Guidelines for Analyzing the Benefits and Costs of Bicycle Facilities

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ABSTRACT:
Transportation planning and policy efforts at all levels of government aim to increase levels of walking and bicycling. This has led to a need to develop a way of measuring the costs, demand, and benefits of walking and bicycling. In response to this demand, researchers at the University of Minnesota, Planners' Collaborative, and the University of North Carolina National Highway Safety Research Center developed a set of guidelines, *Guidelines for Analysis of Investments in Bicycle Facilities*, to evaluate bicycle facilities.

The purpose of this paper is to describe an on-line planning tool that can be used to estimate the costs and benefits of bicycle facilities. The tool is based on the guidelines and is intended to provide planners, policy officials, and decision makers with a consistent framework to guide decisions about cycling facilities. The guidelines are based on several research projects. This manuscript is broken into four parts. The first part discusses the overall framework of the guidelines, to whom they are oriented, and matters related to their overall design and application. Part two walks the user through some aspects of each of the three components of the guidelines. Part three describes some of the results of field-testing of the guidelines and future applications. The final part discusses the limitations of the guidelines and the future steps need to improve the guidelines.

GUIDELINES FOR ANALYING THE BENEFITS AND COSTS OF BICYCLE FACILITES

Planning and policy efforts at all levels of transportation planning aim to increase levels of walking and bicycling. In many cases, initiatives are motivated by a desire to reduce auto use and its attendant environmental consequences (e.g., pollution, natural resource consumption). Alternatively, they are motivated by concerns of livability, public health, or physical activity. In response, urban planners, transportation specialists, elected officials, and health advocates are all looking to non-motorized travel to address myriad concerns, whether they relate to congestion, the environment, health, or quality of life.

An initial step in doing so is to ensure that adequate facilities exist to encourage use of alternative modes. For walking, this includes sidewalks, public spaces, and/or street crossings. Similarly, for bicycling, this includes relatively wide curb lanes, on-street or off-street bike paths, and even secure parking or showers at the workplace. However, bicycle facilities cost money, their merits are often called into question, and many consider spending on them a luxury. Planners and other transportation specialists often find themselves justifying such spending with the claim that these facilities benefit the common good and that they induce increased use. Especially in austere economic times, they are often grasping for ways to "economize" such facilities.

Estimating the economic aspects of cycling remains a topic often discussed in policy circles but has yet to be directly tackled. Urban planners, policy officials, and decision-makers lack a consistent framework from which to understand the merits of such facilities. These officials are often bombarded with information and arguments about how much these facilities cost. Opponents of bicycle projects consistently use such information to argue how trimming particular projects would preserve funds.

Cost data for cycling facilities is readily obtainable. The task of uncovering costs related to acquisition, development, maintenance and other dimensions of bicycle trails is a relatively straightforward exercise. Once the costs of various parts of the facility have been determined, they can be evaluated in a similar manner to other transportation facilities. Estimating the demand induced by constructing bicycle facilities and subsequently the benefits that might ensue from constructing such facilities, however, are considerably more difficult endeavors.

The purpose of this paper is to describe a planning tool that can be used to estimate the costs and benefits of bicycle facilities. The aim of this endeavor is to introduce the reader to the *Guidelines for Analysis of Investments in Bicycle Facilities* ("the guidelines"), provide an overview of their capabilities, and describe preliminary field-testing applications. The web-based tool that is described provides planners, policy officials, and decision makers with a consistent framework to guide decisions about cycling facilities. The research underlying the guidelines and tool itself were developed at the University of Minnesota (Humphrey Institute of Public Affairs and Civil Engineering), Planners' Collaborative consulting firm, and the University of North Carolina-Chapel Hill, National Highway Safety Research Center. The paper does not review details from the underlying research. The reader is encouraged to consult other manuscripts provided as part of this stream of research, including an overview of available literature on the subject[1], methodologies for estimating the demand for bicycle facilities [2-5], and user preferences for different types of bicycle facilities [5, 6]. Together, these manuscripts provide the underlying knowledge relied upon in the process of crafting the guidelines. The reader is strongly encouraged to consult these resources for more elaborate justifications or descriptions for each application.

Four parts comprise the body of this manuscript. The first part discusses the overall framework of the guidelines, to whom they are oriented, and matters related to their overall design and application. Part two walks the user through some aspects of each of the three components of the guidelines. Part three describes some of the results of field-testing of the guidelines and future applications. The final part discusses the limitations of the guidelines and the future steps that need to be taken in order to improve them.

OVERALL FRAMEWORK AND DESCRIPTION OF THE GUIDELINES

The guidelines are designed to provide planners and project managers with an easy-to-use online tool to supply them with a consistent framework to estimate the cost, demand, and benefits associated with a given bicycle facility. They are intended to produce the most reliable results assuming the user has a particular facility in mind—existing or proposed. The basic framework of the guidelines is presented in FIGURE 1 below. As shown, the framework is oriented around the user wanting to know of one or more of three aspects of a particular facility: costs, induced demand, and economic benefits. Regardless of the output information is desired, the user is prompted to enter general characteristics of the region or the given facility (e.g., type of facility, when and where it will be built). The user is then directed down one of two paths. The first asks either for additional information about specifics related to the cost and construction of the facility. The outputs from this worksheet include the capital cost of the facility and annualized maintenance costs. The second path orients the user toward better understanding the likely induced demand for the facility and additional information needed to calculate the economic benefits. Outputs are twofold, including ranges of estimates for new cyclists induced by the facility and monetary estimates of the range of benefits associated with the facility.

The guidelines are currently housed on the web site of the University of North Carolina Highway Safety Research Center (FIGURE 2), http://www.bicyclinginfo.org/bikecost/. The initial and opening page provides the user with useful information that is available through various links. For example, there is a link to what we refer to as the Bicyclopedia—a glossary of terms used throughout the guidelines and in the process of planning for and constructing bicycle facilities. There is a primer describing various design considerations when planning or constructing a bicycle facility. Also included is a guide to using the tool and a complete description of the approaches and research methodologies used in researching and developing the guidelines (available as copy of the full report, *Guidelines for Analysis of Investments in Bicycle Facilities).*

Throughout the guidelines, several accompaniments provide the user with more information in the form of “i” buttons (i). The “i” buttons help explain various definition and input information to enable the user to better understand the information that is being requested (FIGURE 3). The explanations associated with the “i” buttons and the glossary appear in a separate popup windows so that data entered by the user is retained. Depending on the user’s interests, the guidelines can produce different outputs. If the planner or project manager requested information about costs, they will receive information about the capital cost and annual maintenance costs. If they requested information about the demand, an output will be provided describing the number of cyclists and the number of new cyclists. If the user requested information about the benefits, they shall receive dollar amounts for the expected mobility, health, and recreation benefits (sample output shown in FIGURE 4). The guidelines were prepared for various levels of user input. Assuming limited or cursory information is entered, the user can navigate to an output in roughly 10 minutes. However, the guidelines are also flexible to account for relatively detailed input material querying, for example, relatively sophisticated GIS information. In these cases, it is not unreasonable to assume a sample run would take on the order of an hour.

OVERVIEW OF INDIVIDUAL COMPONENTS

Cost

The first part of the application develops the cost estimates, the basis of which are actual cost values for different elements of a bicycle facility. Relying on researched costs from around the U.S., one or more cost values were obtained for each element. In the end, the value considered to be most reliable, representative, or up to date was relied upon.

The cost worksheet (FIGURE 5) of the guidelines solicits the users for information about the particular facility being considered. Such parameters include factors related to the length, width, materials used, security, lighting, and landscaping. The guidelines provide a baseline for prices and labor costs. However, if the planner or project manager has more accurate or applicable data for a given area or facility, they can override the default values (e.g., if they have a quote for how much it will cost to lay the concrete for a facility).

Inflation

The Producer Price Index for highway and street construction was used to adjust construction costs to the base year. The Consumer Price Index for housing was used for real estate costs. Both indexes are compiled by the U.S. Bureau of Labor Statistics. Data for the years 1987-2003 were collected for both indexes.

All construction values were normalized to a base year of 2002. Inflation factors were developed to convert unit costs from 2002 levels to the build year. Growth rates for both the construction and real estate costs were projected from the 1987-2003 data by the MS Excel Growth function. The Growth function predicts the exponential growth by using the existing data. The projected growth rates were then used to predict construction and real estate costs up to the year 2012 based on the mid-point of construction entered by the user.

Geographical

Cost values for each element were gathered from a number of sources around the country. In order to normalize each cost element to a national level, a construction cost index by state or region was developed. The base index is the Construction Cost Index as published in the Engineering News Record (ENR) [7], June 30, 2003. This ENR index was chosen as it identifies regional construction costs relative to the national base of 1.00. The index identifies 36 major construction markets throughout the country.

Not all major cities are listed in the ENR index, nor are all states represented. To fill in the geographical gaps in the index, the 36 construction markets were mapped and then abutting states and regions with similar characteristics were assigned similar values. Additionally, in states with significant variance in the construction costs for urban centers due to high labor and/or material cost (specifically, New York City, Boston, Philadelphia, and the Bay Area in California), we developed separate indices for those urban areas and the remainder of the states.

The geographic index was applied to selected unit costs to normalize base values geographically. When the model user enters a project location (city and state) into the cost model, the model applies the geographic index to the construction cost to reflect cost for that state or urban area.

No data was available for either Alaska or Hawaii. The user may use the default national values, though it is suspected that construction costs in both states may be higher than average due to their remote locations. The user is encouraged to enter construction factors if known.

Demand

At the *Demand/Benefits Inputs* stage (FIGURE 6), the planner or project manager is queried about the bicycle commute share and residential density within 400 meters, 400-799 meters, and 800-1,600 meters of the facility. Since these figures can sometimes be hard to gather, the guidelines use the average for the Metropolitan Statistical Area as the default value. However, the planner or project manager can adjust them if better data is available. Lastly, the planner or project manager is asked to provide the median household size and median property value in the area surrounding the facility.

Our approach to estimating the use of a new facility rests on two main assumptions. First, all existing bicyclists near a new facility will shift from some other facility to the new one. Second, the new facility will induce new bicyclists as a function of the number of existing bicyclists. Research for this project uncovered that urban residents are more likely to ride a bicycle if they live within 1600 meters (1 mile) of a facility than if they live outside this distance [2]. The likelihood of bicycling increases even more at 800 and 400 meters. We therefore estimate existing and induced demand using 400, 800, and 1,600 meter buffers around a facility.

We base our estimates of existing bicycling demand on U.S. Census journey to work mode shares [8]. We establish the number of residents within 400, 800, and 1,600 meter buffers of the facility by multiplying the area of each buffer by a user-supplied population density. To identify the number of existing daily bicycle commuters who will shift to the new facility, we multiply the number of residents in each buffer (R) by 0.4, assuming that 80 percent of residents are adults and 50 percent of adults are commuters. We then multiply this number of commuters in each buffer by the region's bicycle commute share (C).

$$\text{Daily existing bicycle commuters} = R \cdot C \cdot 0.4$$

Adult commuters represent only a portion of adult bicyclists. We compared U.S. Census[8] commute shares to National Household Transportation Survey (NHTS)[9] data and found that the total adult bicycling rate ranges from the Census commute rate at the low end, to 0.6 percent plus three times the commute rate at the high end [2]. This allows us to use readily available Census commute shares to extrapolate total adult bicycling rates (*T*).

$$Thigh = 0.6+3C$$
$$Tmoderate = 0.4+1.2C$$
$$Tlow = C$$

We multiply the estimated low, moderate, and high rates by the number of adults in each buffer to arrive at the total number of daily adult cyclists. We multiply the number of residents in each buffer by 0.8 to account for the approximate 20%[10, 8] of the population that are children. Our calculations due not include children because their cycling behavior is less likely to be influenced by the presence of a facility. In addition, the benefits of cycling on children are different from the influence of cycling on adults.

$$\text{Total daily existing adult cyclists} = R \cdot T \cdot 0.8$$

Multiplying each of the existing cycling groups (commuters and total adults) by the likelihood multipliers found in our research (*L*) (minus one) for each buffer provides an estimated number of induced cyclists in each group.

$$\text{New commuters} = \sum_{d = 400, 800, 1,600} (\text{Existing commuters} * (L_d-1)$$
$$\text{New adult cyclists} = \sum_{d = 400, 800, 1,600} (\text{Existing adult cyclists} * (L_d-1)$$

Where

$$L400m = 2.04$$
$$L800m = 1.54$$
$$L1200m = 1.21$$

Economic Benefits

Past research indicates that different audiences demand widely varying information about the effects of bicycle facilities. Attempting to satisfy all often ends up satisfying few. The central challenge for urban planners, policy officials, and researchers is to focus on the benefits of bicycle facilities that pointedly satisfy certain criteria. After reviewing existing literature, canvassing available data and methods, and consulting a variety of policy officials, we suggest that to be most useful, bicycling benefits need to satisfy five criteria. They need to be: (1) measured on a municipal or regional scale; (2) central to assisting decision makers about transportation/urban planning; (3) estimable via available existing data or other survey means; (4) converted to measures comparable to one another; (5) be measuring benefits for both users and non-users (i.e. the community at large).

Our benefits are guided by previous research and include *direct* benefits to the user—in the form of what we refer to as mobility, health, and safety benefits—and *indirect* benefits to society—in the form of decreased auto use, increased livability, and fiscal savings.

Other benefits certainly exist and the beneficiaries are not always that clear. Our aim is not to dismiss their significance but merely suggest that practical considerations related to data, methodologies, and measurement often preclude more detailed analysis. The six benefits mentioned usually have different beneficiaries. These range from society-at-large to individual users (potential and current) to agencies; there is crossover between beneficiaries for each benefit. Consider, for example, that the most common argument in favor of cycling suggests that an increase in facilities will result in increased levels of cycling. This assumed increase in cycling will be derived from: (1) existing cyclists whose current levels of riding will be heightened (because of more attractive facilities), and/or (2) potential cyclists whose probability for riding will be increased. Thus, we see potential benefits for two different populations of beneficiaries (current and potential cyclists). However, if any of these heightened levels of cycling result in decreased auto use, then an third beneficiary results—society-at-large—in terms of reduced congestion and resource consumption.

For each benefit a value is estimated. This value is almost always a product of how many users are likely to be taking advantage of the facility multiplied by the value ascribed by the various benefit. For example, to calculate the mobility benefit we used stated preference analysis to find out that bicycle commuters are willing to spend, on average 20.38 extra minutes per trip to travel on an off-street bicycle trail when the alternative is riding on a street with parked cars [6]. Commuters are willing to spend 18.02 minutes (M) for an on-street bicycle lane without parking and 15.83 minutes for a lane with parking. Assuming an hourly value of time (V) of $12, the per-trip benefit is $4.08, $3.60, and $3.17, respectively. We multiply the per-trip benefit for the appropriate facility by the number of daily existing *and* induced commuters, then double it to include trips both to and from work. This results in a daily mobility benefit. Multiplying the daily benefit by 50 weeks per year and 5 days per week results in an annual benefit (Annual mobility benefit = $M \cdot V/60$ · (existing commuters + new commuters) ·50 · 5 · 2).

The health benefit is quantified by using an annual per-capita cost savings from physical activity of $128. This value was determined by taking the median value of ten studies [11]. We multiply $128 by the total number of new bicyclists to arrive at an annual health benefit (Annual health benefit = total new cyclists · $128).

To develop a reliable measure for the value of the recreation we analyzed a wide variety of studies of outdoor recreational activities (non-bicycling) generated typical values of about $40 per day in 2004 dollars[12]. If a typical day of recreation is about 4 hours, this would be about $10/hour. Note that this is an estimate of the *net* benefits, above and beyond the value of the time taken by the activity itself. This estimate is also in line with a recent study of urban trails in Indianapolis, which used the travel cost method to find typical implied values per trip of about $7 – $20[13]. Both NHTS[9] and Twin Cities TBI[10] reveal that the average adult cycling day includes about 40 minutes of cycling. We use this, plus some preparation and cleanup time to arrive at the assumption that the typical day of bicycling involves about an hour bicycling activity, thus we value a day at $10 ($D$). We multiply this by the number of new cyclists minus the number of new commuters (Annual recreation benefit = D · 365 · (total new cyclists – new commuters)).

FIELD TESTING

An important part of this project's outcome lies in its utility as a tool to assist the local community transportation planning process. Toward this end, the research team conducted field-testing of the guidelines before general release to the public. This effort took place in two parallel tracks: one aimed at soliciting comments from the broad cycling community and another focused on communities with a strong interest in testing and potentially using the guidelines.

The research team solicited field testing from the cycling and planning communities through announcements at three conferences taking place in 2005:

Through announcements made at three conferences taking place in 2005, and an email invitation and a newsletter article aimed at the bicycle/pedestrian community, participation in field testing was sought from planners, bicycle and pedestrian professionals, and other interested parties. To augment this "public" field-testing track, the research team extended personal invitations to a select group of bicycle planners and advocates to test and offer comments on the guidelines. This effort focused on a targeted list of bicycle planning professionals with a strong interest in testing and potentially using the guidelines. The goal was to receive detailed and substantive comments from geographically distributed communities where bicycle planning is a priority. Key to this effort was our partnership with Active Living By Design (ALBD), a program of The Robert Wood Johnson Foundation (RWJF) and part of the University of North Carolina School of Public Health in Chapel Hill. The research team recruited three ALBD partnership communities to pilot test the guidelines: Seattle, WA, Somerville, MA, and Chapel Hill, NC. These cities represented a variety of settings, each providing a different context for planning different types of bicycle facilities.

Both sets of field testers were asked to apply the online tool to a planned or existing bicycle facility whenever possible and provide comments using the survey. The survey was distributed to these groups it contained a series of questions about the tool's applicability, accuracy, ease of use, "look and feel," and technical bugs. Some questions asked for narrative responses, while others solicited numerical ratings to allow for quantitative analysis.

Comments received via the online survey, from both groups, were used to improve the tool. The comments generally fit four categories. First, several comments pointed out technical bugs in the tool. Second, a substantial number of comments related to ease of use, providing the research team with opportunities to improve the user experience. A third body of comments pointed out specific inaccuracies in methodology, cost estimates, and glossary items. Finally, a number of respondents offered broad methodological comments that could be incorporated into future research. When appropriate and feasible, suggestions for improving the web tool and the supporting calculations were incorporated into the guidelines. Some comments, however, went beyond the scope of the project at this time but refer to issues that could be considered in future revisions of the tool. On the whole, the comments received confirmed the validity of our approach and the applicability of the results generated.

SUMMARY, LIMITATIONS AND FUTURE DEVELOPMENTS

The guidelines web tool provides valuable baseline information about what kind of costs and benefits can be expected from a given bicycle facility. While all the cost, demand, and benefit figures in the tool are calculated from previously available sources, the web tool is the first attempt to bring this kind of information together in an easy-to-use application. An especially remarkable aspect of the tool is that it can be used at many levels: a neighborhood group considering lobbying for a facility might input minimal specifications in order to get ballpark figures, while a professional planner could enter highly detailed information and in turn receive substantially more accurate cost, demand, and benefit output.

Numerous comments about the tool received in the field-testing phase offered ideas that were beyond the research scope of this project, but these ideas can be used to provide direction for future study. The ideas that seem most promising for future investigation include:

- Costs and benefits should include information about safety in terms of crashes.
- The effect that bicycle commute share has on commute time.
- The effect that bicycling has on air quality or how much bicycling must be taking place in order to have an effect in air quality.
- The effect that bicycling has on quality of life and community cohesion.
- Studies to determine if certain populations are more inclined to bicycle. If so, which populations?
- How can bicycle facilities be designed to target different groups of cyclists for maximum benefit?

Further research into these areas will produce more reliable and better estimates for the costs, demand, and benefits of bicycle activity and bicycle facilities.

This project is ongoing, and the guidelines will continue to be reviewed, updated, and improved. We are continuing to do research analyzing the demand and benefits of bicycling. Currently, researchers at the Humphrey Institute are analyzing changes in bicycle commute share in relation to new bicycle facilities in the Twin Cities. They are also conducting research analyzing the spatial location of bicycle crashes, in part to help determine if urban form has an impact on bicycle safety and if the information that is currently being collected from Police reports is the type of information that is needed to determine the cause of crashes. As better research becomes available, the guidelines will be adjusted accordingly. In addition to conducting on-going research on quantifiable costs, demand, and benefits, we will continue to improve the user-friendliness of the guidelines.

As further revisions of the guidelines are completed, they will be better able to assist urban planners, policy officials, and decision-makers as they evaluate various bicycle facilities. The guidelines provide planners and policy makers with knowledge about how bicycle facilities will assist them in addressing larger public policy questions. They provide urban planners, policy officials, and decision-makers with an easy-to-use, defendable, assessment of the costs, demand, and benefits of a bicycle facility.

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List of Figures:

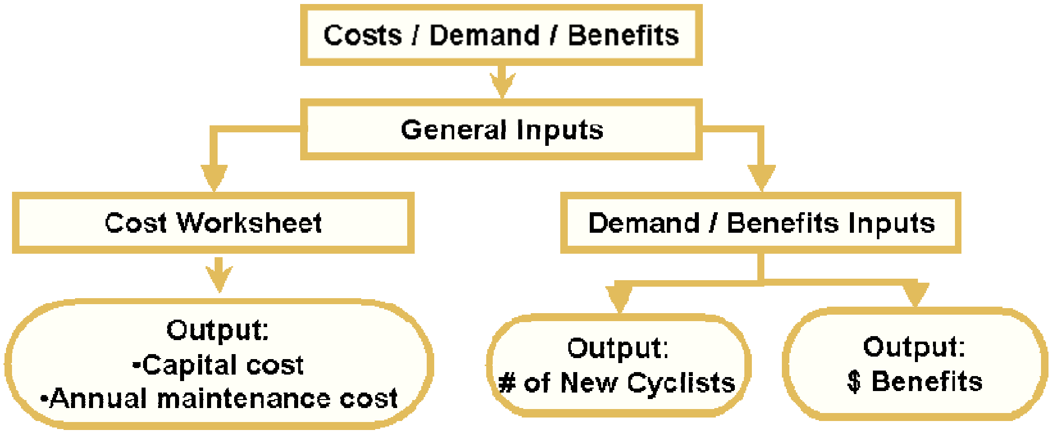

FIGURE 1 Overall framework of the guidelines.

FIGURE 2 Screen shot of the Benefit-Cost Analysis of Bicycle Facilities online tool.

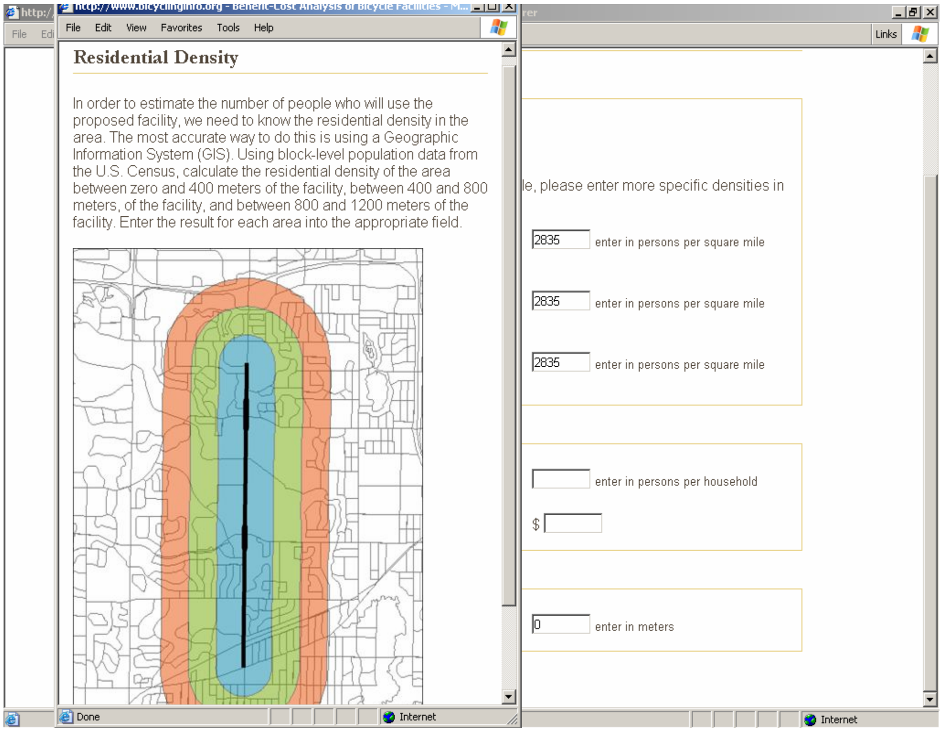

FIGURE 3 Information from i buttons explaining the input variables provided in separate popup windows.

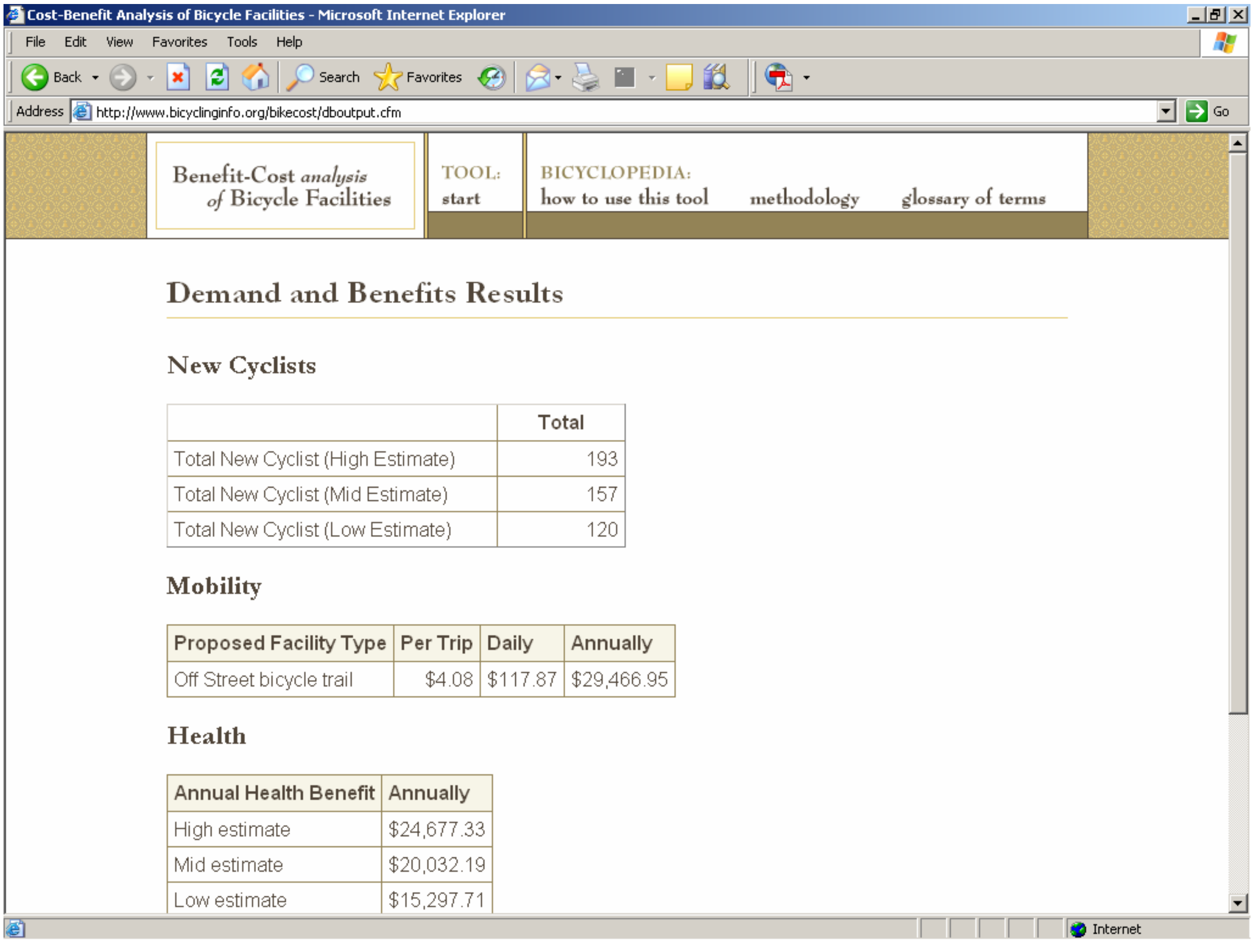

FIGURE 4 Outputs of demand and benefits.

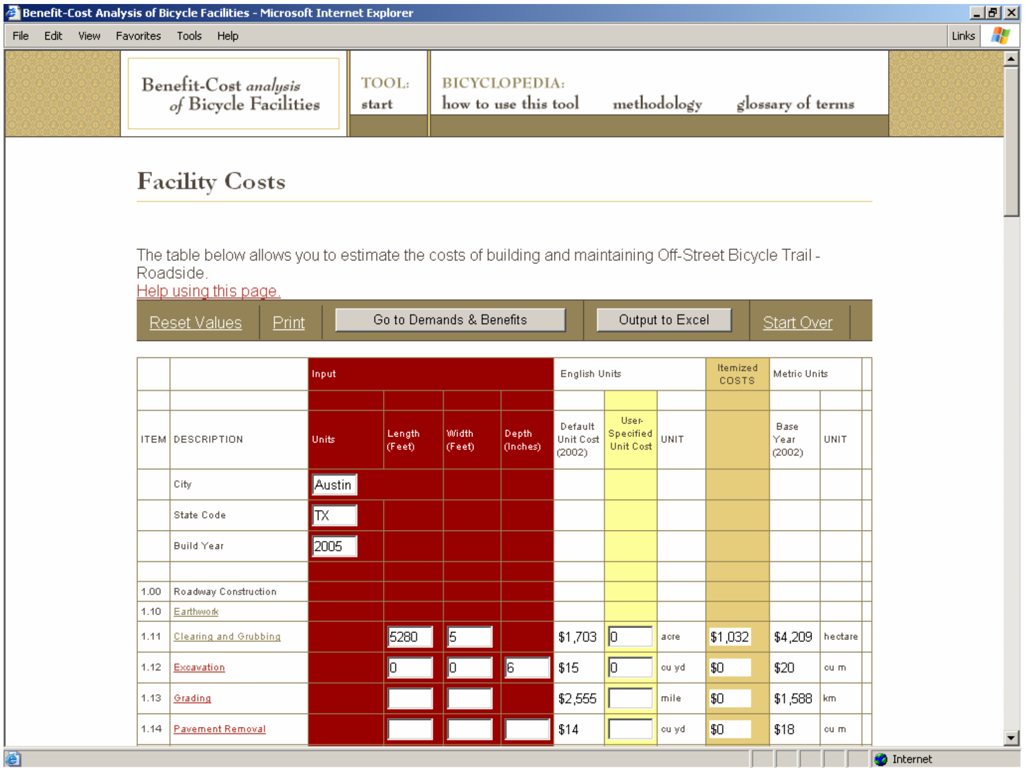

FIGURE 5 Facility cost spreadsheet.

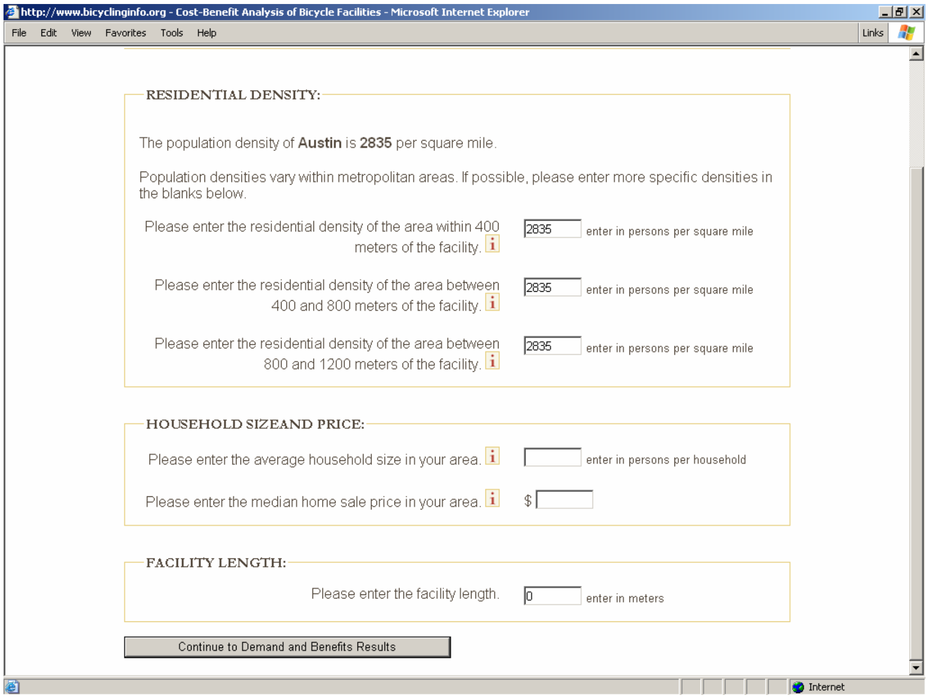

FIGURE 6 Demand and benefits inputs.