HealthScape Transportation Programming Tool (TPT)

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EXECUTIVE SUMMARY and KEY DISCUSSION POINTS

Purpose & Objectives:

The purpose of the TPT is to prioritize potential non-motorized transportation improvements based on air quality, health, and transportation outcomes. The TPT should meet the following objectives:

- Evidence-based
- Simple to use
- Transferable
- Consistent and Fair
- Aligned with existing processes and priorities

Potential Criteria:

- Transportation benefits
- Safety benefits
- Environmental benefits
- Economic benefits
- Equity benefits
- Health benefits

Potential Measures:

- Connectivity/Route directness
- Connections to Transit
- Reduced Conflicts with vehicle modes
- Size and Characteristics of surrounding population

Key Questions to Consider:

Keep these questions in mind as we go through the workshop:

- How can the TPT influence, fit into, or otherwise relate to larger planning, funding and programming decisions, such as funding source requirements, ability to piggyback on planned construction, the opportunity to acquire right of way, etc.

- What can we do to make this tool helpful to you in your local bike/ped planning?

- How do the potential criteria types fit in with existing jurisdictional priorities?

- Although some pots of money compare only nonmotorized projects to one another, some compare nonmotorized projects with road or transit projects. How might we develop something that can inform multimodal prioritization processes as well?

Next Steps:

The County and the consultant team will review the results of the survey and the workshop, and begin developing a final list of criteria and a draft version of the TPT in spring 2007.

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I. Introduction

The first phase of King County's LUTAQH project focused on the assessment of relationships between land use patterns, travel behavior, air quality and climate change, and obesity and physical activity (see http://www.metrokc.gov/kcdot/tp/ORTP/LUTAQH). The current phase, Phase II, applies results from this research to the development of tools to evaluate the impacts of transportation investments and land use actions on travel, environment, and health related outcomes. The Transportation Programming Tool (TPT) is the first of these tools.

Purpose

The purpose of the TPT is to prioritize potential non-motorized transportation improvements based on air quality, health, and transportation outcomes.

Objectives

The goal is to move towards an approach to non-motorized project evaluation that is:

- **Evidence-based** – based on documented research.
- **Simple to use** – users will likely be non-technical and evaluating many projects, therefore an approach that is straightforward and sensitive to time requirements.
- **Transferable** – can be used in local, countywide, or other prioritization processes.
- **Consistent and Fair** – leads to reasonable, impartial outcomes.
- **Aligned with existing processes** – can supplement or nest into existing programming processes without redundancy and builds on current best practices.

In 2006, the Transportation Research Board reviewed the most recent methods for modeling demand and assessing non-motorized project benefits. They list several elements of a successful bike/ped transportation programming effort:
• Measured on a municipal or regional scale
• Central to assisting decision-makers about transportation/urban planning
• Estimable via available existing data or other survey means
• Converted to measures comparable to one another
• Described for both users and non-users (i.e., the community at large).

Background and Context

The effort to evaluate and prioritize non-motorized transportation projects is not a new endeavor. During the 1990s a number of attempts were made to develop methods to define levels of service and needs within the non-motorized transportation arena. Once needs were defined, it was thought that a more objective approach to evaluating relative benefits of different investments could be made and provide a more equal standing relative to roadway and transit investment processes. Non-motorized planners adopted two key concepts used in the roadway transportation planning process:

1) Demand forecasting, which identifies how much 'latent demand' there is for a proposed facility, or shows where demand is greatest.
2) 'Level of Service' (LOS) designations, which set performance goals and pinpoint system deficiencies.

In the process of adapting these concepts, they were altered substantially from their origins in highway planning. Without the benefit of 50 years of vehicle counts and modeling, non-motorized demand evaluation is at a much earlier stage of development and must rely on other data sources, often surrounding population or 'travel sheds'. In addition, bicycle or pedestrian

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Levels of Service standards typically encompass broader and more qualitative goals than roadway LOS goals, which are congestion-focused. Many factors that increase the attractiveness of walking or biking, such as the presence of other pedestrians, contradict traditional volume to capacity metrics.

While these more sophisticated practices have had some success in bringing pedestrian and bicycle investment practices up to par with vehicular planning, the methods are generally limited and their application is not widespread. This is primarily because most non-motorized project prioritization and programming processes focus on addressing unsafe conditions, and are limited in calculating the many other benefits that a non-motorized project can have. As Litman (2006) notes, understanding the potential benefits that stem from a particular transportation investment is critical to the process of assessing its priority. Planners are beginning to recognize the need to systematically and consistently evaluate non-motorized projects across a range of goal-based, outcome-driven criteria and to view them more holistically (Walkable Communities 2006).

There is considerable opportunity to enhance the methods used by King County and by other cities in the region. Non-motorized project evaluation can encompass a wider array of benefits to physical activity, air quality, safety and accessibility. To the extent possible, advancements are required that are grounded in objective research. LUTAQH research (Frank et al. 2006) on the links between land use, travel behavior, air quality and physical activity/BMI, provided a means by which we can better understand the relative benefits from non-motorized investments. In addition, other research also offers information to aid in understanding non-motorized travel patterns to specific destinations (Moudon and Lee, 2006) and overall benefits for public health (Frank et al., in press).

Finally, we understand that transportation investments are inevitably a political endeavor and council decisions over competing resources are often made for political reasons other than objective and technical evidence. Our position is that the stronger the evidence over the need and the benefits of a particular investment, and the more able planners are to conceive, articulate, and promote investments that address an array of established concerns, the greater the chance that funding will be awarded.

Types of Improvements

The programming tool will be used on non-motorized projects only. It will not address or be relevant to land use, road or transit investment decisions. The types of non-motorized improvements that the TPT could be used to evaluate could include:

- Existing sidewalk widening
- New sidewalk addition
- Road diets or redesigns
- Trails or pathways
- Stairs or ramps
- Elimination of barriers or hazards, such as highways or bridges
- Traffic calming devices, such as traffic circles or speed humps
- Creation of pedestrian walkways through superblocks, cul de sacs, etc.
- Intersection improvements or reconfigurations
- Curb Cuts
- Signalization changes or additions
- Pedestrian-activated signals
- Streetscape Improvements - street furniture, lighting, street trees
- Bicycle lane improvements or additions

II. Developing Criteria Through Current Evidence

Although the research-based criteria take up the bulk of discussion in this section, a number of other considerations are typically used to rank projects. These benefits are not research-based, but based in "on the ground" realities that are no less important, and in most cases, are the core of the process. While the TPT is tasked to examine projects based on research outcomes, it is important to consider how the larger programming processes look at the following:

A) Opportunity
   a. Builds upon already programmed road or transit projects
   b. Available Right-Of-Way

B) Location
   a. Located in one of the "Regional Pedestrian Improvement Zones"
   b. Located in an Urban Center

C) Time to implement

D) Time to achieve results

E) Community support (compatibility with neighborhood, political standing, etc.)

F) Estimated costs or cost-benefit ratio

G) Multimodal Programming Processes
   Although some pots of money compare only nonmotorized projects to one another, some compare nonmotorized projects with road or transit projects.

In addition to these criteria, when prioritizing proposed improvements, projects can be compared based on how well they reduce risk and increase benefits. These are the *criteria* by which projects are compared. There are several categories of direct and indirect benefits to any nonmotorized transportation project, some of which are listed below. These lists of benefits are all documented quantitatively in the research.

The mechanisms by which these benefits may be achieved are then enumerated after the benefits are discussed. The mechanisms are the specific characteristics of nonmotorized projects and the surrounding environment that the tool could measure, which would then translate into benefits.

1. Direct Benefits

Nonmotorized improvements create other indirect benefits because they can potentially offset vehicular travel demand and increase safety, or the perception thereof.

A) Transportation. Non-motorized projects have the potential to increase transit and non-motorized mode share and decrease vehicle mode share; and decrease per capita rates of vehicle use (hours/miles/trips/mode share), and increase per capita rates of walking, bicycling, and transit (hours/miles/trips/mode share) (Ewing & Cervero, 2001).

Background: Many studies have shown how aspects of the built environment, individually and in combination, affect travel behavior and associated outcomes (Cervero & Kockelman, 1997; Ewing & Cervero, 2001; Frank et al. 2000; Handy, 1996; Holtzclaw et al., 2002). Others have shown how complex the interrelated factors are (Boarnet & Crane, 2001; Hess et al. 1999; Saelens et al., 2003). The variables developed through

Central Puget Sound research over the past decade, including the LUTAQH phase I research, have proven to be robust as indicators of travel and quality of life outcomes.

B) Safety. Non-motorized projects can slow vehicle traffic (traffic calming), provide vehicle-free pathways, reduce vehicle conflicts with pedestrians (intersection redesign) and increase the number of users, all of which have been shown to reduce risk and/or the perception thereof.

Background: Safety is a more developed area of nonmotorized project evaluation than connectivity. Various measurable elements of infrastructure and traffic patterns have been associated with safety risk, including vehicle speeds and traffic volumes (Stevenson et al. 1995; Daisa & Peers, 1992), number of lanes and separation from traffic (Landis, 2000), and crossing distance. For example, Washington State Department of Transportation provides criteria to local agencies to help guide safety project priorities (see box at right).

2. Indirect Benefits

A number of indirect benefits stem from the direct benefits to travel demand and safety. Each of the benefits listed below has been documented in research as associated with changes in travel behavior and safety.

A). Environmental Benefits

Non-motorized projects shift travel from polluting modes (vehicular) to those that have less or no health-damaging air pollutant emissions (NOx, CO2, VOCs, and hydrocarbons) and dramatically lower carbon dioxide and greenhouse gas releases. Moreover, the vehicle trips replaced are largely short trips, which are more frequently higher-polluting 'cold starts' (WSDOT, 2005 and LUTAQH, 2005).

B) Economic Benefits

Our economy benefits from more efficient, productive use of energy. Non-motorized travel is highly energy efficient, and increases as walkability increases (Frank et al. 2006). The increased physical activity is efficiently accomplished as part of daily routine trips to both work and non-work destinations. Moreover, the reduction in health care costs, as a result of facility improvements inducing physical activity, can be quantified (TRB, 2006).

C) Equity Benefits

Depending on where a project is located (close to a school, for example) it can improve access for sensitive populations or those who are less reliant on vehicle travel (for example, low income, youth and elderly).

WSDOT safety criteria:

- Pedestrian exposure to vehicles
- Current ADT
- Posted Travel Speed
- Prior vehicle-pedestrian crashes at location within past three years
- Width of Roadway
- Horizontal and/or Vertical Stopping Sight Distance

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D) Health Benefits
As noted above, non-motorized transportation projects generate more walking and bicycling travel. Such physical activity, whether for the purpose recreation or transportation, is associated with higher rates of physical activity, and lower rates of obesity and other chronic diseases (LUTAQH, 2005; McGinnis, 2002).

3. Mechanisms

Nonmotorized projects create benefits because of changes to the following aspects of the urban environment. These are the mechanisms, or the measures that could be used to define the relative benefits (criteria).

A) Increased Route Directness (Connectivity).
Nonmotorized projects can create more direct routes between destinations for cyclists and pedestrians.

Background: Dill (2005) provides a summary of all the measures used for connectivity measurement in bicycle and pedestrian planning, finding among these that some are quite commonly used:

- block size,
- intersection density, and
- link-to-node ratio.

Ultimately connectivity measures the degree of route directness between destinations. Geographic Information Systems in place at most local governments in King County have the capacity to evaluate the relative route directness that results from different types of transportation investments. Directly measuring the change in route directness between two destinations that results from a given investment (e.g. the ratio between proposed distances between two destinations) offers a more robust indication of the effects of connectivity on travel. Route directness is a simple concept and can be measured on the network by travel mode for origin-destination pairs (the basis for trip generation modeling). This kind of measurement involves more intensive data collection and processing than grid based analyses of connectivity (e.g. intersection density). However, a specific project will not likely impact intersection density very much in an overall area but will have a significant impact in terms of its ability to connect specific destinations. Measurement of the effective travel distance between two destinations may be a more powerful outcome than minor changes to the overall network unless major sets of improvements are proposed for a given area.

Identification of best measures of connectivity for non-motorized transportation is ongoing. Bruce Landis, a well noted non-motorized transportation planner, notes that connectivity is a less-reliable measure if it is simply used to identify where an improvement adds to an existing facility.[1] Therefore, improvements to connectivity are most effective where a case can be made that there is significant latent demand for movement on foot or bike between two locations. This requires combining land use/urban form data (e.g. concentrations of people, jobs, services across space) with

[1] Sprinkle Consulting. LUTAQH communication.

relative distances between complementary uses resulting from distinct investments. Improvements that provide only non-motorized access between currently disconnected destinations (e.g. a cul-de-sac and a nearby commercial node) offer considerable potential to increase the relative utility or benefit of walking or biking compared to driving. Simply put, driving around the block and parking may take up to 15 minutes while walking may only take 10 minutes where direct connections are provided.

LUTAQH found that changes in degree of walkability (measured through an index of land use and connectivity measures) are associated with lower vehicles miles of travel (VMT) and higher levels of active transportation (walking and bicycling). LUTAQH used intersection density to measure connectivity and found that a quartile increase in number of intersections per acre corresponded to a 14% increase in likelihood of walking.

Increased connectivity may also be measured by a decrease in the travel time it takes to access a destination by foot or bicycle. In the case of street crossing improvements or changes in signalization, although distance may not change, the time it takes to make a trip may decrease substantially. Decreases in travel time have been shown to be one of the most highly associated variables with mode choice, and can induce shifts from driving to walking, bicycling, and transit (WSDOT 2005).

B) Connections to Transit

Although it is related to connectivity, access to transit is important to measure outside of the other connectivity measures. Transportation benefits are not exclusive to bicycling and walking - transit ridership is dependent on good access by nonmotorized modes. In the LUTAQH study, a measure of transit inaccessibility (distance from home to nearest bus stop) was found to be positively related to VMT, and each ¼ mile increase in distance to transit reduced the odds of someone reporting a transit trip to work by 16%. Another Puget Sound region study for WSDOT (2005) found each mile to a bus stop was associated with a 5% increase in VMT, and just over 4% increase in VHT.

C) Reduced Conflicts With Vehicular Modes

The various non-motorized level of service tools use measures like vehicle speeds, traffic volumes, number of lanes or roadway width, and separation from traffic, and crossing distance to score the safety/comfort conditions, many of which are statistically associated either with lower rates of collision or perception of reduced risk.

D) Size and Characteristics of Impacted Population

The size of the surrounding population – the 'travelshed' of the improvement - acts as a multiplier to the other benefits. Certain locations, such as those that have a high density or many destinations, may be more 'ripe' for nonmotorized transportation improvements. This is, essentially, the concept of latent demand for nonmotorized improvements. Demographics of the impacted population may also change the equity benefits.

IV. Conclusion

There are several key points that emerge from LUTAQH's research to date for the development of the Transportation Programming Tool:

- *Achievement of the region's land use and transportation vision can be helped by objectively measuring goal-based criteria transportation programming at the local level.*
- *Non-motorized transportation programming needs to consider a broader set of benefits than safety and local environment improvements. Neighborhood characteristics are significant to the likelihood of walking.*
- *The criteria for measuring multiple benefits that are suggested by the literature and best practices appear to align well with the national funding objectives, desired regional and local outcomes, and current practices. The groundwork is in place for an enhanced method of prioritization.*
- *There are opportunities emerging in King County, as local governments revise and update their bicycle and pedestrian plans, conduct inventories of bike/ped facilities, and seek new ways of creating enhanced active transportation.*

Tool Development - Next Steps

The development of a non-motorized transportation programming tool that is at once responsive to local needs and the opportunities to benefit the health and quality of life for King County residents and to the regional transportation planning process is an iterative one. We are eager to gather the best knowledge from local practitioners, other experts, and models from other regions. Please join this effort and assist us in creating the optimal tool for use by King County's communities. Among the remaining questions we would like you to consider and respond to are:

- Can we achieve the objectives for this tool (i.e. do you think the tool would be helpful to you in your local bike/ped planning)?
- Which of the research-based criteria will you be able to make use of in your local planning process?

LUTAQH will gather more information on how to fit the research-based prioritization criteria to the process for planning non-motorized projects in the region, through surveying local practitioners and hosting a workshop, Dec. 5, 2006. Tool development will proceed through the following stages:

1. **Survey:** The nonmotorized programming survey will help to define how the TPT interacts with existing tools, processes and criteria (in process).
2. **Workshop:** The workshop will provide further input on what the criteria priorities should be, the intersection between the TPT criteria and those existing processes.
3. **Criteria Development:** Research from the first phase of LUTAQH and other sources will form the basis of much of the criteria (final list of criteria in early 2007).
4. **Tool Development:** Based on the first three steps, the consultant team will develop a preliminary version of the TPT (spring 2007).
5. **Testing:** The preliminary version of the TPT will be subjected to testing and refinement based on feedback from a small, expert "focus group" (spring 2007).
6. **Project List Development:** An actual list of proposed nonmotorized projects will be scored and ranked using the TPT (summer and fall 2007).
7. **Training:** Training in use of the TPT will be held for King County staff and staff from other interested local jurisdictions (early 2008).

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Appendix A. Example Programming Processes
Local and Regional Examples

A. Regional programming framework

The King County region is part of a four-county metropolitan planning region. The regional planning agency, the Puget Sound Regional Council, has established a bold vision for improvements to bicycling and walking.[2] PSRC administers and allocates federal programs that provide the largest share of needed funding on non-motorized transport projects in the region. Their guidance to local governments for prioritization is driven in part by those federal funding authorizations, ISTEA, TEA-21 and now the Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU, the reauthorization of those earlier transportation funding acts). SAFETEA-LU sets eight main planning factors that guide PSRC's allocations. The regional planning agency then provides additional guidance derived from the adopted regional transportation policy in *Destination 2030*: focus improvement work in "support for centers and connecting corridors." PSRC also delineates a "Countywide Forum" process which puts the responsibility for development of project lists to the local governments within the region.

SAFETEA-LU Goals:
1. Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency.
2. Increase the safety of the transportation system for motorized and non-motorized users.
3. Increase the security of the transportation system for motorized and nonmotorized users
4. Increase the accessibility and mobility options available to people and for freight.
5. Protect and enhance the environment, promote energy conservation, and improve quality of life, and promote consistency between transportation improvements and State and local planned growth and economic development patterns.
6. Enhance the integration and connectivity of the transportation system, across and between modes, for people and for freight.
7. Promote efficient system management and operation.
8. Emphasize the preservation of the existing transportation

B. Examples from Local Practice

Kirkland

The City of Kirkland has utilized the following categories of criteria, in a scoring sheet format, to prioritize their transportation projects, including non-motorized:

- Fiscal
- Plan consistency
- Neighborhood integrity
- Connections
- Multimodal (non-SOV)
- Safety

The means of measuring these criteria are a series of questions with points associated with multiple-choice responses to be selected by the planner based on their judgment, as shown in the example below:

[2] PSRC. 2003. Regional bicycle and pedestrian implementation strategy for the Central Puget Sound region.

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Excerpt from City of Kirkland's CIP Appendix: Ad Hoc Committee

_____ (10) 4. Does the proposed project maintain or enhance the safety of the following modes?

	Positive impact enhances (2.5)	No impact neutral (1)	Negative Impact inhibits/reduces (0)	Total
Bicycle	_____	_____	_____	_____
Pedestrian	_____	_____	_____	_____
Vehicular	_____	_____	_____	_____
Transit/HOV	_____	_____	_____	_____

Data gathered by the transportation and other departments on traffic volumes, speeds and collisions/incidents probably assists the planner in scoring projects through this system. The data may have been used to calibrate or otherwise inform the weighting for various point levels.

Bellevue

Recognized by the HSRC for its model Bicycle and Pedestrian plan, City of Bellevue like many of its neighbors and King County has a wealth of GIS data and infrastructure that is being steadily improved to provide greater bicyclist and pedestrian supportiveness. Even with this success, there is recognition that improvement is possible in the area of prioritization using objective measures.[3] The City is in the process of revising its bicycle and pedestrian plan over the next year. Among the outcomes Bellevue seeks to accomplish in its management of transportation are:

- Desired Land Use
- Reduced Use of the Single-occupant Vehicle
- Viable Travel Options
- Adequate and Fair Financing
- Protection of the Environment and Quality of Life
- Effective Interjurisdictional Coordination

National Examples

There are a number of model non-motorized planning efforts around the United States to look to as examples. A selection of them is presented here and others may be viewed at the HSRC Pedestrian and Bicycle Information Center website (www.pedbikeinfo.org).

Houston[4]

The Houston-Galveston Area Council[5] has a three-pronged approach to improvements involves "building it right the first time," "retrofitting selectively," and "investing strategically." The planning agency prioritizes at a regional scale by breaking a massive multi-county metro area into walking and bicycling districts, evaluating them using a composite indicator, and then conducting special district planning with the affected communities that evaluates improvements specific to these more localized areas. The indicator combines measures of demographics, destination quality, land use, and travel conditions (including mode to work, safety and transit access). See their discussion of "Invest Strategically" at the link noted below.

Portland[6]

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[3] Franz Loewenherz, LUTAQH communication. Respondent indicated that there is interest in developing criteria with objective measures consistent with other jurisdictions in the region.

[4] Jeff Taebel, Houston-Galveston regional government. LUTAQH Communication (October 2006)

[5] See http://www.h-gac.com/HGAC/Programs/Community+Resources/Bicycles+and+Pedestrians_2.htm

[6] See FHWA 1999. http://www.tfhrc.gov/safety/pedbike/vol2/sec2.14.htm, and Portland http://www.portlandonline.com/shared/cfm/image.cfm?id=90244

City of Portland has utilized Pedestrian Potential Index combined with a Pedestrian Deficiency Index, which are both derived from the Pedestrian Environment Factor, to identify and prioritize projects addressing walking conditions. Thus in addition to accounting for street crossing, sidewalk continuity and street connectivity of their PEF index on the deficiency side using various proxies measurements, this process makes use of the power of GIS to conduct measurements of potential based on built environment factors (mixed use/density, proximity, street connectivity and continuity, average parcel size, and topography).

Other Related Efforts

The primary review of demand estimation for non-motorized projects through the late 1990s is the Federal Highway Administration's Guidebook, which identified and reviewed a wide array of techniques and programs.[7]

The TRB study on non-motorized planning evaluation discusses a new evidence-based and easy-to-use web tool for cost/benefit analysis that they have approved for public use via the Pedestrian Bicycle Information Center. They highly recommend consistently quantifying benefits (across mobility, safety, health and transportation dimensions).

Moudon and Lee (2003) review a full range of audit instruments related to the environment for non-motorized travel modes, cataloguing the various level of service and bicycle or pedestrian quality of experience measurement systems. They used this assessment to develop a scoring tool that builds on these route/corridor instruments and the improving understanding of the importance of the built environment, called Walkable-Bikeable Communities (WBC) Analyst.[8] This tool has the advantage of considering site-specific location and area urban-form measurements in the same framework, but the sophistication is made possible through data intensiveness.

Among the LOS tools, the best known are the pedestrian and bicycle LOS measures developed by Bruce Landis in Florida (Landis et al. 2000, 2003) and the Bicycle Compatibility Index (BCI) developed at the Highway Safety Research Council (HSRC). These measures mainly take into account conditions in the area immediately adjacent to the street segment being considered for a project:

- width of outside lane, shoulder or bike lane (feet)
- on-street parking presence and buffer width
- width of sidewalk,
- total number of (through) lanes for road or street
- Average running speed and volumes of motor vehicle traffic

This detailed information provides excellent guidance for the type of project needed and design issues, but as acknowledged by Landis et al (2000), it requires complementary tools to address the "capacity" and qualitative performance of the facilities.

The current process used by Sprinkle Consulting with many local and regional governments involves use of multiple factors including the bicycle/pedestrian LOS to estimate safety and comfort, a latent demand measure, recreational value, community support and (less reliably) connectivity.[9] Cost to implement is then used as a denominator to provide a benefit to cost ratio.

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[7] FHWA 1999. Guidebook on methods to estimate non-motorized travel: overview of methods. Accessed at http://www.tfhrc.gov/safety/pedbike/vol1/contents.htm. Also, HSRC's Pedestrian and Bicycle Information Center has a webpage about implementation of plans including their top objectives. Accessed at: http://www.walkinginfo.org/de/curb1.cfm?codename=1imp&CM_maingroup=Implementation

[8] Hurvitz. 2006. Walkable-Bikeable Communities Analyst Extension for ArcView GIS 3.x.

[9] Sprinkle Consulting (Bruce Landis). LUTAQH communication (15 November 2006).

Appendix B. References and Resources

Boarnet, M.. and Crane, R. 2001. Travel by design: the influence of urban form on travel. Oxford, UK: Oxford University Press.

Daisa, J. and Peers, J. 1997. "Narrow Residential Streets: Do They Really Slow Down Speeds." Fehr & Peer.

Dill, Jennifer, 2005. Measuring network connectivity for bicycling and walking. Summary of research accessed at http://web.pdx.edu/~jdill/research.htm#Connectivity. (4 April 2005).

Cervero, R. & Kockelman, K. 1997. Travel demand and the 3 Ds: Density, diversity and design. Transportation Research Part D. 2, 3: 199-219.

Ewing, R. & Cervero, R. 2001. Travel and the built environment: A synthesis. Transportation Research Record, 1780, 87-114.

Federal Highway Administration – USDOT (FHWA). 1999. Guidebook on methods to estimate non-motorized travel: overview of methods. Accessed at http://www.tfhrc.gov/safety/pedbike/vol1/contents.htm.

Frank, L.D., Sallis, J.F., Conway, T.L., Chapman, J.E., Saelens, B.E. and Bachman, W. 2006. Many pathways from land use to health. *Journal of the American Planning Association*. 71:1, 75-87.

Frank, L.D., Stone B. and Bachman, W. 2000. Linking land use with household vehicle emissions in the central Puget Sound: Methodological framework and findings. Transportation Research Part D. 5, 3: 173-196.

Handy, Susan L. 1996. Understanding the link between urban form and nonwork travel behavior. Journal of Planning Education and Research, 15, 3: 183-198.

Harkey, D., Donald, R., Knuiman, M., Stewart, J., Sorton, A. 1998. Development of the Bicycle Compatibility Index: A level of service concept, Final Report, FHWA, Department of Transportation.

Hess, P., Moudon, A.V., Snyder, M.C., and Stanilov, K. 1999. Site design and pedestrian travel. *Transportation Research Record, 1674*, 9-19.

Holtzclaw, J., Clear, R., Dittmar, H., Goldstein, D., and Haas, P. 2002. Location efficiency: Neighborhood and socio-economic characteristics determine auto ownership and use; Studies in Chicago, Los Angeles, and San Francisco. Transportation Planning and Technology, 25, 1: 1-27.

Hurvitz, Phillip M. 2006. Bikeable Communities Analyst Extension for ArcView GIS 3.x. Accessed at: http://gis.esri.com/library/userconf/proc05/papers/pap1040.pdf (14 November 2006).

Landis, B. W., Vattikuti, V. R., Ottenberg, R. M., and T. A. Petritsch. 2003. Intersection Level of Service for the bicycle through movement. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1828*, TRB, National Research Council, Washington, D.C., p. 101–106.

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funding provided by King County through a Federal Transit Administration grant.

Landis, B., Vattikuti, V.R., Ottenberg, R.M., McLeod, D.S., and M. Guttenplan. 2000. Modeling the roadside walking environment: a pedestrian level of service. TRB Paper No. 01-0511. Accessed at: http://www.perspectives.cutr.usf.edu/articles/Pedestrianism/0016.pdf (6 November 2006)

Litman, Todd. 2006. "Evaluating nonmotorized transport." In the On-line TDM Encyclopedia. Accessed at: http://www.vtpi.org/tdm/tdm63.htm#_Toc121444872 (13 November 2006).

LUTAQH. 2005. Achieving sustainability through healthy community design. Executive summary of the Land Use, Transportation, Air Quality and Health Study by LFC.

McGinnis. J. Michael. 2002. Diabetes and physical activity translating evidence into action *American Journal of Preventive Medicine*, 22, 4S: 1-2.

Moudon, Anne and Chanam Lee. 2003. Walking and Bicycling: An Evaluation of Environmental Audit Instruments. American Journal of Health Promotion. 18, 1: 21-37.

Puget Sound Regional Council (PSRC). 2003. Regional bicycle and pedestrian implementation strategy for the Central Puget Sound region.

Stevenson, M.R., Jamrozik, K.D. and J.A. Spittle. 1995. A case-control study of traffic risk factors and child pedestrian injury. *International Journal of Epedemiology*. 24: 957-964.

Swift, Peter. 2005. Residential street typology and injury accident frequency. Accessed at: http://www.sierraclub.org/sprawl/articles/narrow.asp (15 November 2006).

Transportation Research Board (TRB). 2006. Guidelines for analysis of investments in bicycle facilities. NCHRP Report 552. Krizek, K. J., Barnes, G. , Poindexter, G. , Mogush, P., Thompson, K., Levinson, D., Tilahun, N., Loutzenheiser, D., Kidston, D., Hunter, W., Tharpe, D., Gillenwater, D., and R. Killingsworth, authors.

Washington State Department of Transportation (WSDOT). 2005. Travel behavior, emissions, & land use: correlation analysis in the central Puget Sound. WA-RD 625.1 Final Research Report by LFC (Frank, Chapman, Bradley and Lawton).

Washington State Department of Transportation (WSDOT). 2001. Pedestrian risk project identification form. LUTAQH communication with Paula Reeves.

LUTAQH Survey respondents and Communications with Experts in Non-motorized Planning Field:
Bellevue (Franz Loewenherz)
Issaquah (Mary Joe deBeck and others)
Kirkland (David Godfrey)
King County Dept. of Transportation (Jennifer Lindwall, John Shively and others)
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