5.0 Secondary Research

5.0 Secondary Research

This section summarizes the results of the secondary research task of the Twin Cities High-Occupancy Vehicle (HOV) Lane Evaluation. This task involved reviewing and summarizing relevant research regarding the benefits and costs of HOV strategies employed in other comparable metropolitan areas. In addition, city agencies and HOV lane experts were interviewed to obtain more detailed insight into the objectives, strategies, successes, and challenges with their HOV facilities.

5.1 Basics of HOV Lanes

The Federal Highway Administration (FHWA) defines HOV lanes as "lanes where only high-occupancy vehicles are allowed to operate, which include exclusive bus lanes and bus ways." Currently, there are more than 2,500 lane-miles of HOV facilities in the United States and Canada. There are usually no specific warrants for HOV lanes, other than recurring congestion. Corridors with heavy peak-period demands are usually prioritized for HOV lane deployment. HOV lanes are used to help ease traffic congestion by maximizing person mobility, rather than vehicle throughput.

5.1.1 Benefits of HOV lanes

When applied effectively, HOV lanes may produce the following benefits:

- Increased person movement/mobility;
- Improved speed and travel time to HOV lane users;
- Larger variety of mode choice to the public;
- Improved transit schedule adherence and reliability;
- Reduced peak period congestion; and
- Improved air quality and energy conservation.

5.1.2 HOV Operations

In general, HOV facilities across the country operate during the weekday a.m. and p.m. peak periods, usually from 5:00 a.m. to 9:00 a.m. and from 3:00 p.m. to 7:00 p.m. In areas where underutilizations exist, agencies often reduce the operating times in order to avoid the "empty lane syndrome" and offer more effective capacity utilization of the lanes.

The following are the most common types of HOV lane restrictions (motorcycles are usually permitted in all cases except bus ways):

- **HOV 2+ (two or more) –** The most common type in the U.S. and Canada, over 70 percent of HOV facilities impose this restriction, including Minnesota.

- **HOV 3+ (three or more) –** The second most common HOV requirement; however, they are having recent setbacks, mostly being downgraded to HOV 2+, due to low 3+ demands.

- **HOV 4+ (four or more) –** The U.S.-Mexico border crossing near San Diego (CA) has the only HOV 4+ lanes in North America.

- **Exclusive bus way and bus lane –** Bus ways and bus lanes are built exclusively for transit, with the primary goal of improving transit reliability and schedule adherence. A local example of an exclusive bus way is the University of Minnesota transit way that connects the Minneapolis and St. Paul campuses.

- **Bus, taxi, and vanpools only –** Exclusive HOV lanes limited to transit and paratransit vehicles (both vacant or occupied) and registered vanpools.

- **HOV/Toll (HOT) lanes –** HOT lanes allow carpools to use the facility for free (or at a discount), but also allow single-occupancy vehicles (SOVs) to travel on them for a fixed or variable premium. Variable toll prices are determined depending on the time of day, direction, and potential timesavings. Since HOT lanes require toll collection booths or Electronic Toll Collection (ETC) equipment and must be separated from the mixed-flow lanes, they normally cost more to build and operate (Section 10.0 describes HOT lane deployments in the U.S. in more detail.).

5.1.3 HOV and Ridesharing

There are different types of ridesharing that are supported and possibly encouraged by HOV lanes. The dominant forms of ridesharing include:

- **Household carpooling –** The most common form of carpooling, where commuters from the same household travel together to similar destinations. Makes up the largest group of HOV lane users.

- **Office carpooling –** Office carpools share the same destination, but not the same origin. The biggest obstacle to office carpooling is the advent of flexible work hours and telecommuting.

- **Organized carpool/rideshare services –** Typically a public or non-profit agency that coordinates carpooling among people with similar origins and destinations. Metro Commuter Services in the Twin Cities provides such services.

- **Casual carpooling –** A rare carpooling method, often raising safety concerns, casual carpoolers are strangers sharing a vehicle to a general destination.

- **Transit –** Destination and schedule inflexibilities are considerable tradeoffs between transit and auto. Some view transit as the only effective form of ridesharing, urging transportation agencies to consider future planning and construction of HOV and bus lanes.

5.1.4 HOV Lane Types

There are several types of HOV lanes, including the following:

- **Concurrent flow –** Concurrent flow HOV lanes are located adjacent to mixed-flow traffic lanes (usually the left-most lane), only separated by traffic striping. Both I-35W and I-394 west of Highway 100 fall under this category.

- **Barrier-separated –** Concrete barriers separate this HOV lane type from the mixed-flow lanes. These facilities are usually more expensive to construct, but bring advantages depending on how they are utilized, since they are easier to enforce and hence provide travel time advantages to legitimate users. Speed limits on these facilities may be different than on the mixed-flow lanes without raising safety concerns due to high speed differentials with general-purpose lanes. There are two types of barrier-separated HOV lanes: 1) fixed and 2) reversible. In the fixed-flow case, the HOV lane is used for one fixed direction. Reversible lanes can serve two directions, usually the peak direction during a given peak period. However, expensive twice-daily efforts to open and close appropriate entry/exit points must be maintained over the life of the facilities. I-394 east of Highway 100 is a reversible HOV lane.

- **Contraflow –** Like barrier-separated, reversible HOV lanes, contraflow lanes are also reversible. Lanes from the off-peak direction may be "borrowed" to serve as HOV lanes for the peak direction. Highway crews must arrange rubber pylons or movable concrete barriers to determine the directions of the lane resulting in high operating costs.

- **Shoulder lane –** California, Washington, and Maryland are the only U.S. states with shoulder HOV lanes, with a total of less than 70 lane-miles nationwide. Criticisms against shoulder lanes include weaving and merging safety issues. Minnesota allows transit buses to drive on designated shoulders under strict operating rules (no other types of HOVs allowed).

- **Ramp meter bypass –** When a freeway on-ramp has two lanes, one lane may be metered, while the other is used as a bypass for carpools and buses. The success of bypass lanes is closely related to the ramp metering policy; highly restrictive metering may lead to illegal use of the bypass lanes. The Twin Cities has an extensive ramp meter bypass system.

5.2 HOV Evaluation

Numerous evaluations of HOV systems have been performed nationwide. The following are the main observations of the studies of existing HOV facilities:

- HOV lanes carry more people than a congested mixed-flow lane. Each HOV lane typically transports twice as many people as a mixed-flow lane during the peak hour.

- In some cases, HOV lanes are underutilized, carrying fewer vehicles per lane than their mixed-flow counterparts. Effective HOV lanes should carry between 400 and 1,500 vehicles per hour per lane.

- HOV lane speeds are 20 to 30 mph higher than their regular counterparts. Speeds along bus ways are also excellent; but taking into account the transit stops, the average speed tends to be lower.

- HOV lanes generate travel timesavings to their users. According to a Portland study, HOV travel time benefits are approximately one minute per mile. Combining HOV lanes with Intelligent Transportation Systems (ITS) could increase the benefits further as high as two minutes per mile.

- Bus ways and bus lanes move the most number of commuters. The best example of a high productivity bus way is Route I-495, a 2.5-mile bus way connecting New York City with New Jersey via the Lincoln Tunnel, which carries over 700 buses during the peak hour, transporting approximately 35,000 commuters.

- Violation rates vary depending on the level and method of enforcement, but are typically around 10 percent. Concurrent flow HOV lanes typically have higher violation rates than barrier-separated lanes.

- Incident rates on HOV lanes and their adjacent mixed-flow lanes range between two to three incidents per one million miles of travel, largely due to weaving and large speed differentials. Barrier-separated facilities usually have lower incident rates, about 1.4 incidents per million miles of travel. The incident rate for interstate and trunk highways in Minnesota is about 0.8.

- Public acceptance of HOV lanes vary by metro area, but generally, HOV lanes are accepted as a good idea when the corridors experiences recurring congestion.

5.3 HOV Lane Challenges

Like other transportation solutions, HOV lanes have their limitations and weaknesses. Operating HOV lanes at an optimum level can be a tough challenge. The following list summarizes the major challenges facing HOV lane operations.

- **Underutilization –** Although moving about twice the number of people than on each mixed-flow lane, most existing HOV lanes are still underutilized from a vehicle throughput standpoint. Remedies for underutilization include:

  – "Backsliding" to mixed flow – Backsliding is reverting HOV lanes to general-purpose lanes. Starting in 1994, states were required to refund the federal grants if the HOV lanes did not operate as such, or did not meet the FHWA usage requirements. Since travel demand is much larger than the available roadway capacity, extra capacities created by backsliding are quickly absorbed by mode shifting from HOV to SOV use and, in some cases, by induced travel demand (new trip generation).

  – Lower HOV requirement – The most common outcome of underutilization was lowering minimum occupancy requirements on HOV facilities, usually from 3+ to 2+.

  – Allow incident override – The FHWA will allow SOVs to use the HOV lanes during incidents of long duration. The incident duration that will trigger the override is an issue that must be evaluated on a case-by-case basis.

  – Increase speed limit – Increasing the benefits to the users is another way to increase HOV lane usage. The major concern over increasing speed limits is safety, especially on concurrent HOV lanes.

  – Remove/reduce enforcement – One way to achieve an increase in HOV lane usage is to remove or reduce state patrollers from the corridor, thus increasing violation rates and undermining HOV operations.

  – Improve the transit system – Improving the transit system, including adding more park-and-ride lots, can make transit more attractive increasing both vehicle and person throughput.

  – Education and marketing – Education and marketing programs can improve utilization, ensure public support, and could possibly lower violation rates.

  – Convert to HOT Lanes – HOT lanes allow SOVs to pay a fee for their use. HOT lane critics argue that HOT lanes discriminate against the poor. Studies of SR-91 in Southern California have shown that this is not the case. One issue with conversion to HOT lanes is that it would be very difficult on non-barrier separated HOV lanes based on current technology; and non-barrier separated HOV lanes are the most prevalent type of HOV facility in the U.S.

- **Expense –** Costs to plan, construct, operate, enforce, and market HOV facilities can be high. The cost burden largely depends on the facility type, whether or not a new HOV facility needs to be constructed and what federal grants are available.

- **Enforcement issues –** Many believe that the key success factor for HOV lanes is strong and consistent enforcement. However, still others would argue that the limited police budget and manpower should be used to address more important social problems. Enforcement and violation rates largely depend on the type of HOV facility, enforcement manpower and consistency, availability of refuge areas, number of access and egress points, general public acceptance, and severity of violation penalties. The average enforcement cost nationwide is approximately $150, ranging from $40 to $300. The fine in the Twin Cities is $105.

- **Congestion still occurs –** In many regions, HOV lane volumes have remained consistently low since opening day. Some argue that HOV lanes are in place to provide greater mode choice to travelers and improve transit operations and reliability.

- **Inconvenient or undesirable –** Although HOV lanes may improve travel time, additional time must be invested for carpool setup time. With flexible work hours, keeping a uniform and consistent work schedule among several commuters is difficult. Many citizens fear that HOV lanes would "force" them to carpool; they would rather see their tax dollars go to additional mixed-flow lanes. Carpooling works best in congested corridors with few travel alternatives to dense urban areas with high parking costs.

- **Unsafe –** Since most HOV lanes are located on the inside (left-most) part of the freeway, cars must weave their way through several traffic lanes to get to the HOV lanes, and later from the HOV lanes to the freeway exit. Often, large speed differentials between the lanes may pose safety risks. Also, HOV enforcement without proper refuge areas could disrupt traffic and lead to unsafe circumstances.

- **Lack of data on benefits –** HOV data, including person volumes, violation rates, and average occupancy, are still limited. By having a rich source of data, in addition to better models, HOV lane demand predictions would be more accurate. Also, publishing up-to-date benefits of HOV lanes would likely increase public satisfaction and political support.

5.4 Keys to a Successful HOV Program

The following summarizes keys to a successful HOV program:

- **Select the right segment –** HOV lanes work best in metropolitan areas with high levels of congestion or recurring congestion. Corridors connecting residential neighborhoods to the downtown or major employment centers are good HOV lane candidates.

- **Select the right restriction –** The tradeoff between HOV restrictions and person-volumes must be carefully analyzed. Predicting HOV lane utilization may require years of trial and error and monitoring. Urban area dynamics will constantly change the HOV demand and utilization.

- **Enforcement –** Studies have shown that support for HOV lanes decreases when people start to perceive that the HOV privilege is being abused. Providing a high level of enforcement that is random, consistent, and visible is important.

- **Interagency coordination –** Careful coordination of HOV policies and procedures with city agencies, transit authorities, and bridge authorities are needed. Experts argue that stand-alone HOV lanes would only address specific problems at specific corridors.

- **Synergy –** HOV lanes will be more effective if they are coupled with other facilities, services, technologies, and policies, especially transit and Intelligent Transportation Systems (ITS). HOV lanes are only a component of a big-picture ridesharing and congestion management program, which may also include carpool parking and pickup points (such as park-and-ride lots), express transit, office ridesharing, parking management and pricing policies, trip reduction ordinances, zoning and land use policies, enforcement, and ITS. Of these, preferential and discounted parking is perhaps one of the most important strategies that could promote higher-occupancy vehicle usage. With preferential parking, carpoolers may park at "premium" parking stalls for free or at a discount.

- **Public and policy-maker support –** It is critical that the public and their representatives be participants in every step of an HOV project from planning and design through the implementation stages.

- **Education and marketing programs –** A diligent transportation agency should continue marketing its existing HOV facilities to ensure high public support and possibly lower violation rates. Seattle (WA), for example, continues to educate the public about the benefits of its transportation programs (including HOV lanes), while promoting its "HERO Program," where motorists can alert the authorities about possible HOV lane violations.

- **Continuous monitoring and data collection –** Changes in population, density, growth, suburbanization, and employment may require further revisions in HOV planning, decision-making, and policies. Current surveillance systems are adequate to monitor HOV lane vehicle volumes and speeds; but the more important data, such as person volumes and violation rates, are still collected manually and intermittently.

5.5 Expert Interviews

Interviews with several implementing agencies or research institutions were included in order to obtain more "hands-on" information regarding the strategies, objectives, successes, and challenges related to HOV lane operations in comparable metropolitan areas. The following are summaries of the interviews with four state agencies (Virginia, California, New Jersey, and Washington), as well as one university research agency (Texas Transportation Institute).

5.5.1 Virginia Department of Transportation (VDOT)

As of June 2001, VDOT operated over 200 lane-miles of HOV facilities, which consist of concurrent and reversible lanes. VDOT hopes to double this figure by 2020. The main goal that VDOT has for its HOV facilities is to increase people movement as well as relieving congestion and promoting transit.

Underutilization is the biggest challenge facing Virginia HOV operations. In response to public and political pressures, VDOT has implemented several strategy adjustments. "Backsliding" was not an option, because the FHWA would require VDOT to repay over $170 million in federal grants used to build the HOV lanes. In 1992, all occupancy requirements were set at HOV 2+, not the original HOV 3+ used in the 1980s. In July 2000, HOV operating hours were reduced by 30 minutes in the morning and one hour in the afternoon. In June 2001, incident overrides for accidents longer than 10 minutes were adopted. A five-minute trigger was rejected by the FHWA. In July 2001, the speed limit on the barrier-separated, reversible HOV lanes in Hampton Roads was raised by 10 mph. Public reaction to these adjustments has been very favorable without much objection from public safety agencies.

Commuters were slow to accept ridesharing and HOV lanes and preferred to have mixed-flow lanes added to the current infrastructure instead of HOV lanes. However, recent alterations in HOV operations helped improve the public perception about HOV lanes. In addition, VDOT has hired a marketing agency to help promote ridesharing and greater utilization of HOV lanes. Some of the media used by the VDOT include television ads, radio spots, souvenirs, public meetings and posters.

5.5.2 California Department of Transportation (Caltrans)

Caltrans operates over 1,000 lane-miles of HOV lanes and expects to double this amount by 2023 through corridor expansions, and not mixed-flow lane conversions. The main objective of HOV operations in California is to relieve congestion. The main challenge to Caltrans' HOV program is gaining public acceptance prior to facility implementation. Caltrans is investigating more effective public relations media to convey the benefits of HOV lanes to Californians.

Most HOV facilities in California require at least two passengers in each vehicle, and changes in occupancy requirements almost never occur. Adjustments, usually driven by the public, are generally made by extending or shortening the HOV lane hours. It usually takes six months of planning and preparation for each change, followed by 14 to 18 months of pilot study, during which the facility is continuously monitored.

Caltrans acknowledged that underutilization occurs at some segments, and that HOT lanes would be an effective way to "sell" the extra capacity. However, Caltrans believes that such conversion is "too drastic," and all HOT lane implementations require the Governor's approval. Caltrans never considered adjusting the HOV lane speed limits to boost utilization. The safety committee sets the speed limits, and this committee is largely detached from the operations division. In the case of major incidents, HOV lanes may be opened up to general traffic. The Traffic Management Center and Caltrans make this decision on a case-by-case basis.

"Backsliding" occurred once in California on a five-mile concurrent HOV segment on I-580 in Richmond that was implemented as an emergency measure after the Loma Prieta earthquake. Caltrans decided in 2000 that this HOV segment was too short, the operating window too small, and traffic too low to produce significant timesavings. In the 1990s, Caltrans experimented with opening freeway shoulders to traffic during peak periods, but

the pilot project was quickly terminated because of high crash rates from cars rear-ending stalled vehicles that were moved to the shoulders prior to the peak periods. Shoulder lanes are deemed "confusing" and "unsafe."

San Diego operates eight-mile, reversible, barrier-separated HOT lanes on I-15. Carpools of two or more persons and motorcycles are allowed to use the facility for free, while SOVs with special FasTrak accounts can pay to use the facility. Initially opposed by many, fearing a "Lexus Lane Syndrome," it now enjoys favorable public perceptions and volume has doubled to 18,000 vehicles per day.

SR-91 Express Lanes in Southern California were opened in 1995 as a HOT lane facility. Due to high demand, HOVs are now required to pay for their use and tolls have been raised more than five times since opening day. A non-compete clause was built in to the agreement between the private owners and the Orange County Transportation Authority (OCTA) restricting the county from expanding the current free lanes for the next 30 years. OCTA is now looking into purchasing back this non-compete clause because of a dire need to expand capacity in the corridor.

Section 10.0 provides more detail on these HOT lane implementations.

5.5.3 Texas Transportation Institute (TTI)

Houston's 65 miles of barrier-separated, reversible HOV lanes are operated and enforced by its transit authority, enabling the coordinated planning and promotion of transit and HOV usage. The Texas Department of Transportation (TxDOT) is only responsible for the maintenance of the HOV infrastructure. Houston has no HOV bypass lanes on the ramps, because these HOV lanes have their own access points directly to/from the transit stations and park-and-ride lots. Metro's primary goal for its HOV facilities is first to improve person-throughput, followed by transit reliability. So far, the HOV program in Houston has experienced great success.

Initially implemented as bus- and vanpool-only facilities, the HOV requirement was lowered to 3+ and later to 2+ to overcome underutilization. Recently, however, the requirement was raised back to 3+ during peak periods due to high demand and a need to maintain significant timesavings to users. Metro and TranStar (which consists of five local transportation agencies) may open up the HOV lanes for general traffic use during incidents. The decision to open up the facilities is made on a case-by-case basis, and there are no specific time triggers that are used to make this decision. Metro has adjusted the HOV lanes speed limits from 55 mph up to 70 mph, following similar adjustments TxDOT made on the mixed-flow lanes.

While the State Patrol enforces freeway operations on the mixed-flow lanes, Metro has its own enforcement unit to monitor the HOV lanes. Metro is currently having difficulties enforcing the facilities during the 3+ peak periods, mostly due to 2+ vehicles that might have entered just before the peak. As a result, violation rates may be as high as 44 percent.

HOT lanes operate on I-10 in 1998 and Highway 290 in the Houston area. At these corridors, which operate as HOV 3+ during peak periods, 2+ vehicles may use the facility for a

flat fee of $2 per use. There has been no major oppositions to the HOT lanes. Metro also operates temporary shoulder HOT lanes on I-10 Katy Freeway beginning where the current barrier-separated facility ends. This six-mile stretch operates as HOT lanes during peak periods, HOV lanes during the regular operating hours, and as emergency shoulders at all other times. While TTI acknowledges safety concerns from such a configuration, so far it has not proven dangerous.

5.5.4 Washington Department of Transportation (WashDOT)

Seattle metropolitan area first instituted HOV lanes in 1970, and now operates over 200 lane-miles of HOVs in seven segments. All HOV facilities operate 24 hours a day, with a 2+ carpool requirement, except on SR-520. WashDOT is currently constructing 14 additional miles of HOV lanes, with almost 100 miles in the planning stage. As a policy, WashDOT's HOV facility users must be able to travel at least 45 mph during the peak hour, 90 percent of the time. When these requirements are not met, WashDOT considers raising the occupancy requirement to 3+. WashDOT is also considering different HOT lane options to maintain this speed threshold.

Enforcement remains the biggest issue in Seattle. Violation rates vary between two to 13 percent, but noticeably higher when State Troopers must attend to incidents and cannot effectively monitor the HOV lanes. WashDOT initiated the "HERO Program," which allows motorists to report HOV violators. However, HERO only sends warning letters to violators and might lose its effectiveness without proper enforcement. The HOV lane violation penalty is only $86, which is lower than the national average of $150.

WashDOT operates shoulder HOV lanes on SR-520. To keep the shoulder lanes effective, WashDOT maintains constant camera surveillance to monitor the facility, and around-the-clock service patrols to immediately tow disabled vehicles off of the bridge.

HOV timesavings in Seattle vary between 30 seconds to one minute per mile. Ramp HOV bypass lanes generate additional perceived and real benefits, since delays caused by ramp meters generally run up to three minutes. Currently, both HOV and SOV motorists perceive HOV lanes favorably, with over 90 percent and 70 percent approval ratings, respectively. The main public objection to HOV lanes is the perception of "empty lane syndrome."

5.5.5 New Jersey Department of Transportation (NJDOT)

New Jersey currently has no HOV facilities, except on the New Jersey Turnpike. Since its introduction in 1994, HOV lanes in New Jersey faced tremendous public and media scrutiny until their eventual closure on November 30, 1998. NJDOT has listed several lessons-learned from New Jersey's HOV lane experience:

- Site selection is crucial (observe travel patterns, transit routes, etc.);
- Synergy with transit is key;

- Existing operational problems should be corrected before HOV operation is implemented;
- Consider level of violations, congestion, and road rage in mixed-flow lanes as symptoms of a developing problem;
- A successful opening and operation do not guarantee continual operational success;
- Changes in the administration may affect the level of HOV support or policy;
- Keep marketing and monitoring HOV facilities and advertise benefits; and
- Be vigilant, keep looking for different solutions.

5.6 Comparison of Twin Cities' HOV Facilities to Other HOV Facilities Across the Country

The following highlights some of the key comparisons between the Minnesota HOV facilities and HOV facilities in operation throughout the country (see Appendix C):

- On average, the barrier-separated facilities across the country have one HOV lane and three general-purpose lanes, the Twin Cities has two HOV and three general-purpose lanes. The concurrent flow HOV lanes in the Twin Cities consist of one HOV lane and mostly two general-purpose lanes and a few sections with auxiliary lanes. The literature shows an average of one HOV and three general-purpose lanes. In both the barrier-separated and concurrent flow cases, Minnesota has devoted a greater proportion of the capacity to HOV lanes than the average nationally.
- The model estimated current HOV speed in the Twin Cities is about 56 to 62 mph, while the general-purpose lanes travel at about 32 to 38 mph during the peak periods. Speeds from other studies across the country are on average 54 mph for HOV lanes and 28 mph for general-purpose lanes.
- The Twin Cities barrier-separated HOV lane is moving fewer vehicles per lane than the average barrier-separated HOV lane, 661 versus 703. The I-35W concurrent HOV lane is also below the average (772 versus 834). However, the concurrent HOV lane on I-394 is moving more than the average at 906 vehicles.[1]
- Violation rates on the Twin Cities HOV lanes are higher than the average nationwide, particularly on the concurrent flow facilities. The nationwide average is 9.5 percent on barrier-separated HOV lanes and 13 percent on concurrent. The Twin Cities range from six percent to 12 percent on barrier-separated lanes, and 19 to 41 percent on the concurrent facilities.

[1] Average of a.m. and p.m. peak hour from 2001 Second Quarter HOV Report and only include carpools, vanpools, and transit (no violators).