CHAPTER 5 RISK ANALYSIS

The FHWA's comprehensive document entitled *Highway Routing of Hazardous Materials: Guidelines for Applying Criteria* publication number FHWA-HI-97-003 (FHWA/NHI, 1996) provides a prescribed methodology for assessing risk for NRHM route designation. The guidelines put forth in this publication provide a methodology for evaluating risk factors that can be quantified. These quantifiable risk factors included in the FHWA risk analysis are demographic counts, type of highway, emergency response capabilities, crash statistics, and other parameters.

Included in the following sections are details on how the study team applied the FHWA risk assessment guidelines to the Cameron County area. This chapter also provides information on how the study team implemented the FHWA methodology by collecting data on special populations, emergency responders, and crash locations to perform the risk calculation. Finally, this section describes the study team's process for connecting the risk calculation to the Cameron County TDM in order to generate a refined set of alternative NRHM routes.

METHODOLOGY

The FHWA guidelines Section III, entitled *Method for Determining Risk*, outlines four important considerations that communities should analyze to determine the risk of a route. As defined by the FHWA, risk is the probability that a crash involving a truck carrying hazardous materials will occur multiplied by the potential exposure to a population. These elements include crash consequences, crash probability, risk calculation and route characteristics.

INCIDENT CONSEQUENCES

According to FHWA NRHM route designation guidelines, the consequences of a potential crash, also referred to as the crash consequences, are measured based on exposure of the population within the risk impact area. For the purposes of the routing methodology, the consequence of primary concern is the potential exposure of Cameron County residents to harmful chemicals should a crash involving a truck carrying NRHM occur.

RISK IMPACT ZONE

The study team followed suggested FHWA NRHM route designation guidelines to define the risk impact zone for the Cameron County study area. An impact zone is a corridor around a roadway, included in the TDM network, which measures the maximum distance of exposure (i.e. human health, environmental contamination, environmental contamination and property damage) to a NRHM release based on the specific class of hazardous material involved in a crash. Several factors, such as the commodity carried, climatic conditions, quantity released, and terrain may affect the size of the impact zone.

For the purposes of this study, the main factors influencing the size of the impact zone were terrain and commodity considerations. First, the study team evaluated various terrain considerations to define a possible impact area zone. In particular, the study team reviewed topographical factors impacting the study area, such as Cameron County's proximity to the Gulf of Mexico, and any irregularities in terrain, such as flood plains and wetlands. Given the distance of proposed NRHM routes from the Gulf of Mexico, which only abuts unincorporated areas of the county, the proximity to the Gulf of Mexico was not a significant factor in the risk assessment conducted for this study, the connection of storm water runoff systems to local waterways and those connected to the Gulf, were however considered. In addition, the study team did not find any irregularities in Cameron County's topography near the TDM's roadway segments that might create unusual risk.

Based on research and discussions with the Port of Brownsville, Port of Harlingen and the advisory committee, the study team selected the following hazardous classes to serve as commodity types in the risk impact zone determination: flammable gases, flammable solids, and corrosive materials. As stated in the *Emergency Response Guidebooks* (RSPA P 5800.6), the United States Department of Transportation (USDOT) estimates that all of these commodities have an impact area of approximately one half mile for all the identified commodities. Table 2 is a list of each hazardous material type's class and respective impact area. The study team selected a 0.5 mile value as the impact area zone.

Table 2: Impact Zones by Commodity the *Emergency Response Guidebooks* (RSPA P 5800.6), (USDOT)

Hazardous Material Class	Impact Area
Explosives (EXP)	**1.0 mile (1.6 km) all directions**
Flammable Gas (FL)	**0.5 mile (0.8 km) all directions**
Poison Gas* (PG)	**5.0 mile (8.0 km) all directions**
Flammable/Combustible Liquid (FCL)	**0.5 mile (0.8 km) all directions**
Flammable Solid; Spontaneously Combustible; Dangerous when Wet* (FS)	**0.5 mile (0.8 km) all directions**
Oxidizer/Organic Peroxide* (OXI)	**0.5 mile (0.8 km) all directions**
Poisonous, not gas (POI)	**5.0 mile (8.0 km) all directions**
Corrosive Materials (COR)	**0.5 mile (0.8 km) all directions**

* Consult U.S. DOT 1993 Emergency Response Guidebook (RSPA P 5800.6) for specific chemical impact area or use default value in table.

POPULATION EXPOSED AND INTEGRATION OF COLLECTED DATA INTO THE RISK ANALYSIS

The study team measured the crash consequences as a factor of the total population exposed to a potential release of hazardous materials should a crash involving a truck carrying NRHM occur. The study team evaluated demographic data such as population, employment, and household density information within the risk impact zone. To perform this task, the study team obtained 2004 population, employment, and household estimate data for all traffic analysis zones (TAZs) in Cameron County, from both the Brownsville and Harlingen-San Benito MPOs. Using the overlay function in a GIS program, the study team created a 0.5 mile around each roadway link. Next, the study team selected the count option, which enabled the overlay function to sum up the count of population, employment, and households within 0.5 miles of each roadway segment in the Cameron County TDM. The overlay function then appended the counts for of these demographic attributes to each roadway link.

Subsequently, the study collected data on special populations centers, which would be difficult to evacuate if a release of hazardous materials were to occur. As identified by the Advisory Committee, these centers included schools, older adult facilities (i.e. assisted living sites, nursing homes), childcare facilities, and hospitals. To complete this task, the study team first developed a database, which included the addresses and contact information for each of the special population centers within the study area. Second, the study team contacted each of the facilities to get a count of enrollment and capacity at each site. Once the study team obtained this information, the database was updated with capacity values for each center. Thirdly, the study geographically referenced each of the special population centers in a GIS program by geocoding their addresses based on each site's geographic coordinates. Fourthly, the study team employed the overlay function in a GIS program, and created a 0.5-mile band around each roadway segment within the Cameron County TDM. Then, the study team selected the "count" option and executed the overlay tool. As a result, a new attribute identifying the count of enrolled students by school and childcare facility, and bed capacity by hospital and nursing homes within .5-mile of a roadway for each link in the TDM was created.

Emergency Responders

The study team collected data on emergency responders in the Cameron County region, and obtained a geographic referenced database of fire station locations in the study area from the Brownsville and Harlingen-San Benito MPOs. Using this geographic database, the study team developed a set of isochronal time rings from the location of each emergency response location to identify any segments of potential routes that fell outside of a probable 10-minute response time window. All potential route segments were within the threshold response time, so differentiation of routes on this basis was deemed unnecessary.

Crash Probability

The study team collected crash data from the Texas Department of Transportation in order to determine the probability of a crash occurring on each roadway link of the Cameron County TDM. The following sections provide details on the process the study team employed to integrate the collected crash data into the assessment of risk task.

Crash Data

The FHWA guidelines Section III, entitled *Method for Determining Risk*, includes guidance for including the risk of a crash involving a truck carrying non-radioactive hazardous materials into the risk equation of a route. When insufficient data on crashes in a study area are available, the FHWA suggests utilizing a crash probability rate for trucks carrying NRHM, based on area and roadway type as found in the FHWA guidelines Section III, Exhibit 4. In effect, the FHWA suggests implementing the equation shown in Figure 5, which states that the probability of a crash occurring can be measured by multiplying the crash rate per vehicle-mile along a route segment by the length of a route segment in miles.

Figure 5: Crash Risk Formula

$$P_a = A \times L_s$$

where: P_a = Probability of an accident along a route segment

A = Accident rate or number of accidents per vehicle-mile along a route segment

L_s = Length of route segment in miles

The study team was able to acquire three years, 2006 through 2009, of geocoded crash history for all vehicles types on all roadways in the Cameron County study area from the TxDOT GIS based Crash Reporting Information System (CRIS). This met the FHWA NRHM route designation guidelines that suggests the use of a minimum of three years of crash data. Similar to the processes used in the population exposure analysis, the study team first created a geographically referenced file for all of the crash data, per year, by using each crash site's geographical coordinates to geocode the crash locations. Then the study team used the overlay function to calculate the total number of crashes that fell within each roadway link by directly tagging the crash point layer to the roadway line layer.

Risk Calculation

As recommended by the FHWA guidelines and for the purposes of this study, the risk calculation used was the crash probability multiplied by the potential consequences. Therefore, the study team calculated a risk value for each roadway segment by multiplying the crash probability by the consequences or potential population exposed to a spill based on the defined risk impact zone. Provide below is a basic formula as described in the FHWA NRHM route designation guidance:

$$\text{Risk} = \text{Probability} \times \text{Consequences}$$

Calculating Potential Consequences Value

As mentioned in the previous sections, using the overlay function in a GIS program, the study team was able to provide values for the potential consequences or the exposure of a spill to populations within the defined risk impact zone. These values included counts by population, employment, and households, as well as counts of enrolled students at schools and childcare sites and bed capacity at hospitals and nursing homes. To complete the task of defining the total consequences for each roadway segment of the TDM, a new field was created in the TDM network titled "Risk Consequences." Next, using the "Risk Consequences" field, the study team summed up all of the demographic counts (i.e. population, employment, households, school and childcare enrollment, and capacity at hospitals and nursing homes) and created a consequences attribute for each roadway segment in the Cameron County TDM.

Calculating Crash Probability

The study team calculated the crash probability for each roadway segment in the Cameron County TDM. To complete this task, the study team first normalized the number of crashes by creating a monthly average. Secondly, the study team created a new field in the Cameron County TDM network titled "Average Monthly Crashes." Using the "Average Monthly Crashes" field, the study summed up all of the crash counts for each year, 2006-2009, and divided by the total number of months in which the crashes occurred. As a result, the study team generated a crash probability value or average crashes per month, for each roadway segment in the Cameron County TDM.

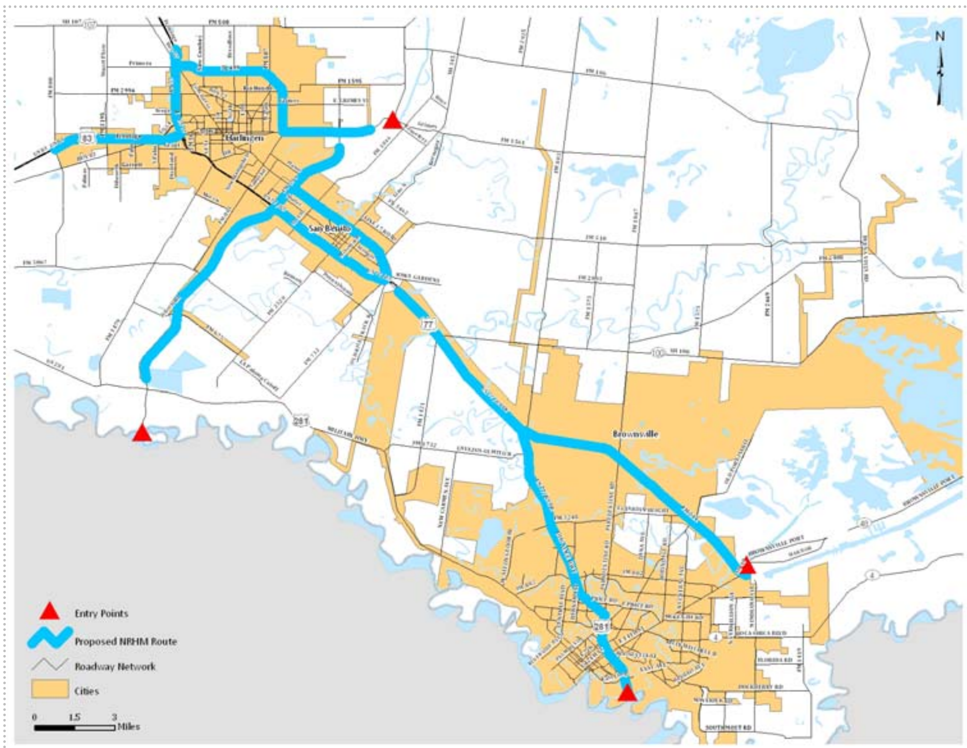
Calculating Risk by Segment

By using, the risk values described above, the study team was able to calculate a risk value for each roadway segment of the Cameron County TDM. To complete this task, the study team created a new field in the TDM network titled: "Total Risk" and then multiplied the remaining value by the "Average Monthly Crashes" field. This step produced a "Total Risk" value for each roadway segment of the Cameron County TDM.

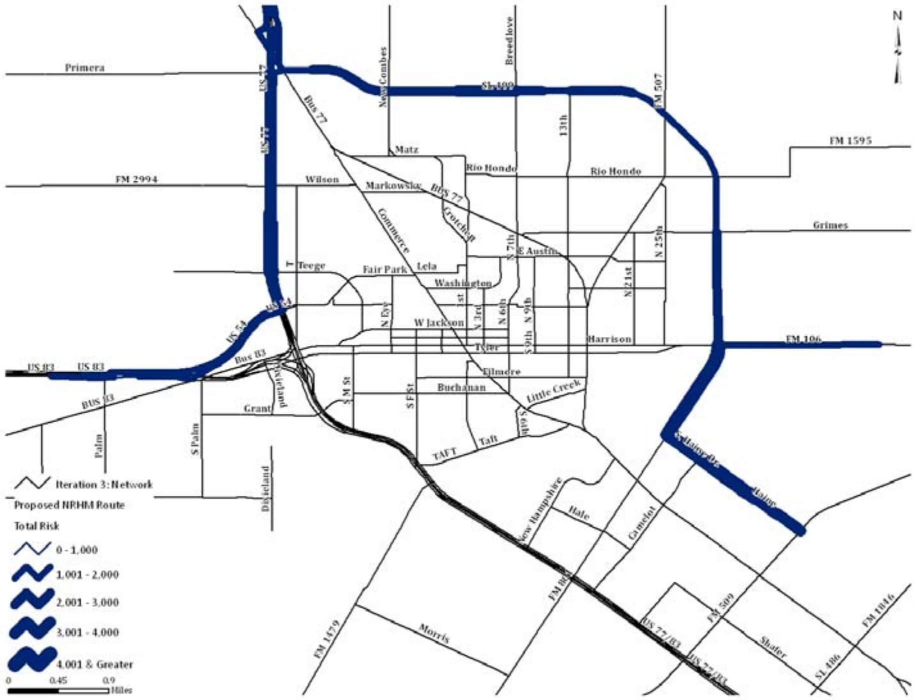
Assessment of Cumulative Risk for each Route

Once the study team produced total risk values each roadway segment of the TDM, the study team was able to generate a set of NRHM route alternatives. The study team completed this task by first importing the updated Cameron County TDM network, based on feedback from the Advisory Committee such as changes to the entry point selection and removal of unsuitable roadways, into Transcad, creating a "Network" file, and choosing the "Total Risk" column as the impedance factor. Secondly, the study team employed the "multiple-path" function, and selected the newly designated entry points, based on feedback from the project Advisory Committee, and generated a new set potential NRHM routes. Map 7 shows the first cut of routes produced by using the risk assessment factor. In addition, as shown in Map 8 and Map 9 below, the total risk in the alternative NRHM route for the Harlingen area is substantially lower than Harlingen's existing NRHM route.

Map 7: First Round NRHM Proposed Route for Cameron



Map 8: First Round Proposed Harlingen NRHM Route showing Total Risk



Map 9: Existing Harlingen NRHM Route - Total Risk

SUMMARY OF RISK ANALYSIS

Assessing the risk of exposure to residents of Cameron County should a crash involving a trucking carrying NRHM occur and hazardous materials be released, is essential to ensuring the safe movement of these materials throughout the region. The study team implemented the following steps to complete the risk assessment process: defined risk impact zone; collected and integrated demographic, emergency response, and crash data into the Cameron County TDM network; calculated consequences, emergency responder impact, and crash probability; and calculated a total risk value for all roadways in the Cameron County TDM. As a result, the study team was able to generate a new set of alternative NRHM routes, based on quantifiable risk factors, using the updated Cameron County TDM network. The next section describes the evaluation of non-quantifiable risk factors, such as environmentally sensitive features and environmental justice considerations, using qualitative methodologies.