Appendix 1   Framework Memorandum

DRAFT

MEMORANDUM

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To:	Tyler Deke and Jovi Anderson, Bend MPO
From:	Ashleigh Ludwig, PE, Brian Ray, PE and Jacki Gulczynski
Project:	Bend Area TSAP
Subject:	Safety Analysis Framework

This memorandum presents a safety analysis framework for the Bend Area Transportation Safety Action Plan (TSAP). The framework plan outlines the purpose and desired outcomes supporting a prioritized list of projects, programs, and policies to reduce crash frequency and severity on City roadways. The Bend Area TSAP will be conducted in parallel with the Deschutes County TSAP; this framework also summarizes how the County and City of Bend will coordinate their Plans.

BACKGROUND

This section provides an overview of the background and purpose of the Bend Area TSAP.

City of Bend

The City of Bend has a history of using quantitative safety to identify priorities for safety countermeasures. In 2012, the City of Bend completed a multimodal traffic safety program that identified several focus areas for the City including alcohol-involved crashes, speed-involved crashes, roadway departure crashes, fatal and injury crashes, and pedestrian and bicycle crashes. The City has invested in projects to address these issues over the past six years. The TSAP will reevaluate crash trends and issues based on current data and identify a broad range of treatments including projects, policies, and programs, to address identified issues.

Transportation Safety Analysis Framework

This transportation safety analysis framework was informed by the City's goals and vision for a transportation safety program. The TSAP will be used to develop strategies to reduce the number of fatalities and serious crashes by identifying projects for implementation, as well as providing guidance on changes to prioritization methods, roadway standards, or other programs and policies that may help reduce crashes on the system.

The framework presented below was developed based on understanding that the City of Bend would like to:

- Apply a repeatable, objective method for identifying and selecting projects to reduce the frequency and severity of crashes within City;
- Use this project as an opportunity to leverage the crash database by applying tools and methods in the *Highway Safety Manual 1st Edition* (HSM);
- Establish and document a comprehensive transportation safety program that creates the opportunity for coordination within and across agency stakeholders in efforts to reduce crashes within the City.

Based on the City's desire for a comprehensive, systematic, and objective safety program, Kittelson and Associates, Inc. (Kittelson) has developed a safety analysis framework that builds upon statewide policies and applies crash analysis tools and methods provided in the HSM and other published resources from the Federal Highway Administration or National Cooperative Highway Research Program.

Oregon TSAP

Oregon developed a statewide TSAP in 2016. The vision of the statewide TSAP is zero deaths or life-changing injuries on the Oregon transportation system by 2035. The TSAP includes all roads in the state and provides the long-term goals and near-term actions to work towards this vision.

The Oregon TSAP identifies the following long-term goals:

- Safety Culture – Transform public attitudes to recognize all transportation system users have responsibility for other people's safety in addition to their own safety while using the transportation system. Transform organizational transportation safety culture among employees and agency partners (e.g., state agencies, MPOs, Tribes, counties, cities, Oregon Health Authority, stakeholders, and public and private employers) to integrate safety considerations into all responsibilities.
- Infrastructure – Develop and improve infrastructure to eliminate fatalities and serious injuries for users of all modes.
- Healthy, Livable Communities – Plan, design, and implement safety systems. Support enforcement and emergency medical services to improve the safety and livability of communities, including improved health outcomes.
- Technology – Plan, prepare for, and implement technologies (existing and new) that can affect transportation safety for all users, including pilot testing innovative technologies as appropriate.
- Collaborate and Communicate – Create and support a collaborative environment for transportation system providers and public and private stakeholders to work together to eliminate fatalities and serious injury crashes.
- Strategic Investments – Target safety funding for effective engineering, emergency response, law enforcement, and education priorities.

The Oregon TSAP identifies the following near-term emphasis areas:

- Risky behaviors (including impaired driving, unbelted, speeding, and distracted driving crashes);
- Infrastructure (intersection and roadway departure crashes);
- Vulnerable users (pedestrians, bicyclists, motorcyclists, and older road users);
- Improved systems (continually improve data, train and educate transportation and safety staff, support law enforcement and emergency responders, and minimize commercial vehicle crashes).

The Bend Area TSAP will summarize how the City is performing in these emphasis areas and provide recommendations to support the statewide TSAP long-term goals.

STUDY AREA

Deschutes County is concurrently developing its own TSAP for the area outside the Bend Urban Growth Boundary (UGB). The simultaneous development of the County and City/MPO TSAPs allows opportunities for coordination between the two jurisdictions and an understanding of City-specific safety performance. This section describes the Bend Area TSAP's study area and how coordination will occur with the Deschutes County TSAP.

The Deschutes County TSAP will include the unincorporated area outside of the Bend UGB, as well as the cities of La Pine, Redmond, and Sisters. The analysis will be conducted concurrently, but the TSAP will identify separate findings and recommendations for each location due the unique context of each area. The unincorporated area is likely to experience safety issues typically seen in rural areas, while the cities will experience more urban issues.

The Bend Area TSAP will focus on the area within the Bend UGB. Recommendations relevant to the area outside the Bend UGB but within the MPO area will be included in both the County and Bend Area TSAP documents. The Bend Area TSAP will include benchmarking against three similar cities: Medford, Springfield, and Corvallis to understand how the City of Bend's safety performance compares.

Coordination with the Bend Area TSAP and Deschutes County TSAP

The Bend Area TSAP will focus on the area within the Bend UGB, with the County TSAP focusing on areas outside the UGB. The two projects will be coordinated, with the analysis being conducted in parallel throughout the project. Many residents commute between communities within the County; therefore coordination between agencies is likely to result in consistency and continuity between each of the TSAP's recommendations.

Upon completion of the County TSAP, projects identified in the County TSAP that fall within the MPO area, but outside of the UGB, will be copied into the Bend Area TSAP. These projects will be located in both plans. Figure 1 illustrates the areas located within the Bend MPO but outside the UGB.

Figure 2 illustrates the process for developing the County and Bend Area TSAPs in parallel. This figure illustrates where coordination between the two projects will occur and how findings and recommendations will be separately identified for each Plan. This process will be further discussed throughout this memo in the Framework sections.
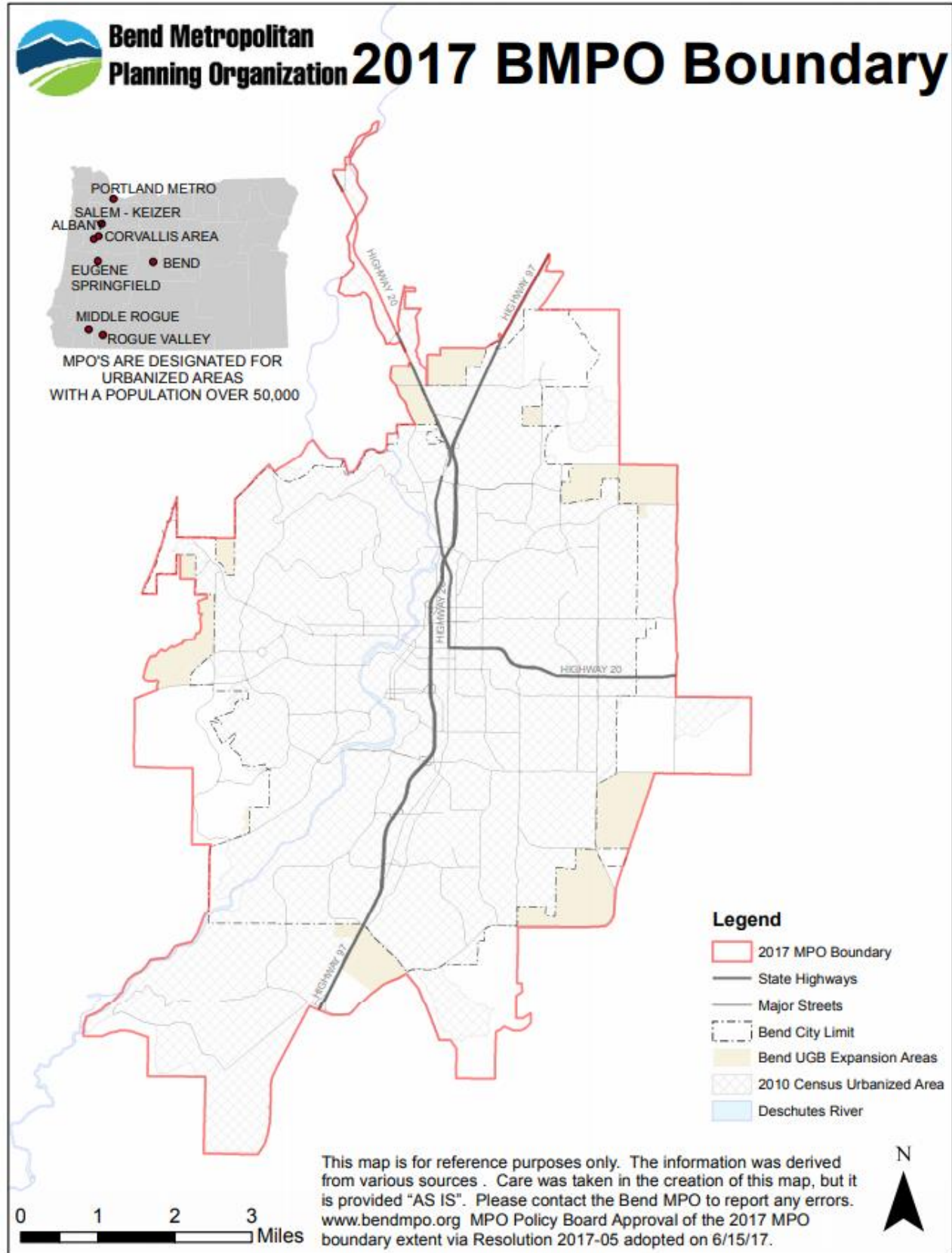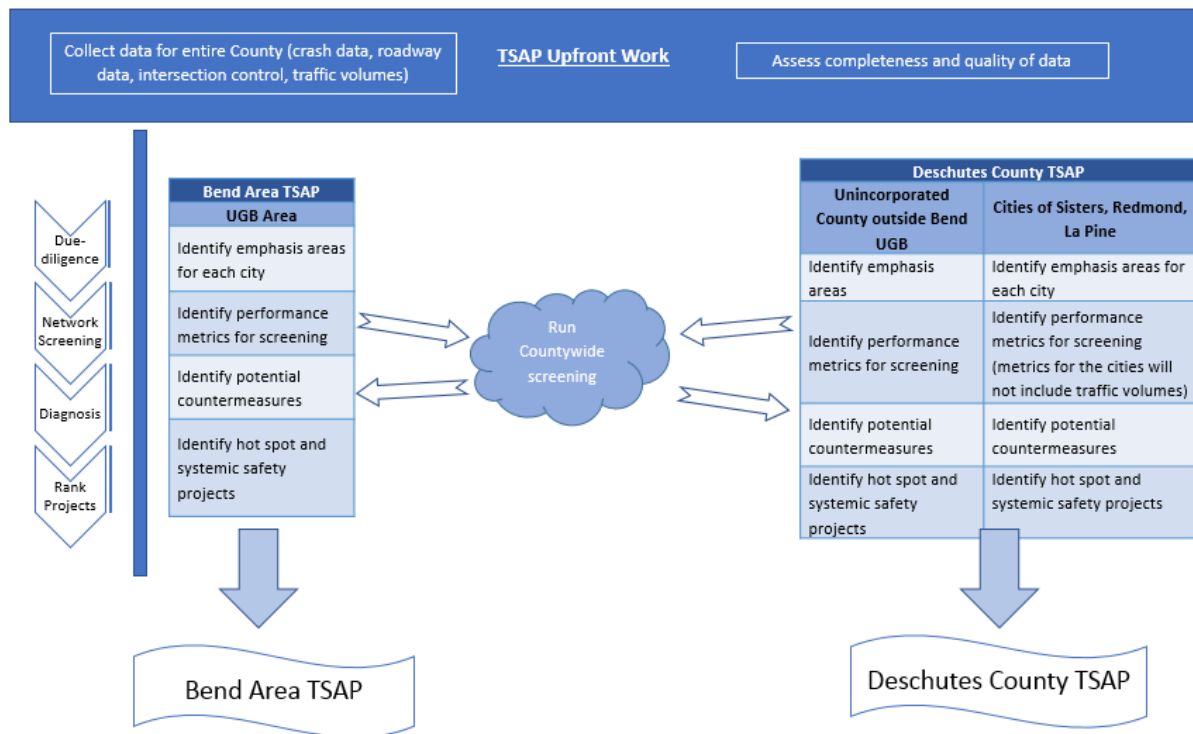
Figure 1. Bend MPO and UGB Boundaries

Figure 2. Deschutes County and Bend Area TSAP Coordination Process

Data Collection and Performance Metrics

The initial data collection and inventory will be completed for the County as a whole. After the data is compiled, analysis will be run for each individual study area to identify emphasis areas specific to each location. Based on the emphasis areas identified, performance metrics for each jurisdiction will be selected.

County performance metrics are likely to relate to rural issues such as roadway departure and speed related crashes. City performance metrics will likely relate to more urban conditions at intersections and with vulnerable users. The 2012 City of Bend Multimodal Safety Program identified issues related to alcohol-crashes, roadway departure crashes, speed-related crashes, and pedestrian and bicycle crashes.

The network screening analysis will be completed for the entire County using the selected performance measures. After the network screening process, results will be filtered into priority lists based on location and reference population; the county and city will have unique lists of sites for further diagnosis. These sites will be further evaluated, and the recommended set of projects will inform the individual plans.

PROJECT GOALS

The City's primary intent is to develop a comprehensive safety program that systematically identifies and prioritizes safety projects and establishes a proactive approach to reducing crashes on all roadways within the City. The vision of the safety program is to create a comprehensive safety management program to achieve zero fatal and serious injury crashes by 2035. Long-term goals to support this vision are consistent with the statewide TSAP goals.

Specific short-term goals to help the City achieve this vision include:

- Apply engineering, education, enforcement, emergency response, and evaluation (a broad base of strategies) to achieve measurable safety goals.

- Establish a proactive approach to reducing crashes on all roadways.

- Incorporate safety performance standards into the Capital Improvement Program (CIP) prioritization process and the development review process.

- Update roadway design standards to improve safety performance.

- Establish an objective project identification process that can be repeated to update the list of priority projects on a regular basis.

- Identify City policy needs to align City goals with emphasis areas identified in the TSAP.

- Coordinate with the City Transportation System Plan (TSP) and Metropolitan Transportation Plan (MTP) updates to incorporate TSAP recommendations into the adopted agency transportation plans.

This initial TSAP will create a baseline from which to measure progress in reducing crash frequency and severity. The City has stated a commitment to conduct future TSAP updates, and the framework established for this TSAP will serve as the base. Future TSAP updates will evaluate progress towards City goals and may result in more short-term goals to address additional emphasis areas, if needed.

COMPREHENSIVE APPROACH TO SAFETY

A comprehensive approach to transportation safety acknowledges that policy, planning, programming, and projects are multidisciplinary and involve "the 4Es" of safety:

- Engineering;
- Emergency Medical Services (EMS);
- Enforcement; and
- Education.

By including elements from the 4Es that complement each other, the TSAP will provide a multidisciplinary approach that could support policy, programs, and project recommendations to achieve a vision of zero transportation fatalities or serious injuries roads within the City of Bend. This

would be consistent with Oregon statewide vision zero objectives. To achieve this multidisciplinary plan, input from a variety of stakeholders will be used throughout the project.

- Project Management Team (PMT) – The PMT will include key staff from the City of Bend, the Bend MPO, and the Oregon Department of Transportation (ODOT) who will meet regularly throughout the project to provide technical input at key steps throughout the project.
- Technical Advisory Committee (TAC) – The MPO TAC meets regularly to provide technical oversight of the Bend MPO. The TAC will meet three times during the TSAP project to provide input on the project framework and goals; the existing conditions analysis and emphasis areas; and the TSAP's policy, program, and project recommendations.
- Citywide Transportation Advisory Committee (CTAC) – The CTAC is a committee of 27 community members that provides policy recommendations and guidance to the Bend City Council on a variety of transportation-related policies and funding strategies. The CTAC has a sub-group focused on transportation safety. This subgroup will meet three times during the project to provide input. One meeting will be focused on the project background (February 2019); one meeting will be focused on data and options for measuring progress (March 2019); and one meeting will be focused on recommended policies and performance metrics (April 2019).
- Brownbag Meeting – There will be one brownbag, informational meeting in which all CTAC members, as well as the general public, will be invited to attend to learn more about the project. This meeting is tentatively planned for January 2019.
- Multidisciplinary Stakeholder Group – This group will include the representatives from a variety of stakeholders who can provide input on non-infrastructure countermeasures. Stakeholders may include representations from emergency services, public health representatives, police, school district staff, and others. This group will meet once in a workshop format with the focus on discussing and identifying non-engineering solutions to further support crash reductions.

FRAMEWORK PLAN

This section documents the process that will be used to develop the Bend Area TSAP and how crash analysis tools and methods provided in the Highway Safety Manual (HSM) will be used to develop the TSAP. The overall framework includes four key phases, summarized in the flow chart in Figure 3.
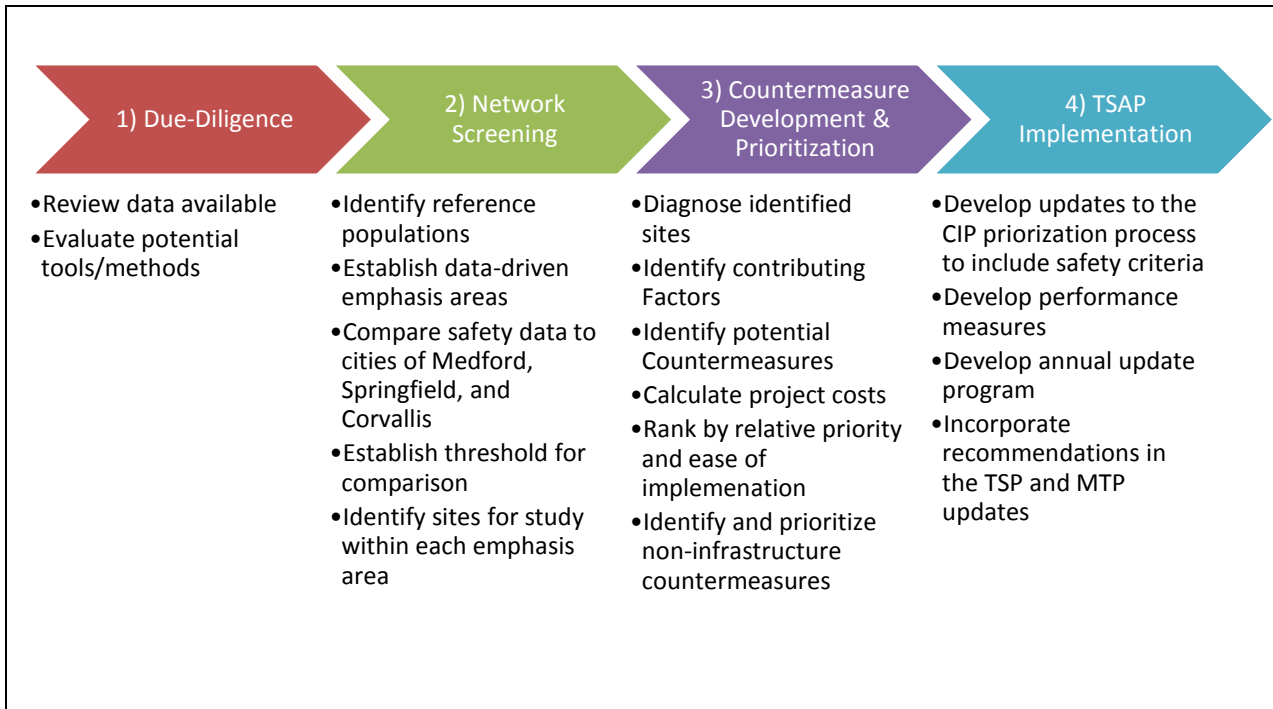
Figure 3 – Bend Area Safety Program Framework

The purpose and desired outcomes of each phase shown in Figure 3 are described below.

Due-Diligence

Purpose: Assess and identify tools and methods to apply now and in future.

The Due Diligence will focus on the following three elements:

1) Assessing data availability and quality;
2) Evaluating methods and recommending the best methods that can be applied in Network Screening with the data available;
3) Identifying data collection needs that could improve the safety program in future years.

Crash, volume, and roadway inventory data is needed to apply an objective analysis in support of a safety management program. By collecting as much data is available, we will gain an understanding of where data is limited or where formats are not conducive for use with analysis tools. In some cases, this may identify the need to convert data formats to be consistent for application of Network Screening methods. Over time, the City could enhance their data collection and information management (i.e., crash data, motorized and non-motorized volume, and roadway characteristics) to increase the effectiveness of future TSAP updates.

Table 1 identifies the data requested and received from the County and MPO. Primary data reflects the critical data needed to complete the safety analysis using crash rates and distinguishing between different reference populations. The secondary data will be used, when possible, for additional analysis and site diagnosis. As shown in Table 1, the countywide data is complete for all primary data. The traffic volumes are currently in two different datasets. One dataset represents the unincorporated county area, and one dataset represents the area within the Bend-Redmond model. Kittelson will evaluate the best way to merge these datasets while retaining as much information as possible. Because the data is in point format, the team will review the dataset and estimate which volumes best apply to the various roadway segments.

Table 1. Data Inventory

Data	Source
Primary Data	
Roadway Functional Classification	County
Traffic Volumes	County and MPO (Countywide and MPO datasets will be merged)
Reported Crash Data	ODOT - Countywide dataset will be used
Jurisdiction	County and MPO
Traffic Control	County and MPO
Secondary Data	
Posted Speed Limit	County and MPO (Limited coverage available.)
Lane Widths	MPO
Sidewalk Presence	MPO
Bicycle Facilities	MPO
Trails	MPO
Bicycle and Pedestrian Volumes	Not Yet Provided, may be available for select areas within MPO
Transit Routes and Stops	MPO

Available data will limit the number of tools and performance measures that can be used immediately within the safety program. The data needed to allow the City to apply more robust tools and methods (reducing statistical bias) will be identified to allow the City to continually improve their safety program during future updates.

Network Screening

Purpose: Apply objective methods to evaluate the City's road network to identify sites with potential

Due-Diligence | Network Screening | Countermeasure Development | Implementation

for reducing crash frequency or severity.

Network screening methods are described in detail in Chapter 4 of the HSM. The methods from the HSM will be adapted to fit the context of Bend and the scope of this project. In general network screening includes the following steps:

1) Establish emphasis areas;
2) Identify reference populations;
3) Select performance measures; and
4) Screen and evaluate results.

Considerations for each of the steps above are discussed in the following subsections.

Establish Emphasis Areas

Analysis results of crash details reflected in the crash database may identify proportions of crash types, severity, location, and other transportation safety trends that the City will want to address to develop priority locations. The emphasis areas will inform goals and the performance measures selected for use in network screening.

Crash analysis to identify emphasis areas will include a review of the following crash trends at a minimum:

- Time of day
- Seasonal variability
- Age
- Crash causes
- Speeding
- Intoxication
- Severity
- Crash type
- Pedestrian and bicycle crashes
- Crash cause

Crash trends for the City of Bend will be compared to three comparison cities (Medford, Springfield, and Corvallis) to show how the City of Bend is performing relative to those similar cities.

Identify Reference Populations

To identify projects that will be most cost-effective at reducing crashes, the network will be organized into reference populations and lists of priority projects will be developed for each population.

The HSM identifies the characteristics listed below as potential characteristics for establishing reference populations. Kittelson will use these same characteristics as a starting place for identifying the appropriate reference population.

- Area type (e.g., urban, rural, suburban);
- Traffic Control (e.g., signalized, unsignalized, roundabout, etc.);
- Number of approaches (e.g., three-leg or four-leg intersection);
- Cross-section (e.g., number of through lanes and turning lanes);
- Functional Classification (e.g., principal arterial, collector, local, etc.); and,
- Traffic Volume.

Kittelson has obtained data and initial reviews indicate data is available to apply a combination of some of these characteristics to establish reference populations. The characteristics with the most comprehensive database will be prioritized. The maximum number of reference populations will be determined based on the number of crashes within each population; a minimum frequency of crashes per population is necessary to be able to establish trends.

Select Performance Measures

Performance measures are used to evaluate the crash data and result in a quantitative "score" at each site. The HSM identifies 13 performance measures that can be used in network screening. Performance measure selection is based on data available, desired statistical rigor, and program priorities. Performance measures with the greatest statistical rigor apply crash prediction models to account for "regression to the mean" bias, which is commonly evident in safety evaluations. Those methods provide the greatest reliability of the screening results and require the greatest amount of data.

Based on the available data, up to two performance measures from the following list are expected to be used in the Bend Area TSAP:

- Crash frequency;
- Equivalent property damage only crash frequency (EPDO crash frequency);
- Relative severity index;
- Crash type performance threshold; or
- Excess proportion of specific crash types.
  .

Screen and Evaluate Results

Kittelson will use Geographic Information System (GIS) tools to implement network screening methods using data from Deschutes County and the Bend MPO. The results will provide a ranked list of 10 sites

within the City of Bend that have the greatest potential for reducing crash frequency and severity based on the two selected performance measures.

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Countermeasure Development

Purpose: Identify factors contributing to crashes and specific countermeasures to reduce the frequency and severity of those crashes.

Developing countermeasures leads to recommendations for infrastructure and non-infrastructure countermeasures. The following sections provide a general overview of the process Kittelson will use to develop these countermeasures.

Identify Contributing Factors at Sites

Diagnosis includes desktop and field reviews for the top ranked sites from network screening. For each site, diagnosis includes reviewing the following three elements:

1) Crash and volume data trends;
2) Site history (e.g., construction, traffic control modifications, etc.); and
3) Field conditions.

Kittelson will work with the City to identify up to 10 sites to be diagnosed to determine factors contributing to crashes and countermeasures will be identified to address those contributing factors. In addition, Kittelson will identify the top crash patterns or characteristics eligible for systemic treatments.

Identify Infrastructure Countermeasures

The contributing factors identified through the desktop and field reviews can be tied to countermeasures having the potential to reduce the number and/or severity of the crashes associated with contributing factors. In general, this step requires considering a range of countermeasures and narrowing the options to consider and select preferred countermeasures that have a documented ability (through empirical study) to reduce a specific crash type. This step uses Crash Modification Factors (CMFs) in the HSM and those identified in the Federal Highway Administration's (FHWA) website (www.cmfclearinghouse.org).

In addition to identifying site specific countermeasures, we will recommend low-cost systemic treatments that can be applied at a broad scale to address the emphasis areas.

Identify Non-Infrastructure Countermeasures

As documented earlier in this memorandum, engineering (infrastructure) countermeasures are only one component of a comprehensive safety program. The Multidisciplinary Stakeholder group will meet in a worksession to provide input on potential non-infrastructure countermeasures that should be considered to address identified emphasis areas for the TSAP.

Prioritize Infrastructure Countermeasures

The goal of prioritizing countermeasures is to prioritize the projects that are expected to result in the greatest reduction in crash frequency and/or severity for the least cost. Chapter 7 and 8 of the HSM outline a variety of methods for ranking projects. The ranking is based on the relative benefit-cost ratio of the projects. Therefore, ranking requires monetary costs and benefits be identified for each project. Project cost estimates will be prepared for projects at 10 sites and up to 3 systemic solutions based on established unit costs. The CMFs identified for countermeasures will be used to estimate benefits in terms of crash reductions, when available. Crash reductions are converted to monetary benefits based on estimates of design life and societal crash costs by crash severity.

When quantitative estimates are not available documenting the effectiveness of a countermeasure or project, the project may not be ranked. Therefore, the ranked project list will only represent those projects with proven countermeasures having the greatest potential to reduce crash frequency or severity. Those projects that do not have proven countermeasures could still be implemented and their effectiveness in the City of Bend could be studied through a before-and-after study.

Coordination with Other Agencies

After an initial list of countermeasures is available, the projects will be referenced against the ODOT All Roads Transportation Safety (ARTS) and Safety Priority Index System (SPIS) sites. Where there is overlap, the site will be reviewed to determine whether the recommendations, if available, are consistent. If the recommendations differ, the TSAP will indicate that recommendations differ and identify the need for coordination with ODOT. ARTS and SPIS sites that are not identified in the TSAP projects will be carried forward into the TSAP document to provide a complete safety project list.

Implementation

| Due-diligence | Network Screening | Countermeasure Development | Implementation |

Purpose: Implement the recommendations from the TSAP by fully integrating the infrastructure and non-infrastructure recommendations. Complete future updates to maintain a current safety program that addresses relevant issues as conditions change over time.

Successful implementation of the TSAP will extend beyond identifying a prioritized list of infrastructure and non-infrastructure countermeasures. The TSAP may identify recommendations in the following areas that will help the City continue to enhance safety performance in the long-term:

- Updating the Capital Improvement Program (CIP) criteria and methods to incorporate safety performance;
- Updating the development review processes to incorporate safety performance;
- Updating roadway standards and standard details based on findings from the TSAP analysis;
- Identifying performance measures to track progress towards achieving the safety goals over time;
- Identifying new programs to improve education and/or enforcement;
- Identifying policy development needs to support the City's long-term vision;
- Identifying data collection needs to reduce statistical bias in future updates of the TSAP;
- Considering public health connections and opportunities to support State and possible future City goals; and
- Recommending approaches for updating the TSAP (methods, frequency) to maintain a current, proactive Plan while continually enhancing the City's roadway safety management program.

The TSAP will be coordinated with the Bend TSP and MTP updates to result in a consistent set of adopted transportation safety recommendations.

Future Data Collection Needs to Reduce Statistical Bias

As discussed in the Performance Measures section of this memo, the HSM identifies 13 performance measures that can be used in network screening. Performance measure selection is based on data available, desired statistical rigor, and program priorities. Performance measures with the greatest statistical rigor apply crash prediction models to account for "regression to the mean" bias, which is commonly evident in safety evaluations. Those methods provide the greatest reliability of the screening results and require the greatest amount of data. Table 2 summarizes the available performance measures.

The Bend Area TSAP will provide recommendations about future data needs that could reduce the statistical bias of the program by allowing the use of some of the long-term performance measures. The City could consider future data collection and management approaches over time to incrementally increase the effectiveness of future safety evaluations. The incremental enhancements to the City's transportation safety management plan could reduce statistical bias and create more confidence in safety programs and countermeasure effectiveness.

Table 2. Summary of Network Screening Performance Measures

Statistical Bias/Data Requirement Continuum*	City of Bend Implementation Category	Network Screening Performance Measure
	Short-Term	Crash Frequency
		Equivalent Property Damage Only Crash Frequency
		Relative Severity Index
		Crash Type Performance Threshold
		Excess Proportion of Specific Crash Types
		Critical Rate
		Method of Moments
	Long-Term – Requires calibrated safety performance functions and detailed geometric information	Excess Predicted Crashes Using SPFs
		Level of Service of Safety
		Expected Crash Frequency with EB Adjustment
		EPDO Crash Frequency with EB Adjustment
		Excess Expected Crash Frequency with EB Adjustment

* Performance measures are sorted by implementation category, which generally reflects a reduction in statistical bias as additional data is included in analysis