# Developing and Applying a Level-of-Service Framework to Port-of-Entry Infrastructure Planning

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ABSTRACT

Major land-based ports of entry (POE's) are key surface transportation gateways that support bi-national trade strategies within the global supply chain. Proposed infrastructure improvements have significant long-term capital investment and project phasing implications. Appropriate planning methodologies are critical to ensuring proposed port infrastructure improvements yield the desired economic benefits. However, the development and application of planning methodologies to assess delay and congestion implications of port improvement scenarios have not kept pace with the growing significance of these key land-based transportation assets.

In response to these methodology gaps, a Level of Service (LOS) framework and analysis was developed for the Pembina-Emerson POE Study (2012). Based on LOS traffic flow concepts in the (2010) Highway Capacity Manual (HCM), the LOS framework and performance measurement algorithms developed for POE`s can be applied to any border crossing to assess port throughput by evaluating various processing times, staffing levels or infrastructure improvement scenarios for primary inspection lanes (PIL's). Combining the LOS framework (a policy-level approach) with 30th highest hour design (an engineering infrastructure design approach) provides transportation policy makers, planners and engineers with greater flexibility to assess infrastructure design and phasing considerations as well as outputs that support benefit / cost analysis for a proposed port improvement concept.

## 1.0 Introduction

Land-based ports of entry (POE's) are key elements of the transportation network connecting two countries. Bottlenecks, delay and congestion at POE's add supply chain costs (time, financial, environmental) and have potential negative impacts on economic growth. The relative importance of land-based POE's are often expressed through trade figures and vehicle movements, which are generally accepted transportation industry metrics. For example, in 2010 the top 6 Canada-United States POE's accounted for $237 billion in two-way truck-based trade and more than 7 million annual truck movements (Table 1).

Table 1: Top Six Canada – United States POE's (2010)

| United States | Canada | Trade ($ B) | Two-Way Truck Traffic |
|---|---|---|---|
| Detroit | Windsor | 91.7 | 2,620,000 |
| Buffalo | Fort Erie | 56.2 | 1,180,000 |
| Port Huron | Sarnia | 42.7 | 1,540,000 |
| Champlain | Lacolle | 18.4 | 620,000 |
| Pembina | Emerson | 14.3 | 370,000 |
| Blaine | Surrey | 13.9 | 700,000 |
| | TOTALS | 237.2 | 7,030,000 |

When describing the operational deficiencies of a specific POE, historical performance measures such as delay or wait time and queue lengths are often referenced. These negative performance measures are often anecdotal, non-standardized or difficult to quantify. Ongoing discussions and initiatives at the Transportation Border Working Group (TBWG is a bi-national forum for coordinating Canada-United States border issues) and Joint Working Committee (JWC is a bi-national forum for coordinating Mexico-United States border issues) underscore this point.

Furthermore, measurements of delay and congestion by themselves are insufficient to support justifications for extensive capital improvements to POE infrastructure. As such, appropriate planning methodologies are essential for developing and evaluating proposed POE infrastructure improvements as well as describing service level improvements. However, the development and application of methodologies to assess the delay and congestion implications of port improvement scenarios have not kept pace with the growing significance of these key land-based transportation assets.

In a recently completed study of the Pembina-Emerson POE (2013), Manitoba Infrastructure and Transportation (MIT) took a leadership role in developing an innovative measure of POE performance based on the Level-of-Service (LOS) concept utilized in the Highway Capacity Manual (HCM). The LOS framework and corresponding algorithms that were developed by MIT for the Pembina-Emerson study can be applied to any POE to assess port throughput. The LOS framework for POE's provides a powerful analytic tool for evaluating multiple combinations of processing times, staffing levels or infrastructure improvement scenarios for primary inspection lanes (PIL's) that orthodox methodologies have not captured.

The purpose of this paper is to illustrate the value of adapting the LOS concepts found in the HCM to evaluate POE performance. The recently completed Pembina-Emerson study provides examples of how the LOS framework is applied to a POE planning context. The significance of the LOS framework and corresponding algorithm derived output is that they can provide easily interpreted annualized data for every hour of every year (8,760 hours in a typical year) over a 20 year planning period and allocate these values on a yearly basis to various LOS categories.

From an infrastructure investment perspective, this output is especially well suited to describing POE service levels for pre and post improvement scenarios. The LOS framework and analysis complements the engineering design approach (30th highest hour) by providing easily interpreted longitudinal output of service level offerings for a variety of port scenarios which can be readily understood by elected officials, stakeholders and the public.

This paper is the companion paper to, "Innovations in Travel Demand Forecasting for Land-Based Port's of Entry" presented at this TAC conference.

## 2.0 Methodology Integration

Figure 1 illustrates the relationship between forecast development, traffic simulation models and the LOS methodology as developed by MIT for the Pembina-Emerson POE study (Ref. 1). The applicability of the LOS methodology is such that, once developed, the model can be adapted to evaluate any major POE with significant traffic volumes. In this regard, there are 120 land-based Canada-United States POE's and 44 land-based Mexico-United States POE's that the methodology could be applied. In practical terms, the top 20 POE's along the Canada-USA and Mexico-USA borders could benefit the most from the application of this methodology.

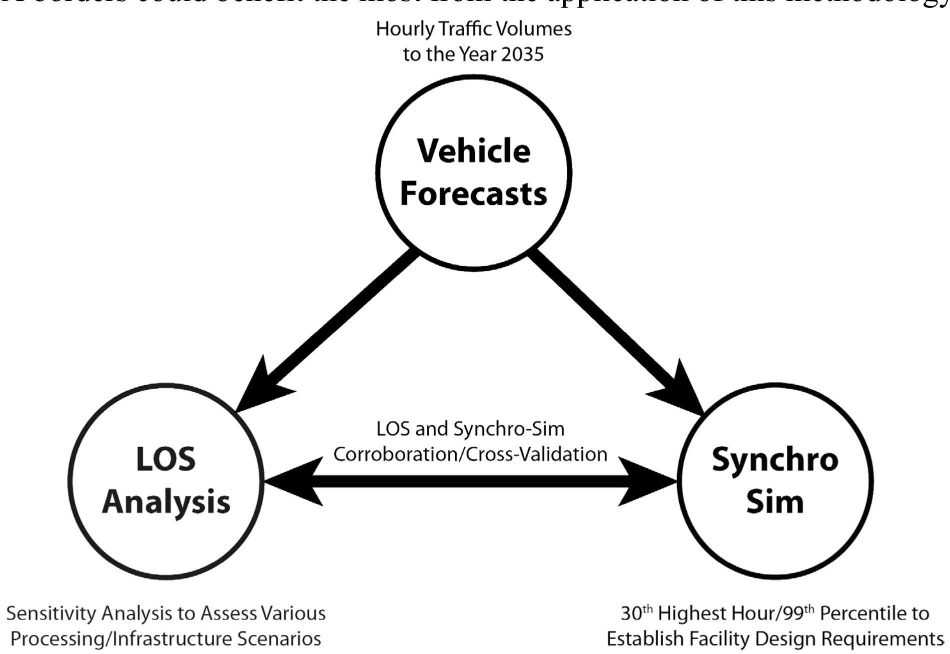



Figure 1: Relationship between Vehicle Forecasts, Level-Of-Service and Micro-Simulation Modeling

## 3.0 Level of Service Concept and Framework

The LOS framework for land-based POE's is derived from concepts in the HCM for uninterrupted (freeway conditions) and interrupted (intersection conditions) flows (Ref. 2, 3, 4, 5). Table 2 illustrates the LOS framework developed by MIT for POE applications.

The LOS framework utilizes standard A-F service level categories found in other HCM applications. Generally speaking, service levels A and B reflect no delay or minimal delay conditions, C and D short to moderate delays and E and F significant to severe delays. Three criteria were utilized to determine service level conditions, namely:

- Volume to Capacity Ratio: Volumes (arrival rates) were developed utilizing the forecast methodology outlined in the companion paper entitled, "Innovations in Travel Demand Forecasting for Land-Based POE's". Maximum theoretical PIL booth processing capacity was used as the proxy for POE capacity. Theoretical processing capacity at Pembina-Emerson was derived using an assumption for processing time per vehicle to obtain POE maximum hourly throughput.

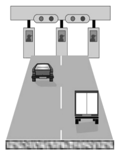
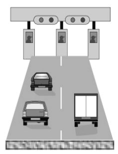
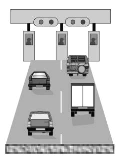
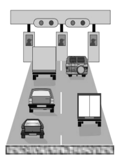
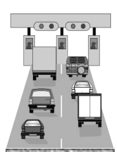
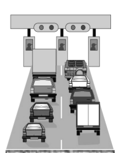
  (vph processed per PIL) x (PIL positions) = Max Capacity

  Therefore if a 2 minute per vehicle processing time was used for a 10 PIL booth configuration the maximum theoretical processing capacity of the POE would be 300 vehicles per hour in a specified direction of travel.

- Magnitude of Delay: Defined as the delay to individual vehicles and calibrated with the simulation model

- Duration of Delay: Defined as the duration of the vehicle queue and calibrated with the simulation model

## Table 2: Level of Service Framework for POE's

| Level of Service | Flow Conditions | LOS Description | Primary Trigger for Capacity Improvements | Secondary Measures to Be Considered | |
|---|---|---|---|---|---|
| | | | Magnitude of Average Vehicle Delay (minutes) | Duration of the Delay Period (hours) | v/c Ratio |
| A |  | Free flow conditions entering PIL plaza, unimpeded manoeuvrability within PIL plaza, queuing limited to a few vehicles in each PIL , no delay, driver comfort levels are very high. **No Delays** | ***<5 min*** | ***negligible*** | ***< 0.9*** |
| B |  | Near free flow conditions entering PIL plaza, drivers experience minor restrictions when manoeuvring vehicles within PIL plaza, queuing within PIL plaza only, minimal delay, driver comfort levels are high. **Minimal Delays** | ***≧ 5 min < 15 min*** | ***negligible*** | ***0.9-1.2*** |
| C |  | Manoeuvring within PIL plaza becomes constrained, queuing extends beyond PIL plaza onto highway facility and begins to affect lane assignment strategies, moderate delay, driver comfort levels are acceptable. **Short Delays** | ***≧ 15 min ≦ 20 min*** | ***< 1 hr*** | ***1.2-1.4*** |
| D |  | Queuing extends upstream on highway facility and begins to affect manoeuvring related to both advance notification and lane assignment strategies, moderate delay, drivers may experience poor levels of comfort. **Moderate Delays** | ***>20 min ≦25 min*** | ***1-2 hr*** | ***1.4-1.6*** |
| E |  | Queuing extends significantly upstream on highway facility, queue length limits effectiveness of advance notification and lane assignment strategies, significant delay, very poor driver comfort levels. **Significant Delays** | ***>25 min ≦45 min*** | ***> 2 hr*** | ***1.6-2.5*** |
| F |  | Queuing extends significantly upstream on highway facility, queue length limits effectiveness of advance notification and lane assignment strategies, severe delay, extremely poor driver comfort levels. **Severe Delays** | ***>45 min*** | ***> 2 hr*** | ***>2.5*** |

Notes:
Adapted from concepts in the Highway Capacity Manual (Transportation Research Board)

v/c Ratio
volume: Forecasted hourly arrival rates
capacity: Maximum theoretical capacity (total number of PIL booths x processing rate / vehicle / hour)

## 4.0 Development of Level of Service Algorithms

Figure 2 illustrates the queuing model that was used to develop algorithms for converting hourly vehicle arrival data (forecasts) into various LOS categories. The various phases and inflection points in the model were calibrated with the LOS framework in table 2 and are briefly described as follows:

- State 1: (LOS A and B) Unsaturated state where there are only minor delays and no queues. Up to point a", vehicle arrival rates are less than maximum theoretical processing capacity (capacity).

- State 2: (LOS C and D) Build-up state where vehicle arrival rates exceed capacity beyond point a" and minor to moderate queuing occurs.

- State 3: (LOS E and F) Saturated state where combined vehicle arrival rates/queues beyond point b" exceed capacity and moderate to severe queuing occurs.

- State 4: (LOS A to F) Dissipation state where vehicle arrival rates/queues peak above capacity at point c" and then decline to below capacity at point d". Queue length is the sum of vehicle arrivals over capacity from point a" to point c". Between point b" and c" the peak arrival period ends. Between point c" and d", arriving vehicles are still delayed because of a queue, but the average wait time is declining as the queue begins to dissipate. As the system moves beyond point d", the combined vehicle arrival rates/queues are less than capacity and the system returns to the unsaturated state.

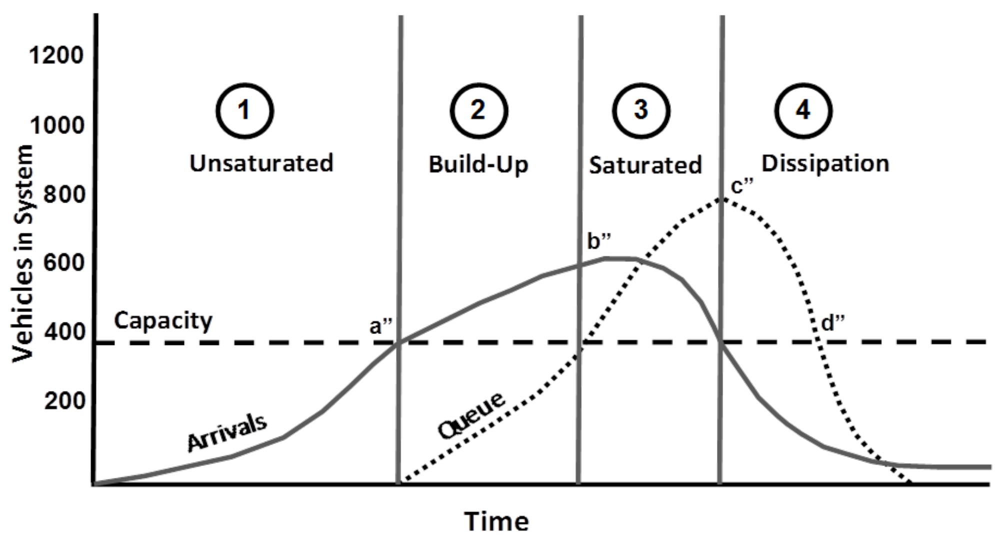



Figure 2: Vehicle arrival and queuing model
used to develop wait time and LOS

Populating LOS output tables required calculation of average vehicle service time. This calculation included both time in the queue, if any, and PIL processing time. Average PIL processing time is approximately 1.25 to 2 minutes per vehicle, depending on document type (ie: passport vs NEXUS). Intervals of 15 seconds were used for the purposes of illustrating the incremental effect of processing time or technology impacts on processing time.

Calculating average vehicle wait time is dependent upon what state and condition the system is in, based on vehicle arrivals and whether a queue exists. Each "condition" required a specific set of custom equations to determine average vehicle time in the system. Average vehicle wait time calibrations for LOS categories A to F were based on Canada Border Services Agency (CBSA) and Customs and Border Protection (CBP) service level policy. A service time of 20 minutes or less was identified as an acceptable operational standard and correlates with lower bound LOS "C" / upper bound LOS "D". Service levels A-F can be custom calibrated to suit any specific service level policy.

Queuing theory equations and applications are the underlying formulae to determine average vehicle wait times in queues. This is the same approach used in multi-sever systems analysis for fast food outlets, banks, and grocery check outs. There were six specific sets of equations used for each state and condition as shown in figure 2, with two conditional sub-sets. Referencing table 3, the conditions are based on the current system state as it exists within the hour of analysis, Q refers to the total vehicles in the queue, AR is the hourly vehicle arrival rate and SR is the service rate or maximum hourly theoretical processing capacity. Queues do not develop until the SR is exceeded.

Q = Queue Length (total vehicles)

AR = Arrival Rate (vehicles per hour)

SR = Service Rate (maximum hourly processing capacity)

Table 3: LOS System State and Conditional Relationships

| State | Description | Conditional and System Relationships | | | |
|---|---|---|---|---|---|
| | | Q to SR | AR to SR | Q to AR | System |
| State 1 | Unsaturated | Q<<SR | AR<<SR | Q<< AR | (Q+AR)<< SR |
| State 2 | Build-Up | Q < SR | AR > SR | Q < AR | (Q+AR) > SR |
| State 3 | Saturated (1) | Q > SR | AR>>SR | Q < AR | (Q+AR)>> SR |
| State 3 | Saturated (2) | Q>>SR | AR > SR | Q > AR | (Q+AR)>> SR |
| State 4 | Dissipation (1) | Q > SR | AR < SR | Q >>AR | (Q+AR)>> SR |
| State 4 | Dissipation (2) | Q < SR | AR < SR | Q > AR | (Q+AR) < SR |

- During State 1, with vehicle arrivals (AR) much less than the service rate (SR) no queues develop and the system never reaches capacity.

- During State 2, a queue (Q) is starting to form but is still less than the SR (meaning the number of vehicles in the queue is less than the SR). Although vehicle arrivals (AR) are greater than the service rate (SR), the queue (Q) volumes are still less than the vehicle arrival rate (AR).

- During the first condition of State 3, the system is now saturated and there are two condition sets. The first is when total vehicles in the queue (Q) are greater than the SR. The queue will not dissipate as vehicle arrivals (AR) are still greater than service rate (SR). The queue (Q) would grow indefinitely under these conditions.

- During the second condition of State 3, vehicle arrivals (AR) are beginning to slow down, but are still greater than the service rate (SR), meaning the queue (Q) continues to grow. When point “c” is reached in figure 2, the queue (Q) is now at its maximum and vehicle arrivals (AR) are dropping below the service rate (SR). Arriving vehicles (AR) still experience significant delay while the queue (Q) is dissipating.

- During the first condition of State 4, arriving vehicles (AR) are less than the service rate (SR) but are still faced with a lengthy wait while the queue (Q) continues to dissipate. Average wait time is now decreasing.

- During the second condition of State 4, at point “d” in figure 2, both the queue (Q) and vehicle arrivals (AR) combined are below the service rate (SR). All vehicles will be processed in less than 1 hour. The queue (Q) remnants have yet to be processed, with new vehicle arrivals (AR) also facing minor delay. At this point the queue (Q) is still greater than vehicle arrivals (AR) but is dissipating and will fall below the arrival rate (AR).

## 5.0 Interpreting Level of Service Output Tables

Two examples of LOS output from the Pembina-Emerson study are provided to illustrate the descriptive capabilities of this methodology.

Example 1: Multi-Dimensional / Multi- Variant Characteristics

LOS time intervals for service levels A to F are based on the calibrations in table 2 (duration: delay to individual vehicles and magnitude: duration of queue). The algorithms allow for time interval calibrations that can be customized to reflect a particular LOS policy, PIL configuration (infrastructure or staffing levels) and custom processing time to reflect a wide array and combination of service offering scenarios. In the case of processing time, blended processing rates based on the ratio of trusted travellers (NEXUS) or trusted traders (FAST) to standard documentation users could be developed to match the characteristics at a specific POE.

The resultant tabular output reflects a multi-dimensional analysis (x-axis: PIL infrastructure or staffing, y-axis: Processing time and z-axis: LOS service level policy) in a two-dimensional format. In this regard, the impact of adjusting either PIL capacity (infrastructure / staffing) or processing time can be evaluated within the context of a pre-set LOS policy. For any given forecast year it is possible to quantify impacts of service level policies. This policy-driven approach is substantively different than methods that merely attempt to ascertain average wait times for queued vehicles. Tables 4 and 5 illustrate how PIL capacity and processing time variables can be used to evaluate pre-set LOS policy by indicating how many hours will fall into each LOS "bucket".

In table 4 (2015 traffic volumes) 8,473 hours will fall in the LOS A category (96.7% of all 8,760 annual hours) with a 6 PIL configuration and a 1.75 mpv (minutes per vehicle) processing rate. The remaining 287 hours (2.3%) will fall in LOS categories B through E.

In table 5 (2030 traffic volumes) only 6,598 hours will fall in the LOS A category (75.3% of all annual hours) with a 6 PIL configuration and a 1.75 mpv (minutes per vehicle) processing rate due to the projected increase in traffic. The remaining 2,162 hours (24.7%) will fall in LOS categories B through E.

Table 4: Pembina-Emerson POE (Northbound 2015)

| | | 2015 | | | | | |
|---|---|---|---|---|---|---|---|
| **Number of PILs** | | **6** | | **8** | | **10** | |
| **Time** | **LOS** | **Total Hours** | **% Hours** | **Total Hours** | **% Hours** | **Total Hours** | **% Hours** |
| **1.75 min 105 sec** | A | 8,473 | 96.7% | 8,735 | 99.7% | 8,756 | 100.0% |
| | B | 36 | 0.4% | 4 | 0.0% | 1 | 0.0% |
| | C | 1 | 0.0% | 1 | 0.0% | 0 | 0.0% |
| | D | 23 | 0.3% | 0 | 0.0% | 1 | 0.0% |
| | E | 192 | 2.2% | 20 | 0.2% | 2 | 0.0% |
| | F | 35 | 0.4% | 0 | 0.0% | 0 | 0.0% |
| **1.50 min 90 sec** | A | 8,670 | 99.0% | 8,749 | 99.9% | 8,760 | 100.0% |
| | B | 27 | 0.3% | 1 | 0.0% | 0 | 0.0% |
| | C | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| | D | 7 | 0.1% | 1 | 0.0% | 0 | 0.0% |
| | E | 40 | 0.5% | 8 | 0.1% | 0 | 0.0% |
| | F | 16 | 0.2% | 1 | 0.0% | 0 | 0.0% |

Table 5: Pembina-Emerson POE (Northbound 2030)

| | | 2030 | | | | | |
|---|---|---|---|---|---|---|---|
| **Number of PILs** | | **6** | | **8** | | **10** | |
| **Time** | **LOS** | **Total Hours** | **% Hours** | **Total Hours** | **% Hours** | **Total Hours** | **% Hours** |
| **1.75 min 105 sec** | A | 6,598 | 75.3% | 7,859 | 89.7% | 8,509 | 97.1% |
| | B | 110 | 1.3% | 78 | 0.9% | 37 | 0.4% |
| | C | 18 | 0.2% | 15 | 0.2% | 5 | 0.1% |
| | D | 29 | 0.3% | 41 | 0.5% | 4 | 0.0% |
| | E | 876 | 10.0% | 539 | 6.2% | 174 | 2.0% |
| | F | 1,129 | 12.9% | 228 | 2.6% | 31 | 0.4% |
| **1.50 min 90 sec** | A | 7,343 | 83.8% | 8,358 | 95.4% | 8,687 | 99.2% |
| | B | 88 | 1.0% | 37 | 0.4% | 8 | 0.1% |
| | C | 6 | 0.1% | 2 | 0.0% | 1 | 0.0% |
| | D | 32 | 0.4% | 16 | 0.2% | 2 | 0.0% |
| | E | 711 | 8.1% | 284 | 3.2% | 52 | 0.6% |
| | F | 580 | 6.6% | 63 | 0.7% | 10 | 0.1% |

Example 2: Pre and Post Improvement Analysis

Tables 6 and 7 illustrate LOS hourly buckets for pre and post improvement scenarios for the northbound direction of travel at the Pembina-Emerson POE. Table 6 illustrates that for the northbound direction of travel, LOS begins to significantly decay by 2025 with the current infrastructure (6 PILS) based on the projected traffic growth. A comparison of the output for 2025 in table 6 (pre improvement scenario of 6 PILS) and table 7 (post improvement scenario of 9 PILS) demonstrates that by adding 3 additional PIL's (a 1.25 mpv processing rate was used for both scenarios) a significant improvement in LOS occurs out to 2035 over the pre improvement conditions.

Table 6: Pre Improvement Scenario (6 PILS Northbound 2015-2035)

| | | 2015 | | 2020 | | 2025 | | 2030 | | 2035 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Max Time (minutes) | LOS | Total Hours | % Hours | Total Hours | % Hours | Total Hours | % Hours | Total Hours | % Hours | Total Hours | % Hours |
| 5 | A | 8,742 | 99.8% | 8,704 | 99.1% | 8,502 | 97.1% | 8,024 | 91.6% | 7,475 | 85.3% |
| 15 | B | 1 | 0.0% | 13 | 0.1% | 31 | 0.4% | 107 | 1.2% | 73 | 0.8% |
| 20 | C | 1 | 0.0% | 1 | 0.0% | 12 | 0.1% | 11 | 0.1% | 11 | 0.1% |
| 25 | D | 1 | 0.0% | 2 | 0.0% | 15 | 0.2% | 42 | 0.5% | 31 | 0.4% |
| 45 | E | 15 | 0.2% | 55 | 0.6% | 168 | 1.9% | 416 | 4.7% | 679 | 7.8% |
| >45 | F | 0 | 0.0% | 9 | 0.1% | 82 | 0.4% | 160 | 1.8% | 491 | 5.6% |

Table 7: Post Improvement Scenario (9 PILS Northbound 2015-2035)

| | | 2015 | | 2020 | | 2025 | | 2030 | | 2035 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Max Time (minutes) | LOS | Total Hours | % Hours | Total Hours | % Hours | Total Hours | % Hours | Total Hours | % Hours | Total Hours | % Hours |
| 5 | A | 8,760 | 100.0% | 8,780 | 100.0% | 8,745 | 99.8% | 8,696 | 99.3% | 8,573 | 97.9% |
| 15 | B | 0 | 0.0% | 2 | 0.0% | 3 | 0.0% | 12 | 0.1% | 18 | 0.2% |
| 20 | C | 0 | 0.0% | 0 | 0.0% | 1 | 0.0% | 1 | 0.0% | 5 | 0.1% |
| 25 | D | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% | 6 | 0.1% | 11 | 0.1% |
| 45 | E | 0 | 0.0% | 3 | 0.0% | 12 | 0.1% | 40 | 0.5% | 131 | 1.5% |
| >45 | F | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% | 7 | 0.1% | 23 | 0.3% |

## 6.0 Comparing 30th Highest Hour Design with Level of Service

The 30th highest hour design is an engineering methodology used to establish and test a specific facility design. In the case of a POE, the 30th hour design can be used to establish the number of PIL positions that are necessary to adequately meet demand up to the planning horizon year. The 30th highest hour is calculated by arranging the hourly volumes for an entire year (8,760 total annual hours) in descending order and then identifying the value for the 30th highest hour to be used as a basis for developing and testing the engineering design. A design based on the 30th highest hour is theoretically capable of providing adequate capacity for most of the demand which occurs throughout the year. As a percentile, the 30th hour design is expected to accommodate traffic during 99.7 % of the hours in a year.

However, this approach does not explain the annual 8,760 hour demand profile for a transportation facility insofar as there is no reference to the specific magnitude of the 29 hours above or 8,730 hours below the 30th highest hour. Furthermore, a 30th highest hour design is based on a single hourly volume and does not capture the cumulative impacts of consecutive high volume hours that can occur on the shoulders of the 30th highest hour. Given that POE peaks are typically of much longer duration (typically > 3 hours) than urban AM or PM commuter peak periods (typically < 3 hours), the 30th highest hour could potentially understate a design if several high volume hours occur consecutively over an extended period of time during the day.

Figure 3 illustrates three scenarios that reflect the aforementioned limitations in using the 30th highest hour design to explain annual demand profiles at a POE. Scenario A reflects a situation where the 29 hours above the 30th hour are significantly higher than the 30th hour. Scenario B illustrates a situation where a large number of hourly volumes above and below the 30th highest hour are clustered. Scenario C represents a situation where the annual demand profile is rather flat at the high volume end for extended periods. In each scenario there is no means available to test the cumulative effect of high volumes that potentially occur during consecutive hours on the shoulders of the 30th hour design.

Figure 4 is a conceptual representation of how the LOS concept can be used to illustrate decay or improvement in LOS attributed to changes in infrastructure, staffing or processing times in conjunction with any projected vehicle demand scenario. In figure 4 a blended LOS trend line is used to conceptually illustrate this principle. The actual LOS output tables could be converted to a blended value using a weighted average to evaluate specific pre and post scenarios.

Integrating 30th highest hour design with LOS principles requires further calibration. Given that the LOS framework developed for POE applications reflects applied research developed during a time bound planning project (Pembina-Emerson study) further case studies may be necessary to corroborate the methodology. Additionally, correlation of the LOS framework with 30th highest hour design outputs should involve further evaluation of the equations and inputs used in various simulation models.

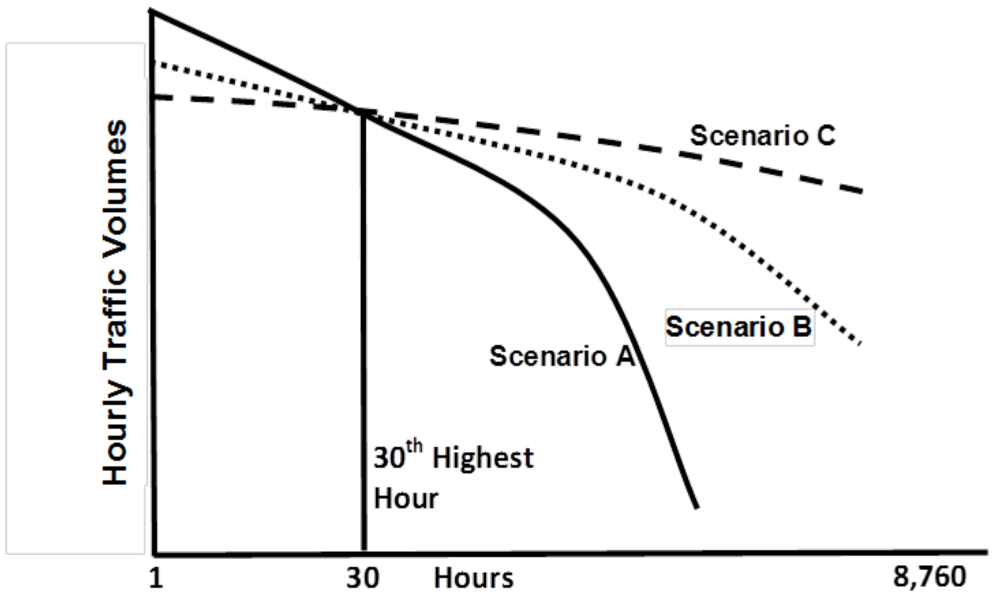



Figure 3: 30th Highest Hour Scenarios

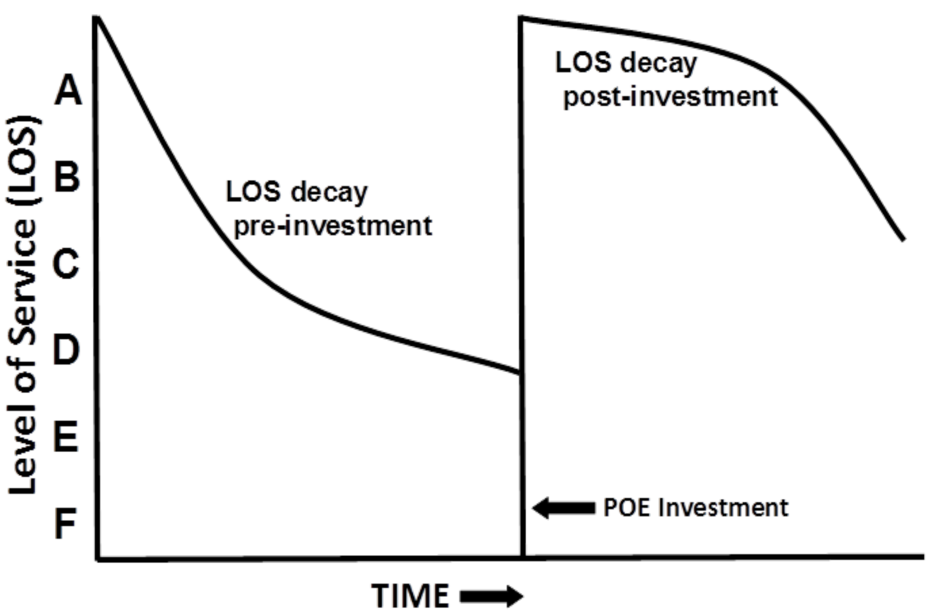



Figure 4: LOS Decay (Pre and Post Investment)

## 7.0 Conclusions

In a decision-making environment that is increasingly influenced by factors related to fiscal restraint, the competition for scarce resources to improve transportation infrastructure requires appropriate merit based justifications to illustrate the case for making strategic investments. Furthermore, in the case of POE infrastructure delivery, the bi-national and multi-agency decision making context requires a lead time of between 6 to 10 years to deliver a coordinated infrastructure solution involving as many as 6 federal, state and provincial agencies.

When planning for projects in a merit-based environment that must meet the needs for 20+ years and can take over a decade to implement, it is crucial to have a policy level tool that can not only help justify proposed POE investments but also clearly illustrate comparative longitudinal service level data for both pre and post improvement scenarios.

The benefits of an LOS framework and analysis for evaluating POE performance are numerous and include the following:

- The LOS framework and corresponding output tables provide data that is user friendly and easily assimilated by elected officials, stakeholders and the public alike,
- The LOS output provides a snapshot for all 8,760 hours in a year and comparative longitudinal analysis of pre and post improvement scenarios for a 20+ year period that reflects multi-dimensional / multi-variant characteristics,
    - Direction of travel
    - Segregation by vehicle type
    - PIL infrastructure or staffing levels
    - Various processing time scenarios
- The LOS framework and output is complementary to 30th highest hour design practice and can assist in corroborating simulation model results,
- The value of the LOS output versus simulation models is that typically simulation models are only run for the design year based on a 30th highest hour volume to evaluate a facility design whereas, one run of the LOS model provides output for every hour in every year of the planning period and summarizes the results in an easy to interpret spread sheet. The LOS model can be modified to reflect different scenarios by simply recalibrating the parameters. It would be not only uneconomical but impractical to run a simulation model for anything other than a 30th highest hour design.

Findings from the Pembina-Emerson study have demonstrated that the LOS framework and corresponding output tables are a powerful and descriptive policy-level tool that can be used by decision-makers to better evaluate, assess and understand the implications (required investments, phasing considerations, benefits) of various POE improvement scenarios.

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