$ -
f.3. TRAFFIC CONTROL STANDARDS	$ 651.00	$ -
g.1. SIGNING AND PAVEMENT MARKING PLANS	$ 2,616.00	$ -
g.2. SIGNING AND PAVEMENT MARKING STANDARDS	$ 1,302.00	$ -
h.1. STORMWATER POLLUTION PREVENTION PLAN	$ 714.00	$ -
h.2. EROSION CONTROL PLANS	$ 2,553.00	$ -
h.3. EROSION CONTROL STANDARDS	$ 1,428.00	$ -
i.1. ILLUMINATION PLANS	$ 19,620.00	$ -
i.2. ELECTRICAL CIRCUIT DIAGRAMS	$ -	$ -
i.3. STREET LIGHT BASE DETAIL	$ -	$ -
i.4. ILLUMINATION STANDARDS	$ -	$ -
j.1. WATERLINE PLAN AND PROFILE SHEETS	$ 24,408.00	$ -
j.2. WATERLINE STANDARDS	$ 2,760.00	$ -
2. Opinion of Probable Construction Cost	$ 1,412.00	$ -
3. Construction Duration Estimate	$ 1,132.00	$ -
4. Contract Documents	$ 3,364.00	$ -
5. Permitting	$ -	$ -
a. TCEQ Chapter 290 Review	$ 382.00	$ -
b. TCEQ NPDES	$ 382.00	$ -
c. TDLR Review Submittal	$ 1,410.00	$ -
6. FEMA Conditional Letter of Map Revision Coordination	$ 4,640.00	$ -
7. Bid and Award Phase Services	$ -	$ -
a. Bid Solicitation	$ 1,636.00	$ -
b. Bid Document Distribution	$ 844.00	$ -
c. Pre-Bid Conference	$ 1,116.00	$ -
d. Addenda Preparation	$ 2,552.00	$ -
e. Bid Opening and Review	$ 1,440.00	$ -
f. Contract Award	$ 1,448.00	$ -
g. Conforming Documents	$ 1,274.00	$ -
PHASE III - CONSTRUCTION PHASE		
1. Construction Phase Services		
a. Pre-Construction Conference	$ 1,484.00	$ -
b. Progress Meetings and Site Visits (16)	$ 5,988.00	$ -
c. Submittal Review	$ 13,386.00	$ -
d. Pay Estimate Review	$ 1,286.00	$ -
e. Preparation of Change Orders	$ 3,144.00	$ -
f. RFI Response	$ 1,388.00	$ -
g. Contract Closeout	$ 2,150.00	$ -
h. Record Drawings	$ 3,084.00	$ -
LABOR COST	**$ 277,555.00**	**$ 44,840.00**
DIRECT NON-LABOR EXPENSES	**$ 3,267.00**	
TOTAL PROJECT COST	**$ 280,822.00**	**$ 44,840.00**

CITY OF KYLE, TEXAS

Meeting Date: 8/4/2015
Date time: 7:00 PM

Lehman Road Mitigation & Utility Engineering Fee Adjustment

Subject/Recommendation: Approve Supplement No. 2 to engineering services agreement with HDR ENGINEERING, INC., Austin, Texas, in an amount not to exceed $72,596.00 for additional engineering and design services for a drainage detention pond, a bridge structure at Plum Creek, and for water line relocation associated with the Lehman Road improvement project. ~ *Leon Barba, P.E., City Engineer*

Other Information: Some of the highlights of this supplement are as follows:

1. Provides additional engineering services for development of a Natural Resources Conservation Service (NRCS) Structure Mitigation plan (Lake Kyle) caused by the impact of the proposed roadway embankment.
2. Approximately 1,600 L.F. of 12" waterline will need to be relocated to an alignment out from under the proposed roadway.
3. A pedestrian signal pole at the intersection of Lehman Rd. and FM 150 will need to be relocated due to the proposed roadway.
4. The initial intent was to use a standard TxDOT bridge design. However, after further review, it was determined the design would require a non-standard skew, bridge width and drainage details. An additional design effort is required for modifying the standard drawings.

Legal Notes:

Budget Information: A Fiscal Note is attached.

Attachments / click to download

- Lehman Road Mitigation Scope & Fees
- Lehman Road Scope & Fees Continued
- Fiscal Note

SUPPLEMENTAL WORK AUTHORIZATION NO. 2
Lehman Road Project

WHEREAS, on the 28th day of March, 2014, a professional services agreement was entered into by and between the City of Kyle ("City") and HDR Engineering, Inc. ("Consultant"), collectively known as the "parties," for the development of a preliminary engineering report, limited environmental studies, schematic, plans, specifications, and estimate (PS&E), utility coordination and design, traffic studies, geotechnical analysis, and pavement design to develop Lehman Road from RR 150 to Goforth Road Intersection, in Hays County, Texas; and,

WHEREAS, during the development of the project additional design effort was identified as necessary, including area inlets and retaining walls, due to the large off-site component of flow to the project corridor as well as mitigation plans for the proposed impacts to the storage pool volumes located at the NRCS Dam Site No. 2 (Lake Kyle). In addition, the City requested sidewalks on both sides of the bridge structures thereby creating a non-standard bridge width. the City also requested the relocation of a 12" water line be included within the roadway construction plans. The Consultant requested additional compensation in the amount of $72,596.00 for these services; and,

WHEREAS, the additional engineering services to be performed by the Consultant ("supplemental work") are described and set forth in EXHIBIT "A" which is attached hereto and incorporated by reference herein; and,

WHEREAS, after careful review of the support documentation, the City has agreed to an amount not to exceed, $72,596.00 for the purpose of compensating the Consultant to perform the supplemental work described in EXHIBIT "A";and,

WHEREAS, at its regular meeting on August 4, 2015, the city council approved an amount not to exceed $72,596.00 for the purpose of compensating the Consultant to perform the supplemental work described in EXHIBIT "A";

NOW THEREFORE, IT IS HEREBY AGREED between the parties hereto that Supplemental Work Authorization #2 ("Authorization") in an amount not to exceed $72,596.00 is fair and reasonable, and this Authorization will become effective immediately upon the signature of both parties.

IN WITNESS WHEREOF, the parties hereby execute this Supplemental Work Authorization #2 on this ___ day of August, 2015.

THE CITY OF KYLE, TEXAS :

____
R. Todd Webster, Mayor

HDR Engineering, Inc.:

____
Kelly J. Kaatz, P.E. Senior Vice President

ATTEST:

____
Amelia Sanchez, City Secretary

SUPPLEMENT NO. 2

TO CONTRACT AGREEMENT FOR PROFESSIONAL SERVICES FOR LEHMAN ROAD IMPROVEMENTS

SERVICES TO BE PROVIDED BY THE ENGINEER

WORK DESCRIPTION:

The work to be performed by ENGINEER under Supplement No. 2 to the Contract Agreement for Professional Services for Lehman Road Improvements consists of NRCS Structure Mitigation plan development, water line relocation, pedestrian signal pole relocation, and non-standard design effort for the Plum Creek bridge structure.

NRCS STRUCTURE MITIGATION PLANS

- The ENGINEER will attend one (1) Plum Creek Conservation District (District) Directors meeting to present the Lehman Road project improvements to the District and discuss impacts to the storage pool of SCS Dam No. 2 and proposed mitigation.
- The ENGINEER will create one (1) exhibit of the proposed project improvements relative to the SCS Dam No. 2 to support discussions with the District. This exhibit will be added to the construction documents and will detail the location of impacts to the storage pools of SCS Dam No. 2 caused by the proposed roadway embankment and illustrate the location of excavation to mitigate impacts.
- Following the Plum Creek Conservation District meeting, the ENGINEER will submit a review package electronically to the NRCS. The submittal package will include: summary letter outlining the nature of the project improvements, quantified impacts to the SCS Dam No. 2 Storage Pools, proposed mitigation plan with cut/fill summary table; the construction plan set (stamped released for review); and a copy of the hydraulic model for the Lehman Road Stream Plum-1 crossing.
- A copy of the electronic submittal will be provided to the TCEQ Dam Safety Section Manager Warren Samuelson, PE for review and comment.
- One round of comments from the Plum Creek Conservation District/NRCS/TCEQ will be addressed and incorporated into the plans. A response to comments letter will be drafted to each reviewing authority (as required).
- Following construction of the project improvements, as-built / record drawings will be submitted to the Plum Creek Conservation District and a carbon copy to NRCS and TCEQ documenting that any fill associated to the roadway improvements was properly mitigated for with cut in adjacent parcels.
- The ENGINEER will perform survey coordination for a detailed topographic survey to be performed in the vicinity of the cut that will mitigate for the roadway embankment constructed in the SCS Dam No. 2 storage pool.
- A cut/fill analysis will be performed to identify where cut will be taken to mitigate for the proposed roadway embankment.

- Following construction of the proposed improvements the ENGINEER will perform survey coordination to get detailed survey of the area where cut was performed.
- The ENGINEER will perform a final cut/fill analysis on the as-built survey to ensure that the cut taken fully mitigates for the roadway fill within the SCS Dam No. 2 storage pools.
- This scope of work **DOES NOT** include the initial and subsequent as-built physical survey of the mitigation area which may be required by the NRCS for verification of mitigated volume. These surveys are intended to be incorporated into the construction contract for the project.

DRAINAGE

- As design advanced, it was found that there was a substantial amount of off-site drainage flowing onto the roadway (approximately 58% of the contributing area is off-site) due to the lack of effective drainage ditches. This flow onto the roadway created a significant impact to ponding on the roadway due to the new curb and gutter section. To mitigate these impacts, area inlets and additional storm sewer laterals were made necessary causing a substantial increase to the size of the proposed storm sewer network. Scope of work includes:
  - Determination of off-site drainage area and flows.
  - Appropriate sizing of area inlets and storm sewer laterals.
  - Modification of existing storm sewer designs.
  - Preparation of area inlet and storm sewer lateral detail sheets.

MISCELLANEOUS ROADWAY

- As design advanced, it was determined that the available right of way adjacent to Lehman Road near the intersection with Goforth Road was insufficient to accommodate a typical drainage ditch capable of carrying the off-site drainage flowing towards the roadway without taking a significant amount of right of way from the backyards of the adjacent homes. As a result, it was determined that a small retaining wall would allow for the creation of a small drainage ditch to capture the off-site flow. Scope of work includes:
  - Determination of off-site drainage area and flow and required ditch capacity.
  - Modification of roadway geometrics to accommodate proposed retaining wall.
  - Preparation of retaining wall Plan and Profile sheets.
  - Incorporation of TxDOT Retaining Wall standard details.

SIGNING, PAVEMENT MARKING & ILLUMINATION

- The ENGINEER will develop plans, quantities and specifications for the relocation of the pedestrian signal pole located on the northeastern corner of the Lehman Road / FM 150 intersection. The pedestrian signal pole will be relocated to the landing of the proposed pedestrian ramp.

BRIDGE DESIGN

- Bridge Design and Detailing. Initial project scope for the Plum Creek bridge was based on utilizing TxDOT standards. As design progressed, it was determined that the design would require a non-standard skew, bridge width, and drainage details. This supplement is for the added design effort made necessary by the need for a non-standard design and modification of standard CAD drawings for:

- Non-Standard skew and sidewalk design and detailing for bridge abutments,
- Non-Standard skew and sidewalk design and detailing for bridge interior bents,
- Non-Standard skew and sidewalk design and detailing for bridge spans,
- Non-Standard skew and sidewalk design for bridge beams,
- Development and implementation of non-standard deck drain slots and cover plates.

UTILITY DESIGN

- ENGINEER will prepare drawings and specifications for the relocation of approximately 1,600 LF of 12-inch PVC waterline currently located near the proposed edge of pavement on the south/east side of the road from Station 110+00 to 115+00 and on the north/west side of the road from Station 115+00 to 125+00 to an alignment along the edge of the Lehmann Road ROW on the south/east side of the road.
    - Waterline design meeting: The ENGINEER will attend a meeting to establish the proposed alignment for the new waterline, connection points to the existing waterline, and any applicable design standards, including standard details and/or specifications.
    - No revisions to alignment will be made after the design meeting. Any requested changes in alignment will require a supplement to this Agreement.
    - Prepare final drawings and specifications indicating the scope, extent, and character of the work to be performed and furnished by the Contractor.
        - Specifications: The ENGINEER will utilize TXDOT standard technical specifications. Only technical specifications related to the pipeline relocation will be prepared, for inclusion with the roadway relocation specifications.
    - Drawings
        - 11 x 17 paper, at a horizontal scale of 1 inch equals 100 feet and a vertical scale of 1 inch equals 10 feet.
        - Only general notes, plan and profile sheets, and standard detail sheets will be prepared, for inclusion with the roadway drawings. No additional cover sheet, standard notes, or traffic control sheets will be developed.
            - General Notes for Water Lines
            - Plan and Profile Drawings
            - Standard Details
    - Furnish the bidding documents for review by CITY and revise the bidding documents in accordance with comments and instructions from CITY, as appropriate.
    - Prepare an opinion of probable construction cost based on recent bid tabulations for similar work available to ENGINEER and/or provided by CITY.
- Surveying /Subsurface Utility Engineering
    - ENGINEER will locate horizontally and vertically the existing 10" force main previously uncovered by CITY staff in three (3) locations.
    - ENGINEER will excavate and locate horizontally and vertically the existing 12" water line to be relocated at two (2) locations to assist in the development of the relocation plans.

SUPPLEMENT NO. 2
(LUMP SUM)

Project Description: Prepare Environmental Document, Utility Relocation, and PS&E package for Lehman Road from FM 150 to CR 157 (Goforth Rd.).

Project Length: Approximately 8,500 LF (1.60 miles)

1 - PROJECT MANAGEMENT		$0.00
2 - PRELIMINARY ENGINEERING		
	SUBTOTAL PRELIMINARY ENGINEERING	$0.00
3 - PLANS, SPECIFICATIONS AND ESTIMATES (PS&E)		
3A	ROADWAY GEOMETRICS (P & P SHTS: 1" = 50')	$0.00
3B	ROADWAY DRAINAGE	$10,283.00
3C	SIGNING, PAVEMENT MARKING, & ILLUMINATION	$3,531.00
3D	MISCELLANEOUS ROADWAY	$5,107.00
3E	TRAFFIC CONTROL PLANS	$0.00
3F	UTILITY ENGINEERING - 12" WATER LINE RELOCATION	$10,785.00
3G	DRAINAGE STRUCTURE / BRIDGE DESIGN	$10,025.50
3H	NRCS STRUCTURE MITIGATION	$27,575.00
	SUBTOTAL PS&E PLAN PREPARATION	$67,306.50
4 - RIGHT OF WAY ACQUISITION SERVICES		$0.00
5 - DIRECT EXPENSES		$289.50
6 - SUBCONSULTANT FEES		
	AMATERRA ENVIRONMENTAL, INC. (CULTURAL RESOURCES)(DBE)	$0.00
	THE WALLACE GROUP (UTILITY LOCATE SURVEY)	$5,000.00
		$0.00
	GRAM TRAFFIC COUNTS	$0.00
	PAVETEX ENGINEERING AND TESTING, INC. (DBE)	$0.00
	MACIAS & ASSOCIATES, INC. (QUALITY LEVEL B/A SUE AS NEEDED BY SUPPLEMENT)(DBE)	$0.00
	SUBTOTAL - SUBCONSULTANT FEES	$5,000.00
TOTAL HDR LABOR FEE, SUBCONSULTANTS, AND DIRECT EXPENSES		$72,596.00
		DBE % = 0%

TASK NO.	Project Description: Plum Creek Conservation District Coodination for Lehman Rd.	Project Length: 1.00 miles 8,500 LF													
	TASK DESCRIPTION	SENIOR PROJ. MGR.	ROW. / ENV. MGR.	SR. ENGR.	SR. ENV. SCIENTIST	JR. ENV. SCIENTIST	GIS TECH.	DESIGN ENGR.	EIT	UTILITY DESIGN COORD	CADD TECH.	ARCH/ HISTORIAN/ PI SPECIALIST	BRIDGE CAD TECH	ACCOUNTING CLERICAL/ STENO	TOTAL
3A	ROADWAY GEOMETRICS (P & P SHTS: 1" = 50')														
	NO ADDITIONAL ACTIVITIES REQUIRED														0
	SUBTOTAL ROADWAY GEOMETRICS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3B	ROADWAY DRAINAGE														
	ADDED MITIGATION OF OFF-SITE DRAINAGE (DITCH DESIGN / AREA INLETS / LATERALS)	2		6				12	28	32					80
	SUBTOTAL ROADWAY DRAINAGE	2	0	6	0	0	0	12	28	32	0	0	0	0	80
3C	SIGNING, PAVEMENT MARKING, & ILLUMINATION														
	RELOCATION OF PEDESTRIAN SIGNAL POLE AT LEHMAN RD & FM 150	2		2				6	8		8				26
	SUBTOTAL SIGNING, PAVEMENT MARKING, ILLUMINATION & SIGNALIZATION	2	0	2	0	0	0	6	8	0	8	0	0	0	26
3D	MISCELLANEOUS ROADWAY														
	RETAINING WALL DESIGN AND DETAILING	2		8					18		10				38
	SUBTOTAL MISCELLANEOUS ROADWAY	2	0	8	0	0	0	0	18	0	10	0	0	0	38
3E	TRAFFIC CONTROL PLANS														
	NO ADDITIONAL ACTIVITIES REQUIRED														0
	SUBTOTAL OF TRAFFIC CONTROL PLANS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3F	UTILITY ENGINEERING - 12" WATER LINE RELOCATION														
	PRELIMINARY DESIGN MEETING	2		2											4
	PREPARE PLAN AND ELEVATION FOR RELOCATION			2				22					24		48
	PREPARE SPECIFICATIONS			2											2
	PREPARE STANDARD DETAILS			2									4		6
	QA/QC OF SUBMITTALS (90% & FINAL)	3							2				4		9
	PREPARE CONSTRUCTION ESTIMATE	1		2					2						5
	SUBTOTAL UTILITY COORDINATION	6	0	10	0	0	0	22	4	0	0	0	32	0	74
3G	DRAINAGE STRUCTURE / BRIDGE DESIGN														
	PREPARE BRIDGE ABUTMENT DETAILS - PLUM CREEK - NON-STANDARD DESIGN/SKEW	1		2					8				8		19
	PREPARE INTERIOR BENT DETAILS - PLUM CREEK - NON-STANDARD DESIGN/SKEW	1		2					8				6		17
	PREPARE SPAN DETAILS - PLUM CREEK - NON-STANDARD DESIGN / SKEW	1		2					8				6		17
	PREPARE PRESTRESSED CONCRETE SLAB BEAM DESIGN DATA SHEET (NON-STANDARD)	1		1									4		6
	PREPARE DRAIN SLOT / COVER PLATE DESIGN AND DETAILS	1		2					6				8		17
	SUBTOTAL BRIDGE DESIGN	5	0	9	0	0	0	0	30	0	0	0	32	0	76
3H	NRCS STRUCTURE MITIGATION														
	ATTEND PLUM CREEK CONSERVATION DISTRICT MEETING	3		3										1	7
	PREPARATION OF MEETING EXHIBITS	1		1				4	6		8				20
	PREPARATION AND SUBMITTAL OF REVIEW PACKAGE TO NRCS	2		6				8	30		16				62
	COORDINATION WITH TCEQ	1						4							5
	RESPONSE TO COMMENTS DISTRICT/NRCS/TCEQ	2		2				8			12				24
	ADDITIONAL RECORD DRAWINGS OF MITIGATION AREA	2		2				4	6		10				24
	ADDITIONAL SURVEY COORDINATION	2		2											4
	MITIGATION DESIGN CUT/FILL ANALYSIS	2		2				6	8		8				26
	AS-BUILT SURVEY COORDINATION	2		2							2				6
	AS-BUILT CUT/FILL ANALYSIS	2		2				2	8		8				22
	SUBTOTAL NRCS STRUCTURE MITIGATION	19	0	22	0	0	0	36	58	0	64	0	0	1	200
	TOTAL HDR HOURS	36	0	57	0	0	0	76	146	32	82	0	64	1	494
		HOURLY RATES INCLUDING OVERHEAD AND PROFIT													
	COST COMPONENT, DOLLARS	$ 234.50	$205.00	$187.00	$141.00	$109.00	$131.50	$156.00	$119.00	$109.00	$100.00	$87.50	$112.50	$87.50	
3A	ROADWAY GEOMETRICS (P & P SHTS: 1" = 50')	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3B	ROADWAY DRAINAGE	$469.00	$0.00	$1,122.00	$0.00	$0.00	$0.00	$1,872.00	$3,332.00	$3,488.00	$0.00	$0.00	$0.00	$0.00	$10,283.00
3C	SIGNING, PAVEMENT MARKING, & ILLUMINATION	$469.00	$0.00	$374.00	$0.00	$0.00	$0.00	$936.00	$952.00	$0.00	$800.00	$0.00	$0.00	$0.00	$3,531.00
3D	MISCELLANEOUS ROADWAY	$469.00	$0.00	$1,496.00	$0.00	$0.00	$0.00	$0.00	$2,142.00	$0.00	$1,000.00	$0.00	$0.00	$0.00	$5,107.00
3E	TRAFFIC CONTROL PLANS	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3F	UTILITY ENGINEERING - 12" WATER LINE RELOCATION	$1,407.00	$0.00	$1,870.00	$0.00	$0.00	$0.00	$3,432.00	$476.00	$0.00	$0.00	$0.00	$3,600.00	$0.00	$10,785.00
3G	DRAINAGE STRUCTURE / BRIDGE DESIGN	$1,172.50	$0.00	$1,683.00	$0.00	$0.00	$0.00	$0.00	$3,570.00	$0.00	$0.00	$0.00	$3,600.00	$0.00	$10,025.50
3H	NRCS STRUCTURE MITIGATION	$4,455.50	$0.00	$4,114.00	$0.00	$0.00	$0.00	$5,616.00	$6,902.00	$0.00	$6,400.00	$0.00	$0.00	$87.50	$27,575.00
	TOTAL HDR LABOR FEE	$8,442.00	$0.00	$10,659.00	$0.00	$0.00	$0.00	$11,856.00	$17,374.00	$3,488.00	$8,200.00	$0.00	$7,200.00	$87.50	$67,306.50
	COST COMPONENT DIRECT EXPENSES	UNIT COST	UNIT		QTY										
EXP	MILEAGE	$0.565	MILE		200										$113.00
EXP	COPIES (8.5" x 11")	$0.05	EA		490										$24.50
EXP	COPIES (11" x 17")	$0.10	EA		220										$22.00
EXP	COPIES (8.5" X 11")(COLOR)	$0.15	EA		100										$15.00
EXP	COPIES (11" X 17")(COLOR)	$0.30	EA		50										$15.00
EXP	MYLARS (11" X 17")	$2.00	EA		0										$0.00
EXP	OVERNIGHT DELIVERIES	$25.00	EA		4										$100.00
	TOTAL DIRECT EXPENSES														$289.50
	TOTAL HDR LABOR FEE AND EXPENSES														$67,596.00

City of Kyle, Texas
FISCAL NOTE

DATE OF COUNCIL CONSIDERATION:	August 4, 2015
CONTACT CITY DEPARTMENT:	Engineering Services
CONTACT CITY STAFF:	Leon Barba, P.E., City Engineer

SUBJECT:
Approve Supplement No. 2 to engineering services agreement with HDR ENGINEERING, INC., Austin, Texas, in an amount not to exceed $72,596.00 for additional engineering and design services for a drainage detention pond, a bridge structure at Plum Creek, and for water line relocation associated with the Lehman Road improvement project.

CURRENT YEAR FISCAL IMPACT:
This engineering services amendment to the agreement with HDR ENGINEERING, INC., will require expenditure of funds from the General Obligation Bonds, Series 2013 issued for engineering, design, and related services for the five (5) roadway improvement projects.

1. City Department:	Engineering Services
2. Project Name:	Lehman Road – Additional Eng. Svcs.
3. Budget/Accounting Code(s):	188-681-57313
4. Funding Source:	2013 GO Bond Fund (Road Bonds)
5. Current Appropriation:	$ 5,410,000.00
6. Unencumbered Balance:	$ 329,110.38
7. Amount of This Action:	$ (72,596.00)
8. Remaining Balance:	$ 256,514.38

FUNDING SOURCE OF THIS ACTION:
The funding for this professional services agreement amendment for additional engineering services by HDR ENGINEERING, INC., will be provided from the General Obligation Bonds, Series 2013 issued for engineering, design, and related services for the five (5) roadway improvement projects.

ADDITIONAL INFORMATION/COUNCIL ACTION:

- If approved by City Council, amendment number 2 in the amount of $72,596.00 will increase the total contract award to $965,154.50 for HDR ENGINEERING, INC., for the Lehman Road improvement project.

- On November 5, 2014, City Council, approved an amendment in the amount of $195,558.50 which increased the total contract award to $892,558.50 to HDR ENGINEERING, INC., for the Lehman Road improvement project.

- On March 18, 2014, City Council approved a professional services agreement for engineering services with HDR ENGINEERING, INC., in an amount not to exceed $697,000.00 for engineering services for the Lehman Road project.

7/31/2015

Perwez A. Moheet, CPA - Date
Director of Finance

CITY OF KYLE, TEXAS

Bunton Creek Road Adjustment in Services' Fees

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Approve Supplement No. 3 to engineering services agreement with LJA ENGINEERING, INC., Austin, Texas, in order to modify the scope of work and reallocate contract funding without changing the total contract amount for the Bunton Creek Road improvement project. *~ Leon Barba, P.E., City Engineer*

Other Information: The purpose of this item is to reallocate the funding associated with different services in this contract. During the development of the project it was determined not all of the right of way services were required. However, other additional services were needed to continue moving forward with the design. Design changes were made to accommodate Council direction or right of way negotiations. The reallocation does not change the current contract amount.

Legal Notes:

Budget Information: A Fiscal Note is not required. This City Council action item, if approved, will not increase or decrease the contract amount.

Viewing Attachments Requires Adobe Acrobat. Click here to download.

Attachments / click to download

- Bunton Creek Road Adjustment Letter

LJA Engineering, Inc.

5316 Highway 290 West
Suite 150
Austin, Texas 78735

Phone 512.439.4700
Fax 512.439.4716
www.ljaengineering.com

June 26, 2015

Bunton Creek Road
LJA Project No.: 2173-1401

Mr. Leon Barba, PE
City Engineer
City of Kyle
Public Works
100 W. Center Street
Kyle, Texas 78640

Dear Mr. Barba:

LJA would like to reallocate assigned contract dollars on the Bunton Road Project as follows:

Lower the ROW task budget from $143,910.00 to $100,000.00. This is a decrease of $43,910.00. This change will not have any change to the scope of services provided. ROW negotiations have proceeded at an accelerated schedule and not all available funds are needed for full completion of this task.

Increase the Survey Budget from $76,056.00 to $77,556.00. This is an increase of $1,500.00. This increase will cover the cost of adding the County Line water easement to all effected Meets and Bounds in the Bunton corridor, in addition to reprinting any affected meets and bounds documents at City's request.

Increase the 100% PS&E Budget from $17,921.48 to $61,434.00. This is an increase of $41,410.00. This increase covers the following additional scope items that have occurred over the life of the project.

- Redesign of the 5-lane section roadway to a 3-lane section roadway post schematic design at the request of the City. This included full redesign of the roadway, drainage, cross sections, and ROW.
- Preliminary engineering and cost estimates for the design of possible offsite detention at City's request due to ROW phasing.
- Redesign of the pavement section between Goforth and Dacy to utilize a modified pavement structure at the City's Request.
- Addition of a new proposed driveway along the Franke Property at City's request to accommodate ROW negotiations.
- Redesign of Garcia Driveway, Dacy Lane sidewalk ramps, and storm sewer at City's request to accommodate ROW negotiations.
- Removal of MSI driveway at City's request based on ROW negotiations.

- Addition of MSI driveway and storm sewer modification at City's request based on ROW negotiations.
- Redesign of drainage of the east end of project for the removal of Natividad Romo ROW parcel at City's request based of ROW negotiations.
- Addition of City of Austin survey general notes into Bunton general notes at City's request.
- Additional City Council Meetings that the City requested LJA to attend.
- Additional Public Meetings that the City requested LJA to attend.
- Additional Coordination Meetings (both over the phone and in person) that the City requested to discuss issues such as proposed utilities, existing utilities, geotechnical design, ROW negotiation requests, proposed ROW changes, offsite detention, and project phasing.
- Additional QA/QC and Project Management time to manage sub changes, process additional supplements, and provide responses to all city requests.

Increase the ODC budget from $4,425.00 to $5,425.00. This is an increase of $1,000.00. This increase will cover additional mileage, food, and printing for the changes listed above.

Decrease = $43,910.00
Increase = $1,500.00 + $41,410.00 + $1,000.00 = $43,910.00
Total Contract Difference = $0.00

Sincerely,

Kenneth G. Schrock, P.E.
Vice President
5316 Highway 290 West
Suite 150
Austin, Texas 78735

CITY OF KYLE, TEXAS

RR HPI First Amendment to ED Agreement

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Consider and possible action to Approve First Amendment to Economic Development Agreement with RR HPI, LLP. ~ *James Earp, Assistant City Manager*

Other Information:

Legal Notes:

Budget Information:

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- First Amendment To Economic Development Agreement
- Exhibit B

FIRST AMENDMENT TO ECONOMIC DEVELOPMENT AGREEMENT

THIS FIRST AMENDMENT TO THE ECONOMIC DEVELOPMENT AGREEMENT (this "Amendment") is entered into as of this _____ day of ___________, 2015, by and between the **CITY OF KYLE, TEXAS**, a home rule city of the State of Texas ("City") and **RR HPI LP**, a Texas limited partnership ("Developer"). (Collectively, the City and Developer may be referred to as "Parties," and individually as a "Party.")

Recitals

The City and the Developer entered into that certain Economic Development Agreement dated December 17, 2014, (the "Agreement"), generally providing that certain infrastructure and associated expenditures by Developer for the improvement of the Property, as defined in the Agreement, will be reimbursed to Developer by the City, as set forth in the Agreement.

This Amendment is intended to set forth certain adjustments to the expenditures that must be made by Developer that were unknown at the time the Agreement was executed by the Parties, and the resulting adjustments to the reimbursements due to Developer.

The City has the authority to enter into this Amendment pursuant to Article III, Section 52-a of the Texas Constitution, Chapter 380, Texas Local Government Code, and any other applicable constitutional or statutory provision.

NOW, THEREFORE, for and in consideration of the promises and mutual agreements set forth herein, the City and Developer agree to amend the Agreement as follows:

Article I
Definitions

"Perimeter Road Fee" means the fee imposed by the City on all property owners within the City whose property abuts a collector road. The Perimeter Road Fee (the "Fee") is based on a front foot calculation. The Parties omitted the Fee at the time of the execution of the Agreement and now wish to include it as part of the costs of the Improvements, as defined in the Agreement. The Fee assessed on the Developer is $220,000.

"TxDOT Requirement Costs" means the cost to Developer of complying with requirements imposed on the Developer by the Texas Department of Transportation ("TxDOT") concerning Developer's construction of the road that provides access to the City from the Property, designated as FM 967. The specific requirements to be imposed by TxDOT are not final as of the date of this Amendment, but are generally understood to include construction of a left turn lane and a deceleration lane in addition to the closure of an existing driveway. The Parties estimate that the cost of the TxDOT Requirements will be approximately $260,000.

"Water Line Adjustment" means the additional cost to Developer incurred as a result of the City's request to locate the off-site water line to serve the Property on the south side of Kohler's Crossing. The Parties agree the additional cost to Developer to accommodate the change in location in design fees and the cost of interest on money borrowed is $110,000.

Article II
Improvements

Section 2.01. Perimeter Road Fee. The City will impose upon the Developer a Fee in the amount of $220,000, and agrees that Developer can defer payment of the Fee by deducting the future value of the Fee from the amount Developer is eligible to receive in reimbursements from the City under the Agreement. The Parties agree that the future value of the Fee is $325,000, which shall be multiplied by 3 for a total of $975,000. Developer shall be reimbursed $975,000 less than is provided in **Exhibit "B"** to the Agreement.

Section 2.02. TxDOT Requirements. The Parties acknowledge that they intend to continue negotiating with TxDOT to lower the cost to Developer of the required improvements to FM 967. Developer shall be reimbursed for the actual costs associated with the TxDOT Requirements on FM 967, not to exceed $260,000, as an addition to the reimbursements provided in **Exhibit "B"** to the Agreement.

Section 2.03. Water Line Adjustment. Initially the City and Developer agreed that the off-site water line to be constructed by the Developer to serve the Property would be located on the north side of Kohler's Crossing. Subsequently the City determined it is obligated by a previous agreement with a third party to provide water service at the south side of Kohler's Crossing. Developer thus must pay for certain redesign costs necessitated by the change in location, and interest associated with the delay the redesign will cause. Developer estimates the cost of redesign and interest at $110,000. Developer shall be reimbursed for the actual costs associated with the delay in the construction of the off-site water line in the amount of $110,000, as an addition to the reimbursements provided in **Exhibit "B"** to the Agreement.

Section 2.04. Exhibit "B". Exhibit "B" to the Agreement is amended and is attached to this Amendment. To avoid confusion, its title remains **Exhibit "B"**. This Amendment includes no Exhibit "A".

ARTICLE III
Miscellaneous Provisions

Effect of Amendment. The Parties agree that, except as modified hereby, the Agreement remains valid, binding, and in full force and effect. If there is any conflict or inconsistency between this First Amendment and the Agreement, this First Amendment will control and modify the Agreement.

IN WITNESS WHEREOF, the Parties hereto have executed this Amendment to the Agreement in multiple copies, each of equal dignity, to be effective on the latest date of execution.

EXECUTION PAGE FOLLOWS:

THE CITY OF KYLE, TEXAS

____

R. Todd Webster, Mayor

ATTEST/SEAL:

____

Amelia Sanchez, City Secretary

APPROVED AS TO FORM:

____

Agreed to and accepted on ________________________, 2015.

RR HPI LP

____

Name: Richard Hill

Title: President

Agreed to and accepted on ________________________, 2015.

Exhibit B – Improvements and Cost Estimates, as amended in 2015

EXHIBIT B

HAYS COMMERCE CENTER
Preliminary 380 Budget
7/27/2015

	PHASE I	PHASE II	TOTAL
SOFT COSTS			
Creation Legal	35,000	0	35,000
Admin	0	55,000	55,000
Surveying & Platting	21,000	0	21,000
Engineering	196,800	206,800	403,600
City Inspection Fees	134,193	126,605	260,798
GeoTech	5,650	6,215	11,865
Construciton Materials Testing	30,000	33,000	63,000
Contruction Management	80,000	88,000	168,000
Total Soft Costs	502,643	515,620	1,018,263
HARD COSTS			
Offsite Waterline	791,091	0	791,091
Existing Water Relocation	215,752	0	215,752
Erosion Controls	106,821	81,113	187,935
Roads	975,828	1,070,389	2,046,217
Ponds & Drainage	865,039	473,332	1,338,371
Water in Roadway	249,841	315,023	564,864
Wastewater in Roadway	228,309	372,549	600,858
Telecom Infrastructure	0	189,862	189,862
Streetscape & Signage	0	400,820	400,820
Gas	95,890	105,479	201,369
Electric Crossing	23,972	0	23,972
Lift Station & Force Main	0	781,502	781,502
Total Hard Costs	3,552,544	3,790,068	7,342,613
Contingency	400,000	400,000	800,000
Interest	414,125	425,000	839,125
TOTAL	4,869,312	5,130,688	10,000,000

2015 AMENDMENT ADJUSTMENTS	
Perimeter Road Fee	-975,000
TxDOT Requirements	260,000
Water Line Adjustment	110,000
2015 AMENDED TOTAL	$9,395,000

CITY OF KYLE, TEXAS

Convene-Executive Session

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation:

Pursuant to Chapter 551, Texas Government Code, the City Council reserves the right to convene into Executive Session(s) from time to time as deemed necessary during this meeting. The City Council may convene into Executive Session pursuant to any lawful exception contained in Chapter 551 of the Texas Government Code including any or all of the following topics.

1. Pending or contemplated litigation or to seek the advice of the City Attorney pursuant to Section 551.071.
    - Aqua litigation update
2. Possible purchase, exchange, lease, or value of real estate pursuant to Section 551.072.
3. Personnel matters pursuant to Section 551.074.
4. Economic Development negotiations pursuant to Section 551.087.

Other Information:

Legal Notes:

Budget Information:

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CITY OF KYLE, TEXAS

Meeting Date: 8/4/2015
Date time: 7:00 PM

Reconvene

Subject/Recommendation: Take action on items discussed in Executive Session.

Other Information:

Legal Notes:

Budget Information:

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CITY OF KYLE, TEXAS

(First Reading) Ordinance Curfew for Minors

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: (*First Reading*) An Ordinance of the City of Kyle continuing with Curfew for Minors under seventeen years of age per Sections 23-23 through 23-30; entitled Triennial Review; Providing For Enforcement; Establishing Criminal Penalties; and Setting an Effective Date. ~ *Jeff Barnett, Chief of Police*

- **PUBLIC HEARING**

Other Information:

Legal Notes:

Budget Information:

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Juvenile Curfew Ordinance

ORDINANCE NO. ______

AN ORDINANCE OF THE CITY OF KYLE, TEXAS CONTINUING WITH CURFEW FOR MINORS UNDER SEVENTEEN YEARS OF AGE PER SECTIONS 23-23 THROUGH 23-30; ENTITLED TRIENNIAL REVIEW; PROVIDING FOR ENFORCEMENT; ESTABLISHING CRIMINAL PENALTIES; AND SETTING AN EFFECTIVE DATE

WHEREAS, persons under the age of seventeen are particularly susceptible by their lack of maturity and experience to participate in unlawful and gang-related activities and to be victims of older perpetrators of crime; and

WHEREAS, the City of Kyle has and continues to provide for the protection of minors from each other and from other persons, for the enforcement of parental control of and responsibility for their children, for the protection of the general public, and for the reduction of the incidence of juvenile criminal activities; and

WHEREAS, the City of Kyle adopted Ordinance 583 on September 1, 2009 for the purpose to deter criminal conduct involving juveniles; reduce the number of juvenile crime victims and reduce accidents involving juveniles; provide additional and more effective means and options for dealing with gang related violence and crime; reduce juvenile peer pressure to participate in violent or criminal activities; assist parents in the control of their children; and to make the City a better community and a safer place to live and work, to raise a family; and

WHEREAS, it is believed that the continuation of the current curfew ordinance as modified and amended for minors over the age of nine and under seventeen years of age is in the interest of the public health, safety, and general welfare, and will help to attain the foregoing objectives and to diminish the undesirable impact of such conduct on the citizens of the City of Kyle; and

WHEREAS, Texas Local Government Code Section 370.002 requires review of the curfew ordinance and to conduct a public hearing to be held before readopting it the renewal of the Curfew Ordinance; and

WHEREAS, after receiving the report of the Chief of Police for the City, and conducting a Public Hearing, the City Council has determined there is a continuing need to keep the curfew ordinance in place as modified in the manner provided by law;

NOW THEREFORE BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF KYLE, TEXAS THAT:

Section 1: City of Kyle Code of Ordinances, Chapter 23, Sections 23-23 through 23-30, is hereby renewed for an additional three year period and expiring September 1, 2018.

Section 2: Effective Date. This ordinance shall take effect immediately upon its adoption by the City Council and publication as required by the Local Government Code and the City Charter.

Section 3: Severability. If any section, subsection, sentence, clause or phrase of this ordinance is for any reason held to be unconstitutional or illegal, such decision shall not affect the validity of the remaining sections of this ordinance. The City Council hereby declares that it would have passed this ordinance, and each section, subsection, clause, or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses or phrases be declared void.

PASSED AND APPROVED on this the _____ day of August, 2015.
FINALLY PASSED AND APPROVED on this the ____ day of August, 2015.

ATTEST:	**The City of Kyle, Texas**
______________________________	______________________________
Amelia Sanchez, City Secretary	R. Todd Webster, Mayor

CITY OF KYLE, TEXAS

(First Reading) Ordinance amending Personnel Policy

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: (*First Reading*) An Ordinance of the City of Kyle, Texas, Amending and Replacing Provisions of the City Personnel Policy; and Providing for Related Matters. ~ *Sandra Duran, Director of Human Resources*

Other Information:

Legal Notes:

Budget Information:

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Personnel Policy Ordinance

ORDINANCE NO. ________

AN ORDINANCE OF THE CITY OF KYLE, TEXAS, AMENDING AND REPLACING PROVISIONS OF THE CITY PERSONNEL POLICY; AND PROVIDING FOR RELATED MATTERS

Whereas, the quality and efficiency of the municipal services provided to its citizens and taxpayers by the City of Kyle are significantly dependent on the quality and longevity of city employees and/or personnel; and,

Whereas, it is in the general public interest that the City of Kyle maintain and, from time to time, improve a personnel policy that benefits both the general public and employees of the city;

NOW, THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF KYLE, TEXAS, THAT:

Section 1. **Findings.** The recitals included herein are found to be true and correct and are hereby adopted by the City Council and made a part hereof for all purposes as findings of fact.

Section 2. **Approval and Adoption of City Personnel Policy.** The City Council hereby adopts this ordinance clarifying and amending sections of the City's Personnel Policy to read as set forth in Exhibit "A" attached to and incorporated in this ordinance for all purposes.

Section 3. **Repeal of Conflicting Ordinances.** All existing City of Kyle Ordinances in conflict with the provisions of this Ordinance are repealed to the extent of the conflict.

Section 4. **Effective Date.** This ordinance shall take effect immediately from and after its passage and publication in accordance with the provisions of the City Charter.

Section 4. **Open Meetings.** It is hereby officially found and determined that the meeting at which this ordinance is passed was opened to the public as required and that public notice of the time, place, and purpose of said meeting was given as required by the Open Meetings Act.

PASSED AND APPROVED on this the _____ day of August, 2015.
FINALLY PASSED AND APPROVED on this the ____ day of August, 2015.

ATTEST: **The City of Kyle, Texas**

______________________________ ______________________________

Amelia Sanchez, City Secretary R. Todd Webster, Mayor

Exhibit A

Section 4.06. Job Postings.

All positions will be open to current city employees and shall be posted for at least seven (7) business days. If a shorter publication period is required due to an emergency, written justification should be included with the requisition and must be approved by the City Manager. External positions will be posted on the City Website and at the City Hall bulletin board where city notices are posted. The department head may request positions to be advertised in other media outlets. Applications will be accepted from both internal and external candidates. Internal only vacancies must be approved by the City Manager.

Section 4.12. Types of Positions.

It is the intent of the City of Kyle to clarify the definitions of employment classifications so that employees understand their employment status and benefits eligibility. These classifications do not guarantee employment for any specified period of time. The right to terminate the employment relationship at will at any time is retained by both the employee and the City of Kyle. Employees are informed of their status as exempt or non-exempt at the time of their initial employment, or subsequently if their classification changes for any reason. An employee's exempt or non-exempt classification may be changed only upon written notification by the Director of Human Resources.

(a) **Fair Labor Standards Act Job Classifications.** All employees are designated as either non-exempt or exempt under state and federal wage and hour laws:

(i) **Non-exempt employees** are employees whose work is covered by the Fair Labor Standards Act (FLSA). They are *not* exempt from the law's requirements concerning minimum wage and overtime.

(ii) **Exempt employees** are generally executives or managers or professional, administrative or outside sales staff who are exempt from the minimum wage and overtime provisions of the FLSA. Exempt employees hold jobs that meet the standards and criteria established under the FLSA by the U.S. Department of Labor.

(b) **City Job Classifications.** The City of Kyle has established the following categories for both non-exempt and exempt employees:

(i) **Regular full-time employees** are not in a temporary status and are regularly scheduled to work the department's full-time schedule. Full-time employees are those with an average of at least 30 hours of service per week or 130 hours of service per month. Generally, they are eligible for the full benefits package, subject to the terms, conditions and limitations of each benefit program.

(ii) **Regular part-time employees** are not in a temporary status and are regularly scheduled to work less than the full-time schedule and less than 1,000 hours of work per year. Regular part-time employees are not eligible for benefits offered by the city and are not eligible for participation in TMRS. There are voluntary benefits offered to all City employees by third party providers, subject to the terms, conditions and limitations of each benefit program.

(iii) **Temporary full-time and part-time employees** are hired as interim replacements to temporarily supplement the workforce or to assist in the completion of a specific project and are temporarily scheduled to work the department's schedule for a limited duration. Employment beyond any initially stated period does not in any way imply a change in employment status. Temporary employees receive all legally mandated benefits (such as workers' compensation insurance coverage), but are not eligible for the City's other employment benefits. Temporary employees who are placed with the City but who are actually employed by a temporary staffing agency must look to the temporary staffing agency to determine what benefits are provided. Such employees are not eligible for benefits from the City and are not eligible for participation in TMRS.

(iv) **Seasonal full-time and part-time employees** are hired for only a specific time period associated with certain job duties that arise seasonally. These positions may not exceed 120 days in a calendar year. Employment beyond any initially stated period does not in any way imply a change in employment status. Seasonal employees receive all legally mandated benefits (such as workers' compensation insurance coverage), but are not eligible for the City's other employment benefits.

(v) **Evaluation and Training Employee**. All newly hired employees shall be subject to a six-month evaluation and training period or longer if extended. All employees shall be subject to being placed on evaluation and training status for disciplinary reasons for a term to be determined in writing at the time the evaluation and training status is instituted.

Note: Volunteers and unpaid interns are not employed by the City in any capacity. Volunteers elect to donate their time and services as a volunteer for the City without any expectation of compensation. City of Kyle interns are unpaid and work in exchange for exposure to, and training in, a particular field of work. Volunteers and interns are generally not paid, are not entitled to any benefits, and are not covered by worker's compensation.

Section 5.04 Overtime and Compensatory Time. The City permits eligible employees to earn and use overtime and compensatory time. This policy applies to both full-time civilian exempt and non-exempt employees as defined by the Fair Labor Standards Act.

(a) **Definitions**

(i) ***Fair Labor Standards Act (FLSA):*** Establishes minimum wage, overtime pay, recordkeeping and youth employment standards affecting employees in the private sector and in Federal, State, and local governments.

(ii) ***Exempt employees:*** Employees who are exempt from the Fair Labor Standards Act under the Executive, Professional or Administrative exemption. These employees are salaried employees.

(iii) ***Non-exempt employees:*** Employees who are entitled to the minimum wage and/or overtime pay protections of the FLSA. These employees are hourly employees.

Seasonal employees working in a recreational establishment such as swimming pools and summer camps are exempt hourly employees that are exempt from the calculation of overtime pay and/or compensatory time.

(iv) ***Standard workweek:*** A fixed and recurring period of seven consecutive 24-hour days. The City's workweek begins at 12:01 a.m. Sunday and ends at 12:00 midnight Saturday. The City's regular workweek for full-time employees is eight hours a day on five consecutive days from 8:00 a.m. to 5:00 p.m. Adjusted work schedules may be approved for part-time employees, shift employees, and employees occupying positions which require a workweek other than five days.

(v) ***Hours worked:*** Any hours that the City requires or permits an employee to work. As used in this policy, hours worked may also be referred to as work time.

(vi) ***Flex-time Work Schedule*****:** In situations where overtime payment is not feasible due to budgetary constraints, the Department Director or supervisor may consider flexing the employee's work schedule in an effort to minimize the need for overtime compensation. Flexing must be completed within the same workweek that the overtime was worked and must be accurately reflected on the affected employee's time record.

(vii) ***Standard civilian workday:*** The 24-hour period beginning at 12:01 a.m. and ending at 12:00 midnight. Working more than eight hours in a workday does not constitute overtime. Fair Labor Standards Act (FLSA) overtime occurs only after actually working more than forty (40) hours in a workweek. Any type of leave taken during a workweek will not be used in determining overtime pay.

(viii) ***Overtime:*** Overtime compensation is paid to all non-exempt employees in accordance with federal and state wage and hour requirements. Overtime pay for non-exempt employees is at the rate of one and one-half times the employee's regular hourly rate of pay for hours actually worked in excess of forty (40) hours in the City's workweek with the exception of certain Civil Service positions.

(b) **Earning of Overtime and Compensatory Time**

(i) **Overtime and Compensatory Time for Non-exempt Employees.** When necessary, in order to maintain the proper City services, employees may be required to work overtime. Non-exempt employees may receive overtime, or if an agreement is arrived at between the department head and the employee before the performance of work, the employee may accrue compensatory time. All non-exempt employees required to work overtime shall be compensated at one and one-half times their regular rate of pay. A non-exempt employee does not receive both FLSA overtime pay and compensatory time for the same hours.

(1) **Authorization.** All non-exempt employees must receive their supervisor's and Department Director's prior authorization before performing any overtime work. This means employees may not begin work prior to their scheduled work day, and may not continue working beyond the end of their scheduled workday, without

prior authorization from the appropriate supervisor. Similarly, employees may not work through their lunch break without prior authorization from the appropriate supervisor. On the employee's time sheet, the appropriate supervisor must also approve any overtime before the time sheet is submitted for processing and payment. Non-exempt employees shall not remain at their work station without authorization unless they are on duty or are scheduled to begin work within a short period of time. Non-exempt employees who work overtime without receiving proper authorization will likely be subject to disciplinary action, up to and including possible termination of employment.

(2) **Leaves of Absence.** Paid vacation, sick leave, holiday, jury duty, bereavement leave, or any other accrued leave are not included as hours worked for purposes of determining overtime calculations. Compensatory time may not be transferred or donated to other employees through the Accrued Leave Donation program.

(3**)** **Payment of Compensatory Time.** Non-exempt employees may accrue compensatory time in lieu of being paid overtime compensation. Employees are subject to a cap of one-hundred and sixty (160) hours. Overtime hours worked beyond the applicable cap must be paid or flexed, as described below. Compensatory time accrues at a rate of one and one-half hours for every hour of overtime worked by non-exempt employees. Compensatory time accruals are to be monitored at the department level and maximum hours accrued will be restricted based on the requirements of this policy. All compensatory time earned must be documented on the employee's compensatory timesheet and accrual balances on the payroll system. Non-exempt employees may be paid at the overtime rate for compensatory time hours when the taking of earned compensatory time would be disruptive to critical functions. All employees who are reclassified from a non-exempt position to an exempt position will be paid all accrued compensatory time upon approval of the reclassification and will cease to be eligible for any additional overtime and/or compensatory time at the rate of one and one-half hours for every hour of overtime. Likewise, an employee who is promoted, transferred or demoted to another non-exempt position will be paid in full for any compensatory time accrued before the promotion or demotion becomes effective. Upon leaving employment with the City, a non-exempt employee will be paid for unused compensatory time at the employee's current hourly rate.

(c) **Compensatory Time for Exempt Employees.** Exempt employees are not paid overtime compensation. The City permits exempt employees who work over forty (40) hours in a week to request to his or her supervisor to earn compensatory time for the hours worked over forty (40) hours in a workweek. Any time off during the exempt employee's regular scheduled hours must be accounted for through the use of earned compensatory time, sick leave, or vacation. Compensatory time is earned on a straight time, hour for hour, basis. When the workweek has an observed holiday, the eight hours of holiday should count towards the forty (40) hours in a workweek for the purpose of calculating compensatory time.

(i) Exempt employees are not entitled to be paid out compensatory time accumulated upon termination of employment, including retirement, nor receive any cash payment for the use of compensatory time. An exempt employee shall not be permitted to accumulate a balance of more than eighty (80) hours of compensatory time at any point.

(ii) Exempt employees must track in their bi-weekly timesheet the total amount of hours worked per day, per week, and per pay period. Supervisors will need to authorize all compensatory time on the employee's bi-weekly time sheet.

(iii) Exempt employees must be able to communicate and justify to the head of the Department the need to work over forty (40) hours in a given week to track performance, productivity, and/or results.

(iv) Compensatory time will not be approved for any work performed from home, or City-approved trips, or during other events unless authorized by the City Manager.

(v) Compensatory time may not be transferred or donated to other employees through the Accrued Leave Donation program.

(d) **Use of Compensatory Time**

(i) An employee separating from the City can use up to forty (40) hours of compensatory time during their last week on the payroll.

(ii) An employee shall be permitted to use compensatory time within a reasonable period after making the request, if doing so does not unduly disrupt the operations of the employer.

(e) **Employee Responsibilities**

(i) The employee shall request to use compensatory time through his or her supervisor.

(ii) The employee promptly and accurately records on the weekly time sheet all time worked plus use of paid leave or paid holiday time and the use of compensatory time.

(1) An exempt employee accounts for time on a weekly basis, according to prior arrangements with the supervisor.

(2) A non-exempt employee accounts for time on a daily basis, according to a work-schedule previously agreed upon with the supervisor.

(f) **Supervisor and Department Responsibilities**

(i) The supervisor must review and approve the use of compensatory time, verify the employee has accurately recorded the use of the time on the time sheet and sign it.

(ii) Supervisors are encouraged to accommodate, to the extent practicable, the employee's use of compensatory time.

(iii) All compensatory/overtime must be pre-approved by supervisors and will be allowed when deemed absolutely necessary to finish a project.

(iv) When ordered for the maintenance of essential City functions, compensatory/overtime shall be allocated as equitably as possible among all non-exempt employees qualified to do the work.

(v) Department heads and City Management are charged with authorizing the use of compensatory/overtime and likewise with assuring non-abuse of overtime or compensatory time and the inadvertent use of such by employees.

Section 5.16. Family and Medical Leave.

In accordance with the Family and Medical Leave Act of 1993, an employee may be eligible to take up to twelve (12) weeks of unpaid family and medical leave during a rolling twelve (12) month period. An eligible employee is one who has worked for the City for at least twelve (12) months and has worked at least 1,250 hours during the twelve (12) months preceding the first date leave is to be taken. Leave can be taken for any of the following reasons: birth of a child; placement with the employee of a child for adoption or foster care (entitlement to family and medical leave expires twelve months after birth or placement); when the employee is needed to care for a child, spouse, or parent who has a serious health condition; or when the employee is unable to perform the essential functions of the position because of the employee's own serious health condition.

Family Leave has been expanded to provide Family and Medical Leave due to a call to active military duty. This benefit provides 12 workweeks of unpaid FMLA leave due to a spouse, son, daughter or parent being on active military duty or having been notified of an impending call or order to active military duty in the Armed Forces. Leave may be used for any "qualifying exigency" arising out of the servicemember's current tour of active military duty or because the servicemember is notified of an impending call to military duty in support of a contingency operation.

Also a caregiver needing leave to provide care for an injured servicemember is eligible for extended Family and Medical leave. This benefit provides 26 workweeks of unpaid FMLA leave during a single 12-month period for a spouse, son, daughter, parent, or next of kin caring for a recovering servicemember. A recovering service member is defined as a member of the Armed Forces who suffered an injury or illness while on active military duty that may render the person unable to perform the duties of the member's office, grade, rank or rating.

(a) **PROCEDURES**

(i) **Twelve Month Period:** The twelve (12) month period for counting family and medical leave is a "rolling" 12-month period measured backward from the date an employee requests or is placed on FMLA leave. Each time an employee takes FMLA leave, the remaining leave entitlement would be any balance of the 12 weeks which has not been used during the immediately preceding 12 months, or 26 weeks provided in certain circumstances.

(ii) **Employee Notification:** An employee should give at least thirty (30) days' notice for the need to take foreseeable family and medical leave, unless the need is unforeseeable, in which case, as much notice as is practicable should be given. A form for requesting family and medical leave is available in the Human Resources Department. If it is determined that the need for family and medical leave was foreseeable, the leave may be delayed until at least thirty (30) days after the date that the employee provides notice to the City.

(iii) **Department Notification:** Each department supervisor is responsible for notifying the Human Resource Department immediately when an employee is away from work for a family and medical leave qualifying event (if family and medical leave has not been approved), even if the employee is utilizing paid vacation, sick or any other accrued leave, or is out due to a work related injury. An employee using sick leave should be reported to the Human Resource Department if it is anticipated that the duration of the illness will be three (3) or more days, or once the employee exceeds three (3) days of sick leave use.

(iv) **Human Resource Responsibility:** Human Resources is responsible for central administration of all requests for family and medical leave. The Human Resource Department reserves the right to automatically place an employee on family and medical leave if it is determined that a qualifying event has occurred. The Human Resource Department may retroactively designate the beginning date of FMLA to the beginning date of the employee's absence for the qualifying event.

(v) **Approval:** An employee shall submit an initial request for family and medical leave through proper channels to the Department Director. The employee will then need to meet with someone in the Human Resources Department for approval and to coordinate any approved leave. Confidential medical information that accompanies the application should be submitted directly to the Human Resource Department.

(vi) **Substitution of Paid Leave:** An employee utilizing this policy for the placement of a child for adoption or foster care with the employee shall be required to exhaust all accrued vacation and any other applicable paid leave prior to going on unpaid leave. An employee utilizing this policy for the serious illness of a child, spouse or parent must exhaust all accrued sick leave, vacation leave and any other applicable paid leave prior to going on unpaid leave. If an employee gives birth to a child, sick leave can be utilized until the employee receives a release from the doctor. After being released, the employee may use additional sick leave in accordance with the sick leave policy. Once all applicable sick leave has been used, the employee shall be required to exhaust all accrued vacation leave prior to going on unpaid leave. An employee utilizing this policy for the employee's own serious health condition shall exhaust all accrued sick and vacation leave prior to going on unpaid leave. If an employee is off work due to a work related injury and the employee qualifies for family and medical leave, it will run concurrently with any paid leave. Employees do not accrue paid time off while on unpaid leave. *The City reserves the right to count any paid leave that qualifies for family and medical leave toward the twelve (12) or twenty-six (26) weeks allowed under this policy.*

(vii) **Maximum Time Allowed:** The maximum amount of family and medical leave available is twelve (12) weeks during a twelve (12) month period even if there is more than one family and medical leave qualifying event. The only exception to the twelve (12) week maximum is the leave to provide care of an injured service member, described above, which allows for an extended FMLA leave of 26 weeks.

(viii) **Medical Certification:** The City may require medical certification from a health care provider to support a claim for leave to care for a seriously ill child, spouse or parent, or for the employee's own serious health condition. Medical certifications must be returned to the Human Resource Department within fifteen (15) working days. Recertification may also be required on a monthly basis. For leave to care for a seriously ill child, spouse, or parent, the certification must include an estimate of the amount of time the employee is needed to provide care. For the employee's own serious health condition, the certification must include a statement that the employee is unable to perform the essential functions of the position, and expected duration. The City does not seek and should not be provided genetic information. If an employee or applicant's genetic information is inadvertently received by the City; the City will not use genetic information for any employment decision or action.

Upon returning to work after leave for his or her own illness, an employee is required to provide certification to the supervisor that the employee is able to return to regular duties. If the validity of a certification is questioned, the City may require that a second opinion be obtained. If the first and second opinions differ, the City may require a third opinion be obtained. The employee and the City must agree upon a health care provider for the third opinion and this opinion shall be binding on both parties. The City shall bear the expense of second and third opinions.

(ix) **Return to Work:** When an employee returns to work after family and medical leave, the employee shall be restored to the same position or to an equivalent position involving the same or substantially similar duties and responsibilities. An employee will be restored to the same worksite or to a geographically proximate worksite. The employee is also entitled to return to the same shift or an equivalent schedule.

(x) **Effect on Married Couples:** If a City employee is married to another City employee and either or both employees request family and medical leave for the birth or placement of a child with the employee for adoption or foster care, the total time allowed shall be limited to no more than twelve (12) weeks combined during any rolling twelve (12) month period. For other qualifying family and medical leave events, each employee is entitled to leave as long as the total amount of leave taken during any twelve (12) month period does not exceed twelve (12) weeks or twenty-six (26) weeks if applicable for one employee.

(xi) **Continuation of Insurance Benefits:** While utilizing unpaid family and medical leave, an employee's insurance benefits will continue without interruption as long as the employee pays his or her portion of the insurance premiums and any other voluntary deductions.

(xii) **Intermittent Leave:** When medically necessary, an employee may take family and medical leave on an intermittent basis or work a reduced schedule. Arrangements should be made with the employee's immediate supervisor so that the operations of the department are not unduly disrupted. An employee taking intermittent leave or leave on a reduced schedule may be temporarily assigned to an alternative position with equivalent pay and benefits if it better accommodates the needs of the department.

(xiii) **Holidays:** Holidays will be paid in accordance with the Holidays policy. City holidays will be counted as part of the twelve (12) or twenty-six (26) weeks of family and medical leave, whether the employee is on paid or unpaid leave.

(xiv) **TMRS:** Employee contributions to TMRS may be made on a voluntary basis through a special arrangement with the City while an employee is in a leave without pay status. It is the employee's responsibility to initiate such an arrangement by timely contacting the City's Director of Human Resources and completing the necessary paperwork.

(xv) **Recordkeeping:** Family medical leave time will be tracked on an hourly basis for payroll and compliance purposes. To determine entitlement for employees who work variable hours, the minimum hours required for eligibility is calculated on a pro rata or proportional basis by averaging the weekly hours worked during the twelve (12) weeks prior to the start of family and medical leave.

(xvi) **Exempt Employees:** Paid leave accounts may be charged for less than one (1) full work day according to department policy and the salary of an exempt employee may be docked for absences of less than one (1) full work day. Salaried executive, administrative, professional and other employees of the City who meet the Fair Labor Standards Act (FLSA) criteria for exemption from overtime do not lose their FLSA-exempt status by using any unpaid FMLA leave.

(b) **DEFINITIONS**

(i) **Child:** A biological, adopted, or foster child; a stepchild; a legal ward; or a child of a person standing in loco parentis, who is standing in the place of a parent, who is either under age 18, or age 18 or older and requires active assistance or supervision to provide daily self-care. A biological or legal relationship is not necessary. A more detailed definition is provided in the Family and Medical Leave Act of 1993 which is available in the Human Resource Department.

(ii) **Health Care Provider:** A doctor of medicine or osteopathy who is authorized to practice medicine or surgery (as appropriate) by the State in which the doctor practices; or any other person determined by the Secretary of Labor to be capable of providing health care services. A more expansive definition is provided in the Family and Medical Leave Act of 1993 which is available in the Human Resource Department.

(iii) **Parent:** A biological parent or an individual who stands or stood in the place of a parent to an employee when the employee was a child. This term does not include parents-in-law.

(iv) **Serious Health Condition:** An illness, injury, impairment, or physical or mental condition that involves: (1) any period of incapacity or treatment that results in inpatient care (i.e., an overnight stay) in a hospital, hospice, or residential medical care facility; (2) any period of incapacity requiring absence from work, school, or other regular daily activities, of more than three calendar days, that also involves continuing treatment by (or under the supervision of) a health care provider; or (3) continuing treatment by (or under the supervision of) a health care provider for a chronic or long-term health condition so serious that, if not treated, would likely result in a period of incapacity of more than three calendar days; or 4) for prenatal care. Voluntary or cosmetic treatments (such as most treatments for orthodontia or acne) which are not medically necessary are not "serious health conditions," unless inpatient hospital care is required. Restorative dental surgeries after an accident or removal of cancerous growths are serious health conditions provided all the other conditions of this regulation are met.

(v) **Spouse:** A husband or wife as defined or recognized under State law for purposes of marriage, including common law marriage.

(vi) **Reduced Schedule Leave:** A leave schedule that reduces the usual number of hours per workweek, or hours per workday, of an employee.

(c) **Interpretation and Application of This Section.** This Article and section shall be interpreted and applied by the City in a manner consistent with the Family and Medical Leave Act, 29 U.S. Code Chapter 28. In the event of a conflict between any provision of this section and such Act, the terms and provisions of the Act shall govern and control.

Section 5.18. Volunteer Time Off.

The City of Kyle encourages all employees to take part in projects that support the community in which we serve. Employees are eligible to use up to 12 hours of paid time off during regularly scheduled work hours each calendar year to volunteer for a charitable organization in our community.

(a) **Eligibility.**

(i) **Employee.** All regular full-time City of Kyle employees are eligible to participate in this program after the satisfactory completion of the probationary period from the date of hire. The employee must be in good standing. The 12 hours of paid time off during regularly scheduled work hours may be spread over several days during the calendar year. The hours scheduled to work for the workweek that the employee is requesting to volunteer must not exceed 40 hours. Any volunteer hours that result in overtime or compensatory time will not count towards this program.

Regular part-time employees are eligible to use up to 6 hours of paid time off during regularly scheduled work hours that may be spread over several days during the calendar year.

(ii) **Organization.** Charitable organizations classified by the IRS as 501(c)(3) non-profit, public charities and municipalities (i.e. public schools) are eligible.

(1) **Eligible Activities.** Volunteer activities that benefit the local community are eligible, including, but not limited to serving meals at a soup kitchen; helping build

houses; mentoring area youths; leading a scout troop; assisting students with reading or writing.

Employees may volunteer with a religious organization if the purpose of the activity is to benefit a cause not associated with religious or political activities.

(2) **Ineligible Activities.** Programs or initiatives where the primary purpose is the promotion of religious doctrine or tenets are ineligible for Volunteer Time Off. Activities to carry on propaganda, to attempt to influence legislation or the outcome of any public election or to carry on any voter registration drive are also ineligible.

Volunteer activities performed outside the regularly scheduled work hours or during scheduled time off such as vacation, holidays, or any other approved time off are not eligible for this program.

Volunteer Time Off may not be used for organizations that discriminate based on age, race, religion, sex, national origin, citizenship, disability, genetics, veteran's status or other unlawful basis.

(b) **Participation.** Employees must complete a Volunteer Time Off (VTO) request form and submit to his/her supervisor at least two weeks before the requested time off for approval. The employee is asked to consider peak work periods in his/her department before requesting time off to volunteer. The supervisor should consult with HR regarding any questions or concerns before approving or denying the request. Approval is at the discretion of the employee's supervisor. A copy of the approved VTO forms must be sent to the Human Resources Department for recordkeeping of all city-wide volunteer hours.

Section 10.08 Tuition Reimbursement Program.

The Tuition Reimbursement Program is established to recognize the importance of investing in the learning and development of its workforce to increase employee engagement, career growth, high performance and innovation by providing financial assistance to employees who take job related, City career-enhancing credit courses at accredited degree granting colleges and universities.

As with all City benefits, the City Council may choose to modify the funding of the Tuition Reimbursement Program as the budget permits. Therefore, this program is also contingent upon annual appropriation of funds and acceptance into the program does not guarantee payment.

(a) **Employee.** Employees are eligible for tuition reimbursement if all of the following criteria are met:

(i) Employee is an active full time employee in a regular-budgeted position.
(ii) Employee has successfully completed the six-month probationary period as a new hire before the start of class.
(iii) Employee is not under disciplinary probation or suspension at the time of application or in the twelve months preceding the first day of the course for the employee request for tuition reimbursement.

(iv) Employee must complete an application with the Human Resources Department and receive an approval notice to participate in the course prior to the first day of class.

(b) **Course Eligibility.** Courses are eligible for tuition reimbursement if all of the following criteria are met:

(i) Course is job-related or will enhance the employee's career opportunities within the City of Kyle. Courses must relate to a field on which the City normally recruits employees or seek an Associates, Undergraduate or Master's degree related to a field in which the City normally recruits employees.

(ii) Course is offered at a school or institution that is approved by the Texas Education Agency or other nationally recognized board of accreditation.

(iii) Course is offered for college credit hours.

(iv) Course is offered on a for-grade basis.

(v) Pre-approval from employee's Department Head and the Human Resources Department prior to taking course

(vi) Ineligible Courses: If any of the following criteria are met, the course is not eligible for tuition reimbursement:

(1) Course is required, organized, or coordinated by a City department for its employees.
(2) Course is part of a conference, seminar, annual meeting, certification exam, or certification course not offered for academic credit or on a for-grade basis.

(c) **Eligible Cost.** The Program will reimburse to covered costs of tuition and books (up to the maximum fiscal year allotted amount). Any costs for supplies, travel, student fees, parking permits, etc., are not reimbursable under this Program. The City will not pay the cost of tuition, mandatory fees, and books, which are paid by other sources (i.e., scholarships, grants, aid programs or other subsidies. Sources of assistance will be deducted from the amount that the City will reimburse.

(d) **Grade Requirements.** Employees must attain a course grade equivalent to a "C" or better in each course to be eligible for reimbursement. In circumstances where pass/fail is the only grading system used, this grading system will be accepted. A pass grade must be earned to be eligible for tuition reimbursement. In case where a class is not completed successfully, tuition reimbursement will not take place for that course.

(e) **Benefit Allowance.** Funding for the program is available only if and when approved by the City Council in the City's annual budget. Employees may receive up to a maximum of $1,000 per fiscal year on a first-come first-served basis until all allotted or budgeted funds for this program have been expended. The City will reimburse employees at the conclusion of a successfully completed course, pursuant to the following schedule:

The City will reimburse up to 100% of the tuition cost for an "A" grade.

The City will reimburse up to 85% of the tuition cost for a "B" grade.

The City will reimburse up to 70% of the tuition cost for a "C" grade.

No reimbursements will be made for grades lower than a "C" grade

For courses in which the employee can only receive a "PASS" or "FAIL,", “PASS” will be reimbursed at 100% and “FAIL” will not be reimbursed.

Reimbursement rates are not affected by grades that are accompanied by a plus or a minus sign (+ or -). For example, an eligible employee who receives a B+ will be reimbursed up to 85%. Likewise, an eligible employee who receives a B- will be reimbursed up to 85%.

(f) **Reimbursing Employee.** Required paperwork must be submitted to the Human Resources Department within thirty (30) days of the grade report to be eligible for reimbursement. Upon review and approval of the final grade report and paid fee receipt and confirmation of continued employee eligibility, the Human Resources Department will process the request for reimbursement through the Finance Department. If an employee has reached the maximum reimbursement amount, documents will not be held for payment in future years. A two (2) year service requirement begins on the reimbursement check date. A separate two year service requirement must be completed for each reimbursement payment made to the employee. Employees terminated due to a reduction in force shall not be required to reimburse the monies received for tuition reimbursement.

(g) **Tax Benefits/Implications.** Please consult a tax advisor and/or refer to Section 127 of the Internal Revenue Code and IRS Publication 970 for information regarding tax benefits and implications of company sponsored tuition reimbursement programs. (www.irs.gov)

CITY OF KYLE, TEXAS

Discussion on boats and trailers parking

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Discussion and possible action regarding future ordinance against large trailers and boats being parked for extended periods of time on city streets. ~ *Damon Fogley, Council Member*

Other Information:

Legal Notes:

Budget Information:

Viewing Attachments Requires Adobe Acrobat. Click here to download.

Attachments / click to download

Cover Memo

CITY OF KYLE, TEXAS

Overview of City's Share of Planned CIPs by HCPUA

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Overview of City's share of costs for Phase I water supply associated capital improvement projects planned to be incurred by the Hays Caldwell Public Utility Agency (HCPUA) during fiscal years 2016 through 2020. ~ *Daphne Tenorio, Council Member*

Other Information:

Legal Notes:

Budget Information:

Viewing Attachments Requires Adobe Acrobat. Click here to download.

Attachments / click to download

2015 HCPUA 5-Year CIP

HAYS CALDWELL PUBLIC UTILITY AGENCY

2015 CAPITAL IMPROVEMENTS PLAN

APRIL 22, 2015

HCPUA

HAYS CALDWELL PUBLIC UTILITY AGENCY

BOARD OF DIRECTORS

Hays Caldwell Public Utility Agency
Summary CIP for 2015

Primary Objectives of the CIP

The primary objectives that require capital projects in the 2015 CIP are:

- Delivery of interim water to Buda in 2017 – also allows the Agency's transportation permit with the Gonzales County Underground Water Conservation District to be extended from a 3-year term to a 30-year term; and
- Delivery of Carrizo water to the Sponsors starting in 2023.

Project Phasing

The overall project is split into primary phases. When complete Phase 1 will produce and deliver 15,000 acre-feet per year of water; Phase 2 will add an additional 20,560 acre-feet per year of water for a total amount of 35,560 acre-feet per year. Attached is the draft infrastructure map for the project.

The Phase 2 project has not been included in the CIP as no infrastructure is anticipated to be associated with this phase for several decades. Phase 1 has been split into four sub-phases as follows:

Phase 1A

- Pipeline and pump station interconnecting the Kyle and Buda water systems. The facilities are anticipated to be used in the short-term to provide for interim water sharing and will also eventually serve as the delivery infrastructure of the Carrizo water to Buda.
- The pipeline will be sized to handle the full anticipated flow to Buda. The pump station will allow for expansion to provide the full contract delivery amount to Buda.

Phase 1B

- Two wells will be drilled and installed for a capacity of 5,488 acre-feet per year. The primary collection line from the well field to the treatment plant will be installed along with the individual collection lines.
- The treatment plant will be built – it is anticipated to be a sand filter plant with chlorination equipment, high service pumps and clearwell storage. The site will built to provide for a total capacity of 35 MGD (39,000 acre-feet per year), with filter equipment installed in this phase for 5 MGD of capacity.
- Treated transmission mains from the treatment plant to the Phase 1A infrastructure will be designed and installed. Most of the lines will be sized for their full capacity, except for the line from the treatment plant to Pump Station #1 which will have a capacity of approximately 15,000 acre-feet per year.
- Pump Station #1 will be designed and constructed – it will pump water to the north to connect to the Phase 1A infrastructure and to the southwest to serve Crystal Clear SUD and Green Valley SUD.

Phase 1C

- Two additional wells will be installed along with the collection lines to allow for an additional 5,488 acre-feet per year of supply yielding a total of approximately 11,000 acre-feet per year.
- Additional treatment equipment will be installed to provide a total capacity of 10 MGD.

Phase 1D

- Two additional wells will be installed along with the collection lines to allow for an additional 4,000 acre-feet per year of supply yielding a total of approximately 15,000 acre-feet per year.
- Additional treatment equipment will be installed to provide a total capacity of 15 MGD.

Projected Water Cost

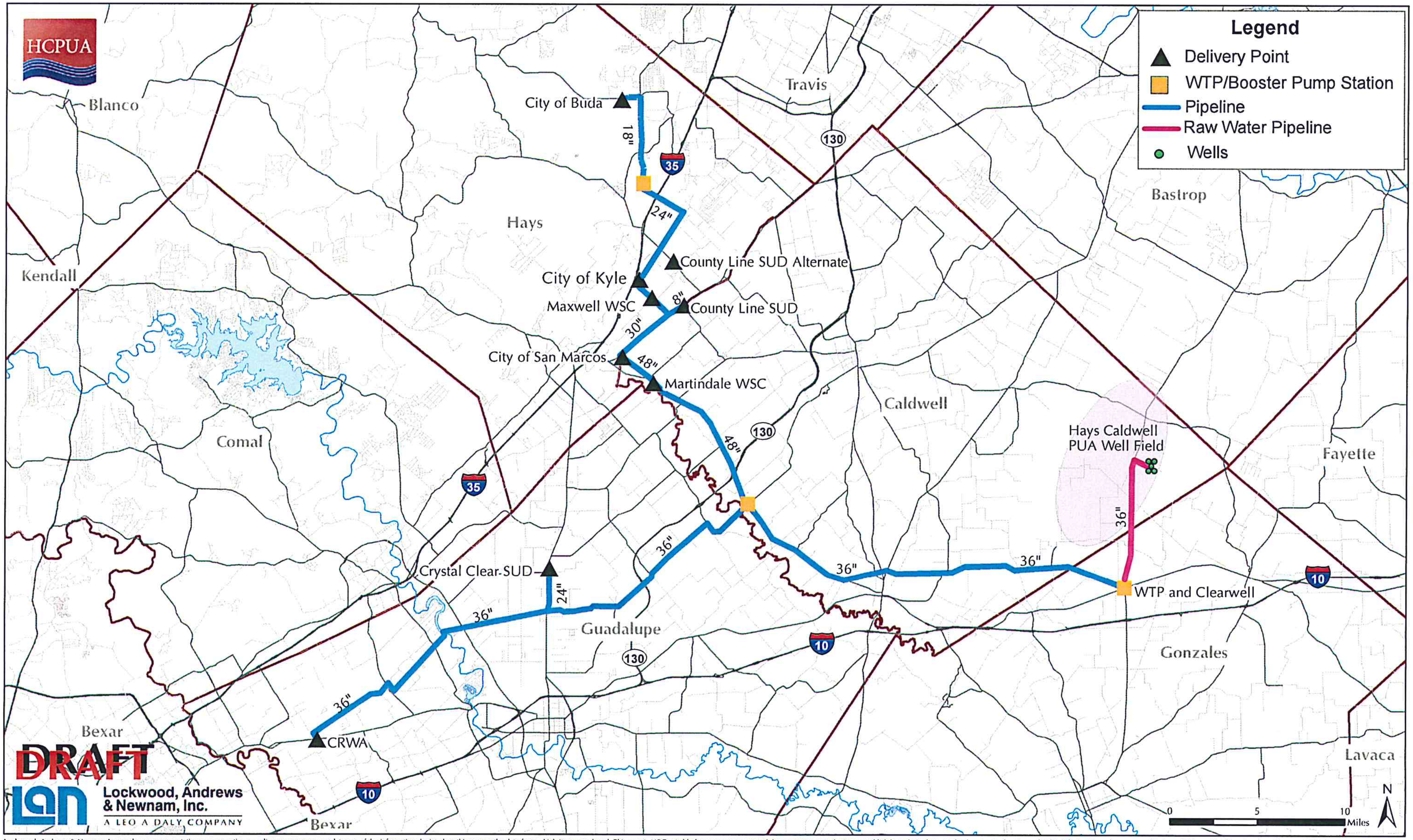
The table below describes the projected delivered water costs at the end of each phase.

	Delivered Water (ac-ft)	Cost ($ per ac-ft)	Cost ($ per 1,000 gallons)
Phase 1A	N/A	-	-
Phase 1B	5,488	$3,366	$10.32
Phase 1C	10,185	$2,089	$6.41
Phase 1D	15,000	$1,539	$4.72

END

HCPUA Project Map - Phase 1B-1D

7/21/2014



Lockwood, Andrews & Newnam Inc. makes no representations or warranties regarding accuracy or completeness of the information depicted on this map or the data from which it was produced. This map is NOT suitable for survey purposes and does not purport to depict or establish boundaries between land owners or locations of utility infrastructure where survey data is available and field locations have been established.

HCPUA

HAYS CALDWELL PUBLIC UTILITY AGENCY
2015 CAPITAL IMPROVEMENTS PLAN

	Total	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	Other	Total
Phase 1A														
Kyle-Buda Pipeline														
Design	$ 475,000	$ 375,000	$ 100,000											$ 475,000
Land Acquisition	$ 2,000,000	$ 300,000	$ 1,700,000											$ 2,000,000
Construction	$ 5,000,000		$ 750,000	$ 4,250,000										$ 5,000,000
Total	**$ 7,475,000**	**$ 675,000**	**$ 2,550,000**	**$ 4,250,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 7,475,000**
Pump Station #2														
Design	$ 500,000	$ 50,000	$ 450,000											$ 500,000
Construction	$ 4,000,000		$ 1,000,000	$ 3,000,000										$ 4,000,000
Total	**$ 4,500,000**	**$ 50,000**	**$ 1,450,000**	**$ 3,000,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 4,500,000**
Phase 1A Total	**$ 11,975,000**	**$ 725,000**	**$ 4,000,000**	**$ 7,250,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 11,975,000**
Debt Issuance #1			**$ 12,000,000**											**$ 12,000,000**
Phase 1B														
Well Field Easements														
Well Site Acquisitions	$ 50,000		$ 50,000											$ 50,000
Pipe & Access Easements	$ 200,000		$ 200,000											$ 200,000
Total	**$ 250,000**	**$ -**	**$ 250,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 250,000**
Alignment Study														
Study & Report	$ 300,000		$ 200,000	$ 100,000										$ 300,000
Total	**$ 300,000**	**$ -**	**$ 200,000**	**$ 100,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 300,000**
Treated Transmission Mains														
Design	$ 12,500,000			$ 6,000,000	$ 6,500,000									$ 12,500,000
Land Acquisition	$ 6,500,000				$ 1,000,000	$ 3,000,000	$ 2,500,000							$ 6,500,000
Construction	$ 122,850,000					$ 21,000,000	$ 31,500,000	$ 38,850,000	$ 31,500,000					$ 122,850,000
Total	**$ 141,850,000**	**$ -**	**$ -**	**$ 6,000,000**	**$ 7,500,000**	**$ 24,000,000**	**$ 34,000,000**	**$ 38,850,000**	**$ 31,500,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 141,850,000**
Operations Building														
Design	$ 125,000				$ 125,000									$ 125,000
Site Acquisition	$ 550,000				$ 550,000									$ 550,000
Construction	$ 2,100,000					$ 2,100,000								$ 2,100,000
Total	**$ 2,775,000**	**$ -**	**$ -**	**$ -**	**$ 675,000**	**$ 2,100,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 2,775,000**
Pump Station #1														
Design	$ 725,000						$ 600,000	$ 125,000						$ 725,000
Site Acquisition	$ 75,000						$ 25,000	$ 50,000						$ 75,000
Construction	$ 7,035,000							$ 2,100,000	$ 4,935,000					$ 7,035,000
Total	**$ 7,835,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 625,000**	**$ 2,275,000**	**$ 4,935,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 7,835,000**
Treatment Plant (5-MGD Capacity)														
Site Acquisition	$ 175,000				$ 75,000	$ 100,000								$ 175,000
Design	$ 2,500,000					$ 1,750,000	$ 750,000							$ 2,500,000
Construction	$ 11,550,000							$ 5,250,000	$ 6,300,000					$ 11,550,000
Total	**$ 14,225,000**	**$ -**	**$ -**	**$ -**	**$ 75,000**	**$ 1,850,000**	**$ 750,000**	**$ 5,250,000**	**$ 6,300,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 14,225,000**

HAYS CALDWELL PUBLIC UTILITY AGENCY
2015 CAPITAL IMPROVEMENTS PLAN

	Total	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	Other	Total
Well Field (2 Wells - 5,488 AF/yr)														
Design	$ 1,400,000				$ 400,000	$ 1,000,000								$ 1,400,000
Easement for Collection Lines	$ 325,000					$ 100,000	$ 225,000							$ 325,000
Construction (Pipeline/Access)	$ 11,550,000						$ 2,100,000	$ 4,725,000	$ 4,725,000					$ 11,550,000
Construction (Wells)	$ 2,940,000								$ 2,940,000					$ 2,940,000
Total	$ 16,215,000	$ -	$ -	$ -	$ 400,000	$ 1,100,000	$ 2,325,000	$ 4,725,000	$ 7,665,000	$ -	$ -	$ -	$ -	$ 16,215,000
Phase 1B Total	$ 183,450,000	$ -	$ 450,000	$ 6,100,000	$ 7,975,000	$ 26,950,000	$ 37,700,000	$ 51,100,000	$ 50,400,000	$ -	$ -	$ -	$ -	$ 183,450,000
Debt Issuance #2				$ 14,650,000										$ 14,650,000
Debt Issuance #3						$ 66,750,000								$ 66,750,000
Debt Issuance #4								$ 101,500,000						$ 101,500,000
Phase 1C														
Treatment Plant (10-MGD Capacity)														
Design	$ 850,000											$ 450,000	$ 400,000	$ 850,000
Construction	$ 10,290,000											$ 4,200,000	$ 6,090,000	$ 10,290,000
Total	$ 11,140,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,650,000	$ 6,490,000	$ 11,140,000
Well Field (2 Wells - 5,488 AF/yr)														
Design	$ 450,000												$ 450,000	$ 450,000
Easements	$ 60,000												$ 60,000	$ 60,000
Construction	$ 2,940,000												$ 2,940,000	$ 2,940,000
Total	$ 3,450,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,450,000	$ 3,450,000
Phase 1C Total	$ 14,590,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,650,000	$ 9,940,000	$ 14,590,000
Phase 1D														
Treatment Plant (15-MGD Capacity)														
Design	$ 850,000												$ 850,000	$ 850,000
Construction	$ 10,290,000												$ 10,290,000	$ 10,290,000
Total	$ 11,140,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 11,140,000	$ 11,140,000
Well Field (2 Wells - 5,488 AF/yr)														
Design	$ 450,000												$ 450,000	$ 450,000
Easements	$ 60,000												$ 60,000	$ 60,000
Construction	$ 2,940,000												$ 2,940,000	$ 2,940,000
Total	$ 3,450,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,450,000	$ 3,450,000
Phase 1D Total	$ 14,590,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 14,590,000	$ 14,590,000
TOTAL	$ 224,605,000	$ 725,000	$ 4,450,000	$ 13,350,000	$ 7,975,000	$ 26,950,000	$ 37,700,000	$ 51,100,000	$ 50,400,000	$ -	$ -	$ 4,650,000	$ 24,530,000	$ 224,605,000

HAYS CALDWELL PUBLIC UTILITY AGENCY
2015 CAPITAL IMPROVEMENTS PLAN

		Total	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	Other	Total
San Marcos	35.86%	$ 80,543,353	$ 259,985	$ 1,595,770	$ 4,787,310	$ 2,859,835	$ 9,664,270	$ 13,519,220	$ 18,324,460	$ 18,073,440	$ -	$ -	$ 1,667,490	$ 8,796,458	$ 80,543,353
Canyon Regional Water Authority	30.89%	$ 69,380,485	$ 223,953	$ 1,374,605	$ 4,123,815	$ 2,463,478	$ 8,324,855	$ 11,645,530	$ 15,784,790	$ 15,568,560	$ -	$ -	$ 1,436,385	$ 7,577,317	$ 69,380,485
Kyle	28.17%	$ 63,271,229	$ 204,233	$ 1,253,565	$ 3,760,695	$ 2,246,558	$ 7,591,815	$ 10,620,090	$ 14,394,870	$ 14,197,680	$ -	$ -	$ 1,309,905	$ 6,910,101	$ 63,271,229
Buda	5.08%	$ 11,409,934	$ 36,830	$ 226,060	$ 678,180	$ 405,130	$ 1,369,060	$ 1,915,160	$ 2,595,880	$ 2,560,320	$ -	$ -	$ 236,220	$ 1,246,124	$ 11,409,934
TOTAL	**100.00%**	**$ 224,605,000**	**$ 725,000**	**$ 4,450,000**	**$ 13,350,000**	**$ 7,975,000**	**$ 26,950,000**	**$ 37,700,000**	**$ 51,100,000**	**$ 50,400,000**	**$ -**	**$ -**	**$ 4,650,000**	**$ 24,530,000**	**$ 224,605,000**

Debt Issuance Amount by Sponsor

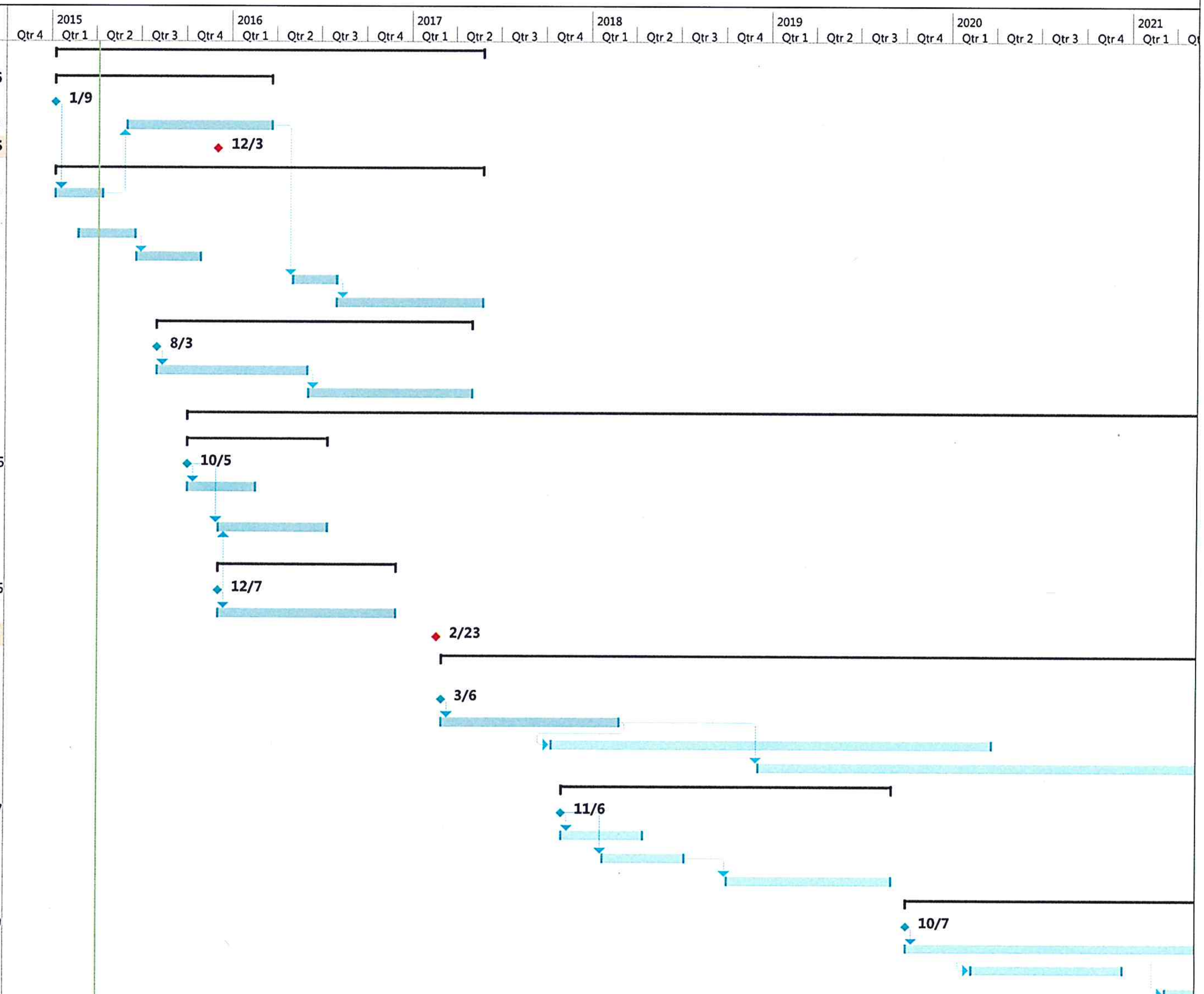
	Date	Amount	San Marcos	CRWA	Kyle	Buda
Debt Issuance #1	Nov/Dec 2015	$ 12,000,000	$ 4,303,200	$ 3,706,800	$ 3,380,400	$ 609,600
Debt Issuance #2	Feb/Mar 2017	$ 14,650,000	$ 5,253,490	$ 4,525,385	$ 4,126,905	$ 744,220
Debt Issuance #3	Aug/Sep 2018	$ 66,750,000	$ 23,936,550	$ 20,619,075	$ 18,803,475	$ 3,390,900
Debt Issuance #4	Aug/Sep 2020	$ 101,500,000	$ 36,397,900	$ 31,353,350	$ 28,592,550	$ 5,156,200

$194,900,000
28.17%
$54,903,330
* w/o cost of issuance

$54,903,330
* w/o cost of issuance

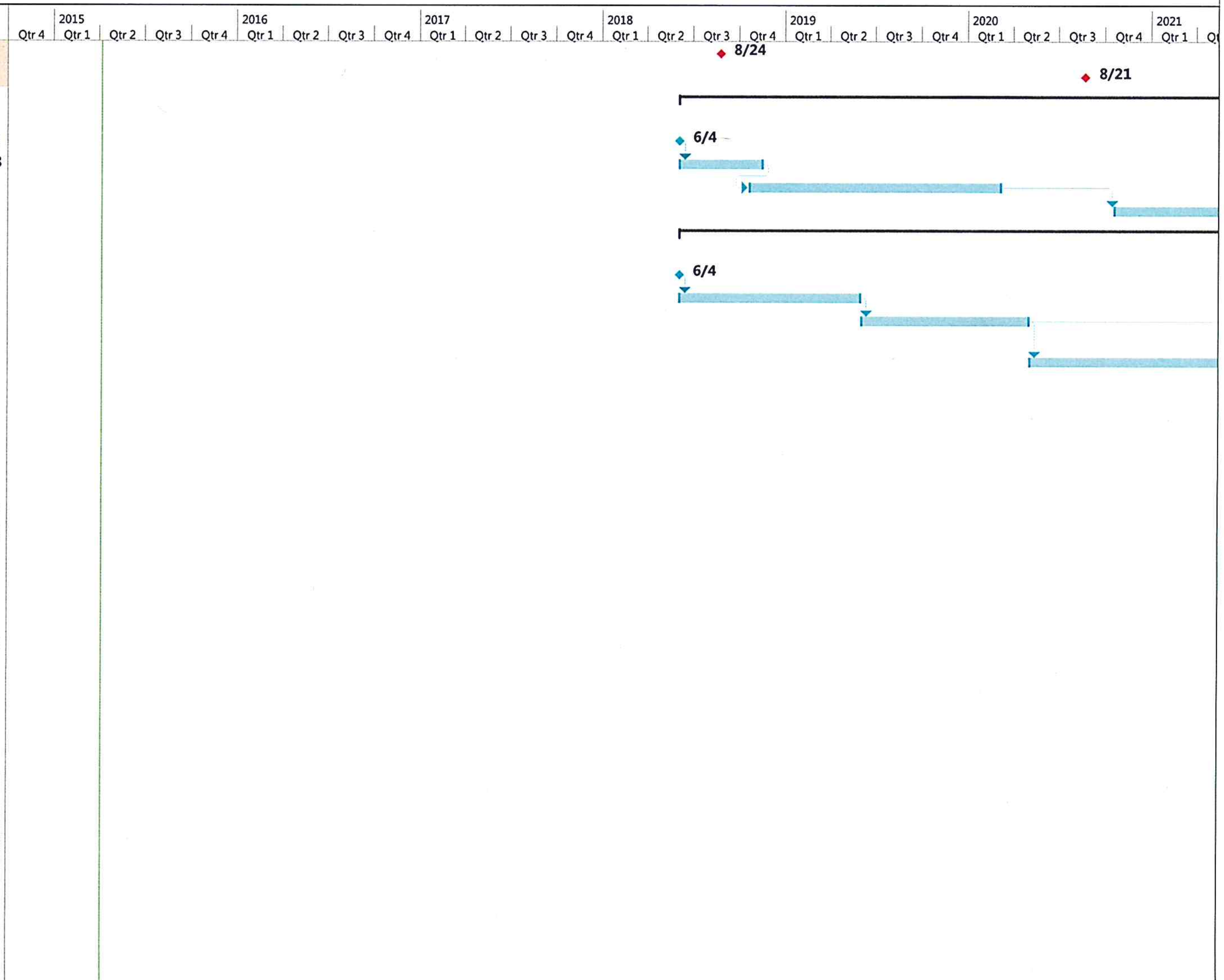
HAYS CALDWELL PUBLIC UTILITY AGENCY
CAPITAL IMPROVEMENTS PLAN

ID	Task Name	Duration	Start	Finish
1	**PHASE 1A**	**621 days**	**Fri 1/9/15**	**Fri 5/26/17**
2	**Kyle-Buda Pipeline**	**313 days**	**Fri 1/9/15**	**Tue 3/22/16**
3	NTP	0 days	Fri 1/9/15	Fri 1/9/15
4	Land Acquisition	210 days	Wed 6/3/15	Tue 3/22/16
5	**Debt Issuance #1**	**1 day**	**Thu 12/3/15**	**Thu 12/3/15**
6	**Design**	**621 days**	**Fri 1/9/15**	**Fri 5/26/17**
7	Preliminary Engineering	68 days	Fri 1/9/15	Tue 4/14/15
8	Interim Design	83 days	Wed 2/25/15	Fri 6/19/15
9	Final Design	95 days	Mon 6/22/15	Fri 10/30/15
10	Bid Phase	64 days	Thu 5/5/16	Tue 8/2/16
11	Construction	214 days	Tue 8/2/16	Fri 5/26/17
12	**Pump Station #2**	**460 days**	**Mon 8/3/15**	**Fri 5/5/17**
13	NTP	0 days	Mon 8/3/15	Mon 8/3/15
14	Design	11 mons	Mon 8/3/15	Fri 6/3/16
15	Construction	12 mons	Mon 6/6/16	Fri 5/5/17
16	**PHASE 1B**	**1820 days**	**Mon 10/5/15**	**Fri 9/23/22**
17	**Well Field Easements**	**205 days**	**Mon 10/5/15**	**Fri 7/15/16**
18	NTP	0 days	Mon 10/5/15	Mon 10/5/15
19	Site Acquisitions (Fee Simple)	5 mons	Mon 10/5/15	Fri 2/19/16
20	Pipe & Access Easements	8 mons	Mon 12/7/15	Fri 7/15/16
21	**Alignment Study**	**260 days**	**Mon 12/7/15**	**Fri 12/2/16**
22	NTP	0 days	Mon 12/7/15	Mon 12/7/15
23	Study & Report	13 mons	Mon 12/7/15	Fri 12/2/16
24	**Debt Issuance #2**	**1 day**	**Thu 2/23/17**	**Thu 2/23/17**
25	**Treated Transmission Mains**	**1380 days**	**Mon 3/6/17**	**Fri 6/17/22**
26	NTP	0 days	Mon 3/6/17	Mon 3/6/17
27	Design	13 mons	Mon 3/6/17	Fri 3/2/18
28	Easements	32 mons	Mon 10/16/17	Fri 3/27/20
29	Construction	46 mons	Mon 12/10/18	Fri 6/17/22
30	**Operations Building**	**480 days**	**Mon 11/6/17**	**Fri 9/6/19**
31	NTP	0 days	Mon 11/6/17	Mon 11/6/17
32	Design	6 mons	Mon 11/6/17	Fri 4/20/18
33	Site Acquisition	6 mons	Mon 1/29/18	Fri 7/13/18
34	Construction	12 mons	Mon 10/8/18	Fri 9/6/19
35	**Pump Station #1**	**775 days**	**Mon 10/7/19**	**Fri 9/23/22**
36	NTP	0 days	Mon 10/7/19	Mon 10/7/19
37	Design	21 mons	Mon 10/7/19	Fri 5/14/21
38	Site Acquisition	11 mons	Mon 2/17/20	Fri 12/18/20
39	Construction	20 mons	Mon 3/15/21	Fri 9/23/22



HAYS CALDWELL PUBLIC UTILITY AGENCY
CAPITAL IMPROVEMENTS PLAN

ID	Task Name	Duration	Start	Finish
40	**Debt Issuance #3**	**1 day**	**Fri 8/24/18**	**Fri 8/24/18**
41	**Debt Issuance #4**	**1 day**	**Fri 8/21/20**	**Fri 8/21/20**
42	**Treatment Plant (5-MGD Capacity**	**1120 days**	**Mon 6/4/18**	**Fri 9/16/22**
43	NTP	0 days	Mon 6/4/18	Mon 6/4/18
44	Easement Acquisiti	6 mons	Mon 6/4/18	Fri 11/16/18
45	Design	18 mons	Mon 10/22/18	Fri 3/6/20
46	Construction	25 mons	Mon 10/19/20	Fri 9/16/22
47	**Well Field (2 Wells - 5,488 AF/yr)**	**1120 days**	**Mon 6/4/18**	**Fri 9/16/22**
48	NTP	0 days	Mon 6/4/18	Mon 6/4/18
49	Design	13 mons	Mon 6/4/18	Fri 5/31/19
50	Easements for Collection Lines	12 mons	Mon 6/3/19	Fri 5/1/20
51	Construction (Pipelines/Access)	31 mons	Mon 5/4/20	Fri 9/16/22
52	Construction (Well:	9 mons	Mon 1/10/22	Fri 9/16/22
53	**PHASE 1C**	**420 days**	**Mon 7/7/25**	**Fri 2/12/27**
54	**Treatment Plant (10-MGD Total Capacity)**	**420 days**	**Mon 7/7/25**	**Fri 2/12/27**
55	NTP	0 days	Mon 7/7/25	Mon 7/7/25
56	Design	6 mons	Mon 7/7/25	Fri 12/19/25
57	Easement Acquisiti	4 mons	Mon 10/27/25	Fri 2/13/26
58	Construction	15 mons	Mon 12/22/25	Fri 2/12/27
59	**Well Field (2 Wells - 10,185 AF/yr total)**	**240 days**	**Mon 2/2/26**	**Fri 1/1/27**
60	NTP	0 days	Mon 2/2/26	Mon 2/2/26
61	Design	5 mons	Mon 2/2/26	Fri 6/19/26
62	Easement Acquisiti	4 mons	Mon 4/27/26	Fri 8/14/26
63	Construction	8 mons	Mon 5/25/26	Fri 1/1/27
64	**PHASE 1D**	**420 days**	**Mon 7/3/28**	**Fri 2/8/30**
65	**Treatment Plant (15-MGD Total Capacity)**	**420 days**	**Mon 7/3/28**	**Fri 2/8/30**
66	NTP	0 days	Mon 7/3/28	Mon 7/3/28
67	Design	6 mons	Mon 7/3/28	Fri 12/15/28
68	Construction	15 mons	Mon 12/18/28	Fri 2/8/30
69	**Well Field (2 Wells - 15,000 AF/yr total)**	**260 days**	**Mon 2/5/29**	**Fri 2/1/30**
70	NTP	0 days	Mon 2/5/29	Mon 2/5/29
71	Design	5 mons	Mon 2/5/29	Fri 6/22/29
72	Construction	8 mons	Mon 6/25/29	Fri 2/1/30



HAYS CALDWELL PUBLIC UTILITY AGENCY
CAPITAL IMPROVEMENTS PLAN

			2022				2023				2024				2025				2026				2027				2028				2029				2030	
Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2

HAYS CALDWELL PUBLIC UTILITY AGENCY
CAPITAL IMPROVEMENTS PLAN

CITY OF KYLE, TEXAS

Status Report on All Five Road Bond Projects

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Status report on all five road bond projects including latest project cost estimates. *~ Daphne Tenorio, Council Member*

Other Information:

Legal Notes:

Budget Information:

Viewing Attachments Requires Adobe Acrobat. Click here to download.

Attachments / click to download

CITY OF KYLE, TEXAS

Meeting Date: 8/4/2015
Date time: 7:00 PM

Goforth Road Reparis

Subject/Recommendation: Update on Goforth Road repairs. ~ *Daphne Tenorio, Council Member*

Other Information:

Legal Notes:

Budget Information:

Attachments / click to download

CITY OF KYLE, TEXAS

Agenda Review

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Discussion regarding setting agenda review workshop meetings. ~ *Diane Hervol, Council Member*

Other Information:

Legal Notes:

Budget Information:

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Cover Memo

CITY OF KYLE, TEXAS

City Managers Report

Meeting Date: 8/4/2015
Date time: 7:00 PM

Subject/Recommendation: Update on various capital improvement projects, road projects, building program, and/or general operational activities. ~ *Scott Sellers, City Manager*

Other Information:

Legal Notes:

Budget Information:

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