DEVELOPMENT OF A WATERSHED-BASED WATER BALANCE TOOL FOR WATER SUPPLY ALTERNATIVE EVALUATIONS

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ABSTRACT

Water resource management in Skagit County, Washington is becoming increasingly complex, due to multiple interests competing for limited water supplies, and the necessary balancing of land and water development strategies. Two key drivers affecting water resource management in the County are population growth (and the associated demands upon the local water resources) and in-stream flow protection. Increasing population densities and environmental regulations are forcing a new integrated water resource management approach to better meet the needs of both the natural and built environments in a long-term, sustainable fashion.

The Skagit County Public Utility District (PUD), in coordination with the County and the Washington Department of Ecology, is embarking on an innovative water resource planning approach that promotes an integrated planning strategy to identify water supply alternatives for the Nookachamps Basin, a rural area expected to experience significant future growth. This approach involves the development of a watershed-based water balance tool to evaluate impacts of various water supply and wastewater management options upon the watershed. Preliminary results of the tool under development indicate that certain combinations of land use and water resource management approaches allow for the basin to accommodate significant population growth while also providing a positive impact upon the water balance (i.e., importing water into the basin). Next steps in this effort include further evaluation of management options within the context of comprehensive watershed management scenarios, followed by a charrette-style meeting to allow multiple interested parties to comment in an open forum on the ability of various scenarios to meet their specific needs. The PUD will then frame future watershed-based utility planning efforts in the context of the issues and discussions brought forth through the water balance analyses and charrette process.

KEYWORDS

Water resource management, water resource planning, smart growth, sustainability

INTRODUCTION

Water resource management in Skagit County, Washington is becoming increasingly complex, due to multiple interests competing for limited water supplies, and the necessary balancing of land and water development strategies. Two key drivers affecting Skagit County (County) water resource management are population growth (and the associated demands upon the local water resources) and in-stream flow protection. Historically, these two elements have been managed independently. Water supply and wastewater management planning efforts focused on the need to efficiently support anticipated levels of population growth and development of the "built" environment. Environmental regulations governing in-stream flows, water quality, and stormwater focus on the need to support local fisheries and beneficial uses associated with the "natural" environment. Population growth (and related land use issues) and environmental regulations are forcing a new, more integrated water resource management approach to better meet the needs of both the natural and built environments in a long-term, sustainable fashion.

This paper describes how the Skagit County Public Utility District (PUD), in coordination with the County and the Washington Department of Ecology (Ecology), is embarking on an innovative water resource planning approach that promotes an integrated and sustainable water and land use management strategy.

BACKGROUND

Skagit County is located in northwest Washington, about halfway between Vancouver, British Columbia and the City of Seattle. The Nookachamps Basin is located southeast of the major urban center of the County (i.e., the Town of Mount Vernon). This watershed area, approximately 44,000 acres (68.5 square miles) in size, is heavily forested and rural in nature, with agriculture and commercial forestry dominating the local economy. Existing residential development is focused within the Mount Vernon Urban Growth Area (UGA) in the western and downstream portion of the basin, and around three lakes (Big Lake, Clear Lake, and Lake McMurray). Nookachamps Creek originates at Lake McMurray, flows through Big Lake, and then ultimately joins the Skagit River upstream of Mount Vernon.

Presently, water supply delivered to the "built" environment in this basin is comprised of public water supplied by the PUD to the more densely populated areas (i.e., the UGA and around Big and Clear Lakes). The sources of the regional water supply for these areas come from outside of the basin (i.e., the PUD "imports" water from larger, regional sources to satisfy these water supply needs). In other, less densely populated areas of the basin, individual ground water wells are relied upon for water supply.

Wastewater management currently takes the form of sewers in the UGA and around Big Lake, with collected flows conveyed out of the basin for treatment and disposal in the Skagit River outside of the basin. Septic systems are utilized in other areas throughout the basin.

The rural area population in the County as a whole is projected to increase from 34,110 in 2000 to 43,330 in 2025. This reflects a nearly 30 percent increase in rural area population over a period of 25 years. A significant portion of this growth is anticipated to occur in the Nookachamps Basin. In addition to the UGA, most of this growth is expected to occur around Big Lake and Lake McMurray. The provision of water supply to support the expected growth in these particular areas is the challenge being studied by the PUD and the County.

Surface water in the basin is unavailable, as use of Nookachamps Creek is a priority for endangered species of salmon and is therefore closed to future surface water right appropriations. Available ground water resources have been determined to likely be in continuity with

Nookachamps Creek. Therefore, additional ground water withdrawals may adversely impact in-stream flows. For this reason, limits on the amount of future additional ground water use have been established in State administrative rules. This creates a situation of limited available in-basin water supplies to meet a range of competing needs.

OBJECTIVES

Given the situation described above, the PUD has developed a watershed-based approach to integrate land and water resource management decisions, aimed at addressing the following objectives:

1. Provide a mechanism to assist planners and water purveyors accommodate growth while meeting environmental and in-stream goals. Specific quantitative objectives include:

   a. Accommodate a compound annual growth rate in population of 2.67 percent, based upon State and County forecasts.

   b. Adhere to the environmental in-stream goal established for the Nookachamps Basin in the recent revisions to State law, which are expressed in the form of a water reservation for out-of-stream uses in the amount of 26,497 gallons per day (gpd) of maximum average consumptive daily use. Additional withdrawals are allowed only in conjunction with appropriate mitigation strategies.

2. Create long-term sustainability (i.e., balancing of the natural and built environments) by evaluating various water resource management and population allocation scenarios over 20- and 50-year time frames.

3. Compare the results of the traditional approach (i.e., considering limited relationships between the natural and built environments) with those of a more comprehensive, watershed-based approach.

APPROACH

The PUD's approach to water supply planning for the Nookachamps Basin consists of a three phase effort. These phases are described generally below, followed by a detailed discussion of development of the second phase, and a description of the software modeling tool being used to support this effort.

General Approach

The three phases of this water supply planning project are:

1. A "traditional" water supply study, aimed at identifying the infrastructure needed to expand the PUD's existing water supply system to serve future growth. The analysis involved projections of area population growth, allocation of this growth according to current land use practices and allowable densities, estimates of associated water demand, and identification of

infrastructure upgrades of existing PUD facilities to support growth in the more densely populated areas. Consistent with most water supply evaluations, this analysis was conducted for a 20-year planning horizon.

2. Development and use of a watershed-based water balance tool to more comprehensively evaluate water resource management decisions and their impacts upon multiple watershed objectives. This phase more closely examines the relationships between land use decisions and water resource management options to meet needs of the built environment. It also then explores the ramifications of such options upon the natural environment over a long-range planning period (50 years). This part of the effort is the focus of this paper.

3. At the conclusion of the first two phases, the PUD plans to host a charrette-style planning event, wherein stakeholders representing various interests of both the natural and built environments will be involved in analyzing a wide range of management decisions by using the tool developed in Phase 2.

Developing a Watershed-Based Water Balance Approach

As described above, the second phase of this effort involves evaluating the relationships of the natural and built environments. This is done primarily by considering the overall water balance of the basin, and the impacts that the built environment has upon the natural water balance. The primary relationships being analyzed by the PUD involve the processes of water being "taken away from" and "imported to" the basin as a result of various water supply and wastewater management options. Such options are a function of management decisions by utility providers (e.g., in certain areas this means the PUD in terms of water supply and the Big Lake Sewer District in terms of wastewater management). For example, the use of ground water wells and septic systems results in a net negative impact to the water balance, as only approximately 50 percent of water withdrawn from wells is returned to basin aquifers via septic drainfields (with the remainder "lost" to evapotranspiration, subsurface flow out of the basin, etc.) By comparison, the use of imported water in conjunction with the collection, treatment, and direct discharge of wastewater to surface water in the basin results in a positive net impact to the water balance, since "new" water is being "added" to basin stream flows.

The magnitude of the effects upon the water balance of the above options is a function of population, which in turn is based upon land use decisions (namely, the density and nature of development). In the Nookachamps Basin, maximum allowable densities have been established for various land use types. The four land use categories capable of supporting the majority of the projected population, and their present associated allowable densities (in terms of units per acres), are:

UGA	4:1
Rural Village Residential (RVR)	1:1
Rural Reserve Residential (RRv)	1:10
Rural Reserve Commercial (RRc)	1:40

To capture a wide range of potential water balance effects, four water/wastewater management options have been considered for analysis, in conjunction with four land use management options. Together, these create a total of 16 ***water resource management options*** for analysis. The water/wastewater and land use options are described below, with Table 1 illustrating how they combine to result in 16 total options.

The four water/wastewater options are as follows:

1. *Current Conditions*. This refers to the continued use of existing water supply and wastewater management approaches throughout the basin. For example, at Big Lake, it is assumed that all future growth in proximity to the lake will receive imported water from the PUD and wastewater will be exported from the basin (i.e., meaning there is no net impact upon the water balance of the basin). At Lake McMurray, this option means that future growth will continue to rely upon ground water wells and septic systems, resulting in a negative impact upon the water balance (i.e., water being removed from the basin).

2. *Wastewater Returns at Big Lake*. This refers to modification of the wastewater management approach at Big Lake. Instead of sewered wastewater being pumped out of the basin, these flows are treated to an acceptable level and are discharged directly to Nookachamps Creek. This results in a positive net impact to the water balance, as PUD-imported water to this area is now retained in the basin.

3. *Wastewater Returns at Big Lake <u>and</u> PUD Water Supply to Lake McMurray.* This builds upon Option 2 by including extension of the PUD's imported supply to Lake McMurray. This results in an increased positive impact upon the water balance, as ground water withdrawals are decreased and a portion of imported water is provided to the basin via septic return flows.

4. *Wastewater Returns at Big Lake, PUD Water Supply to Lake McMurray, <u>and</u> Wastewater Returns at Lake McMurray.* This builds upon Option 3, in that the Lake McMurray area is assumed to be sewered, with collected wastewater flows treated to an acceptable level and discharged directly to Nookachamps Creek. Therefore, the amount of PUD-imported water to this area that is retained in the basin is increased, compared to the amount provided if this area remains on septic systems.

The four land use management options are as follows:

A. *Current Densities*. This refers to the continued use of existing maximum allowable land use densities, as outlined earlier.

B. *Modified Densities*. This refers to increases in the maximum allowable densities within the UGA and RVR designated areas. This results in a larger portion of the future population being allocated to these areas, as opposed to the less dense portions of the basin. This affects the water balance, depending upon which water/wastewater management option is employed, as water supplies and wastewater returns are different for these areas than for the less dense portions of the basin. This also allows for the basin to accommodate a larger total population. The revised allowable densities are:

UGA 10:1
Rural Village Residential (RVR) 5:1

C. *Clustered Development – Current Densities*. This refers to increased requirements for open space, effectively resulting in subareas of increased densities within existing land use designations. While overall maximum allowable densities remain the same, pockets of higher density development are required in some areas.

D. *Clustered Development – Modified Densities*. This option involves the clustering concept, as well as increased overall maximum allowable densities for certain areas.

The 16 possible combinations of these options are depicted in Table 1. At this time, the PUD has only evaluated land use management options A and B. The other options are described here so that a comprehensive view of the analysis may be obtained. They will be analyzed mid-year in 2006, upon definition of specific clustering options.

Table 1 – Summary of Watershed-Based Water Balance Analysis Options

	Water/Wastewater Management Option			
Land Use Management Option	1 Current Conditions	2 Wastewater Returns-Big Lake	3 Wastewater Returns-Big Lake and PUD Supply-Lake McMurray	4 Wastewater Returns-Big Lake, PUD Supply-Lake McMurray, and Wastewater Returns-Lake McMurray
A – Current Densities	A1	A2	A3	A4
B – Modified Densities	B1	B2	B3	B4
C – Clustered Development/Current Densities	C1	C2	C3	C4
D – Clustered Development/Modified Densities	D1	D2	D3	D4

Computer-Aided Modeling

The various options described above are being analyzed with the aid of a conceptual model that converts forecast population growth by land use designation areas into out-of-stream water demand and associated wastewater flows. User inputs regarding growth rates, maximum allowable densities, and water/wastewater management techniques allow for examination of a wide range of water resource management options.

To understand the spatial characteristics of the basin and water balance impacts, the conceptual model has been constructed using a software tool named CommunityViz, developed by the Orton Family Foundation. CommunityViz is a Graphical Information System (GIS) based application that allows users to envision alternatives and understand potential impacts within a spatial context. The tool operates on a GIS platform and provides a user interface that allows for real-time modification of variables and scenario analyses. While the tool has been used to examine pre-defined options to this point in the PUD's efforts, one of its greatest benefits is the use in a charrette-style planning setting, as is envisioned as a next step in the project.

Figures 1-3 provide examples of input and output interfaces offered by this computer-aided modeling tool. Figure 1 depicts a typical user input screen, complete with a map of a portion of the basin and slider bars used to change assumptions regarding variables (e.g., maximum allowable densities, per capita water use factors). Figures 2 and 3 offer examples of output screens, in the forms of graphical and three-dimensional displays, respectively. The CommunityViz application offers many options for user-friendly screens and displays, making it a powerful modeling platform as well as an effective presentation tool.

Figure 1 – Example CommunityViz Input Screen

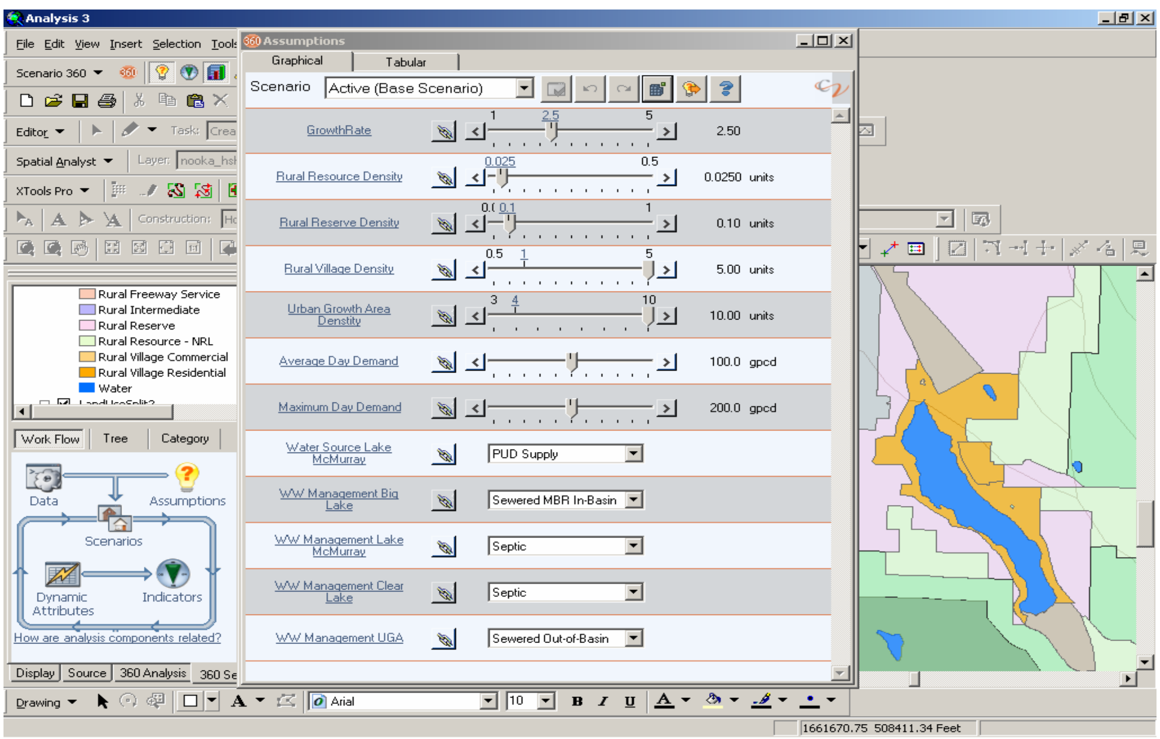


Figure 2 – Example CommunityViz Output Screen

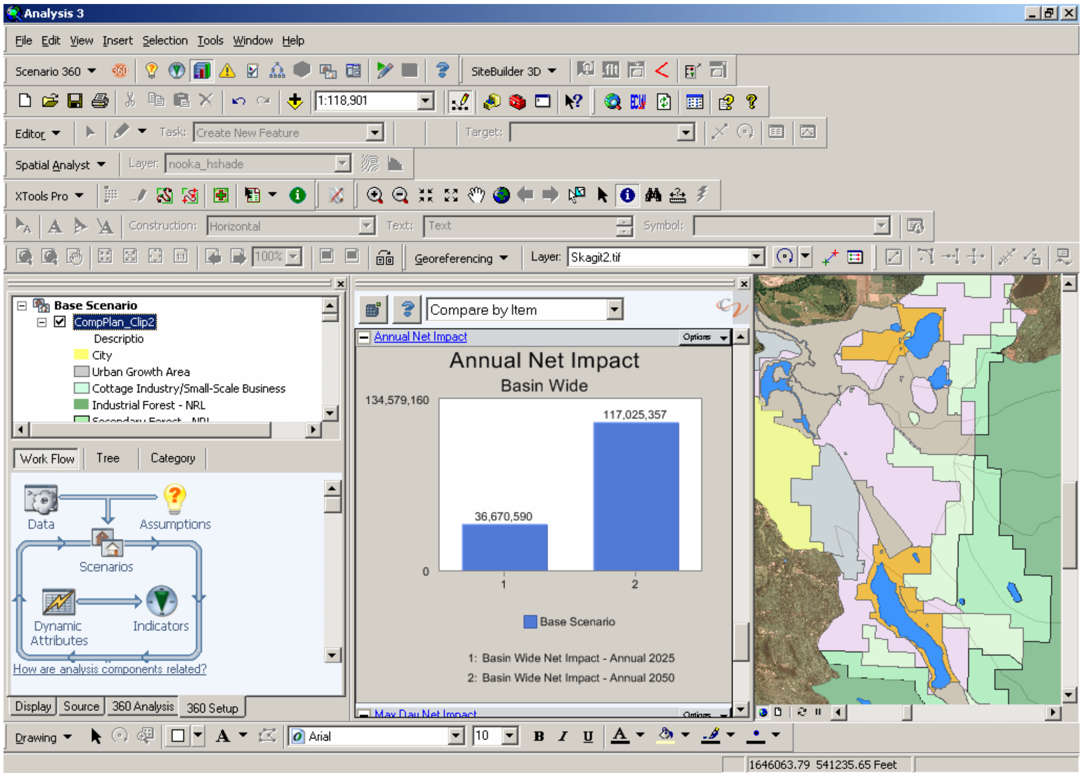
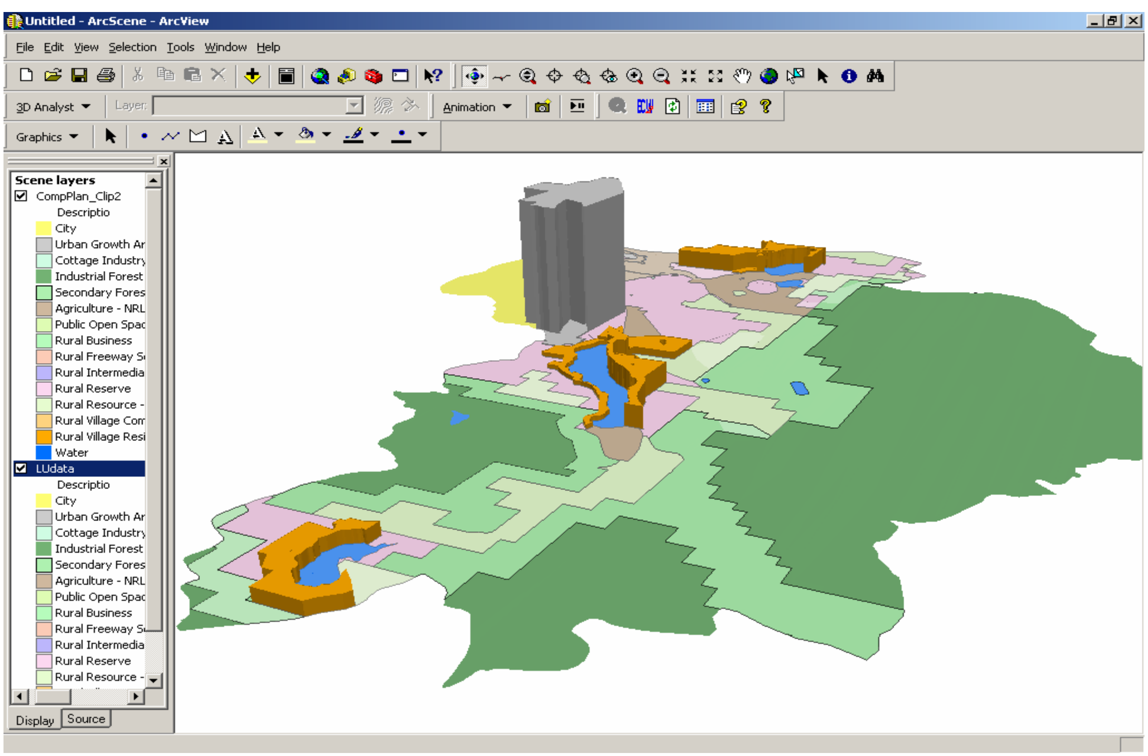


Figure 3 – Example CommunityViz Three-Dimensional Output Display



PRELIMINARY RESULTS

The first eight water resource management options (A1-A4 and B1-B4) have been evaluated within the model. Preliminary results are provided below.

Figures 4 and 5 summarize the impact of the various options on the water balance, on annual and summer day bases, respectively. The results are shown for both years 2025 and 2050, and are depicted separately for the two land use management options (i.e., current densities versus modified densities). For each year, the additional water added to the basin is depicted in a cumulative fashion for the four water/wastewater management options.

As shown in Figure 4, the additional amount of water added to the basin on an annual basis by 2050 is approximately 50 acre-feet (ac-ft) if no changes are made in water supply and wastewater management approaches (i.e., "current conditions"). Modifications to land use densities (and therefore population allocations) has little effect on the water balance given existing water resource management approaches. However, if more water is imported by the PUD (i.e., to serve Lake McMurray) and wastewater flows in the Big Lake and Lake McMurray areas are treated and returned to in-basin stream flows, then the annual amount of water added to the basin increases significantly, up to approximately 275 ac-ft under current land use practices, and almost 400 ac-ft under modified densities.

This indicates that water supply/wastewater management approaches, and land use policies regarding densities and nature of development, can positively affect the basin's water balance. The positive effects of the modified densities option is due to a larger share of the future population residing in more densely-populated areas where public services (i.e., imported PUD water and centralized wastewater management) are more readily available.

Similar findings are depicted in Figure 5, which examines the impact of the various options on the daily water balance during summer months (i.e., when in-stream flows are the lowest and out-of-stream uses are the greatest). Under current water supply and wastewater management strategies, the maximum daily amount of water added to the water balance by 2050 is approximately 0.1 cubic feet per second (cfs), regardless of the land use management option. However, if water resource management strategies are modified, then the daily amount of water added to the basin increases significantly, up to approximately 0.75 cfs under current land use practices, and almost 1.0 cfs under modified densities. The significant rise in positive impact to stream flows is due to the greater out-of-stream water use that occurs during dry summer months. Because, under the modified water/wastewater management options, the densely populated portions of the basin use imported water and then convert a large portion of that water to wastewater return flows, a large amount of "new" water is made available to the basin. With these types of management strategies, the water supply and wastewater needs of future populations are met, while also positively addressing watershed objectives.

Figure 4 – Annual Impact of Water Resource Management Options upon Water Balance

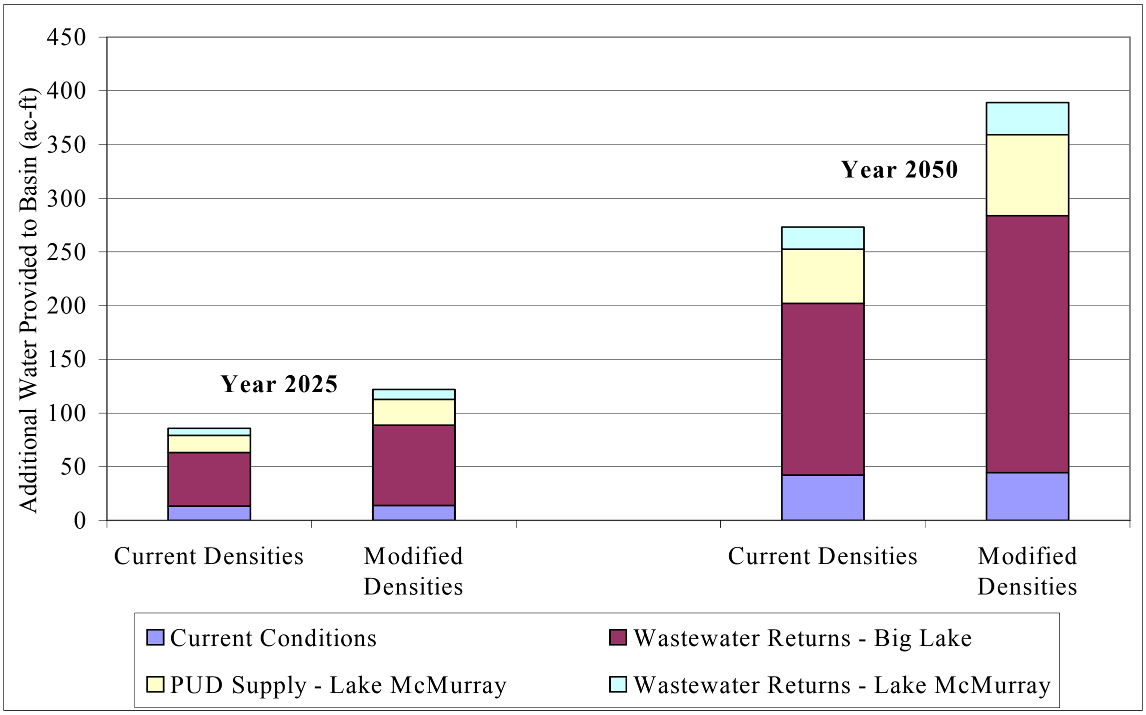
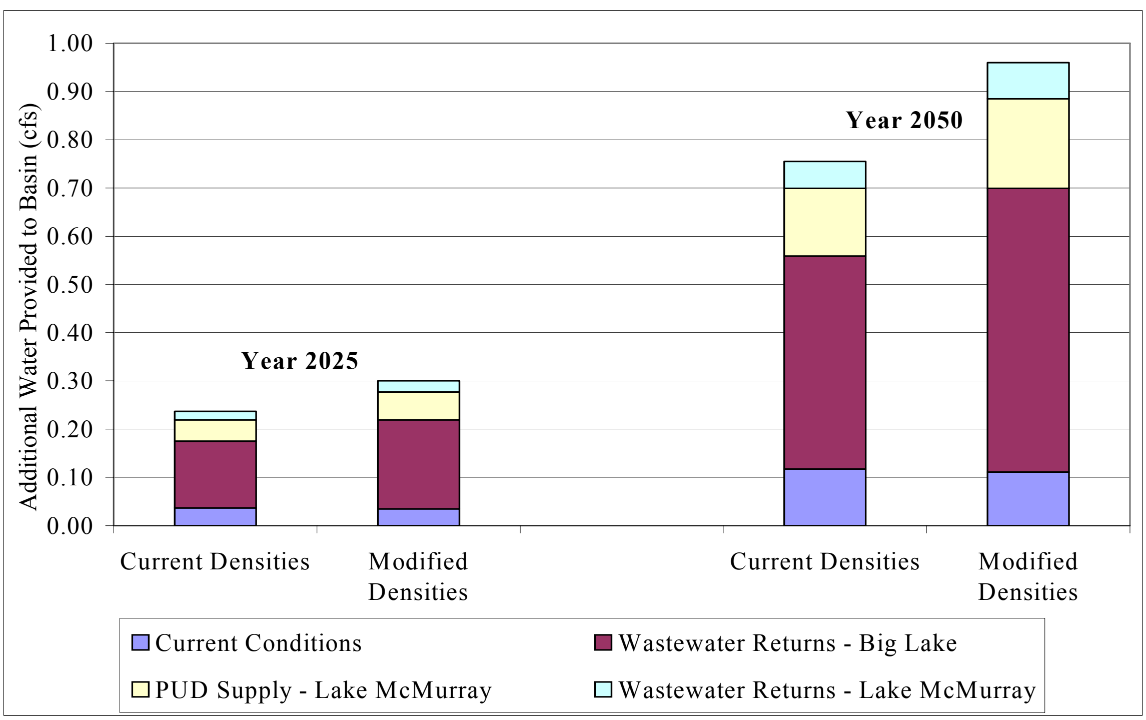


Figure 5 – Summer Month Impact of Water Resource Management Options upon Water Balance



While the information presented in Figures 4 and 5 is helpful in understanding the relative effects of various water/wastewater and land use management options, it does not relate these impacts to present levels of flow in Nookachamps Creek. Such an analysis is made challenging by the lack of historical stream flow monitoring data for this basin. It has been only in very recent years (2003-2005) that Skagit County has occasionally monitored stream flow at a few sites throughout the basin. A cursory analysis of available data indicates that during the short three-year period of record, average annual flow volumes for the basin were on the order of 76,600 ac-ft. By comparison, the maximum positive annual water balance impact depicted in Figure 4 (almost 400 ac-ft) translates to approximately 0.5 percent of this annual total.

During low-flow summer months, the period of record indicates that basin flows drop as low as 1.75 cfs at times. By comparison, the maximum positive daily water balance impact depicted in Figure 5 (almost 1.0 cfs) translates to approximately 57 percent of the low-flow daily total. This indicates that while on an annual basis, revised water resource management strategies may not impart a significant impact to the basin's water balance, such strategies do have the potential of providing a substantial benefit to low-flow period stream flows, thereby supporting the basin's watershed and natural environment objectives while sustaining future growth of the built environment.

Another preliminary result of the analysis regards the ability of the basin's present land use designations to accommodate projected population growth. At the currently-accepted forecast growth rate, the basin's population will reach approximately 22,000 by 2050. At present land use densities, the total population the basin can support is 19,800, meaning that the projected 2050 population can not be accommodated by current densities. Under the modified density option analyzed, the population the basin can accommodate significantly increases to approximately 55,000. This is due primarily to the large land area comprised of the UGA and its ability to support significant growth if maximum densities are modified. This issue will be further investigated as the PUD continues with the project's next steps.

NEXT STEPS

This effort is in the early stages of development. Future activities are envisioned to take place in three sequential steps:

1. Define and analyze the remaining eight water resource management options.

2. Use the watershed-based water balance tool to further evaluate a subset of the 16 water resource management options according to four watershed management scenarios.

3. Explore all of these alternatives, and more, in a charrette-style setting with multiple stakeholders.

Each of these steps is described below.

Analyze Remaining Water Resource Management Options

This step will begin with defining the remaining two land use management options. This will involve establishing a clustered development option, wherein greater amounts of open space are required in certain land use designation areas, thereby forcing small areas of greater density to support projected populations. The anticipated approach involves identifying large tracts of undeveloped or minimally developed land in particular portions of the basins that could potentially be reserved for open space, and other areas that could be developed or redeveloped at higher densities. Once completed, this will form land use management option C, as depicted in Table 1. Combining the clustered development approach with modified maximum allowable densities will develop option D. The four water/wastewater management options will be applied to these two land use management strategies to obtain results of the nature described in the previous section.

All 16 water resource management options will then be compared against each other, and ranked to determine the four options that best support the needs of both the built and natural environments.

Further Evaluation According to Watershed Management Scenarios

The four selected options from the previous step will be carried forward into a second phase of analysis, where they will be further evaluated according to four ***watershed management scenarios***, described briefly below.

- *Scenario 1 - Skagit County Growth*. The population allocation algorithm used in developing the 16 water/wastewater management options assumes that the Nookachamps Basin would accept approximately 5 percent of total County growth from 2005-2025 and approximately 3 percent of total County growth from 2025-2050. Under watershed management scenario 1, it is assumed that the Nookachamps Basin accepts a larger percentage of total Skagit County Growth (e.g., 10 or 20 percent). This scenario is plausible because:

    - The Nookachamps Basin has available water supply and wastewater infrastructure to accommodate additional growth.
    - The proposed restrictions on future water use of ground water may restrict population growth in other areas of the County where public utility infrastructure is not as developed as in the Nookachamps Basin.
    - The Nookachamps Basin is generally at higher elevations and does not include prime bottomland farm areas, for which there is a strong sentiment to preserve in other portions of the County.

- *Scenario 2 – Ecology In-stream Flow Rule*. The 16 water/wastewater management options did not include any land use restrictions based on the availability of water. The reservations established in the recently adopted in-stream flow rule revisions would limit new growth in areas currently using well water and septic tanks. Scenario 2 models the population ramifications of the Ecology in-stream flow rule with and without mitigation. This scenario is plausible because:

- The revised Ecology rule is in presently in effect.
- The revised rule will limit population growth in areas served by well water and septic tanks. In total for the Nookachamps Basin, the reservation quantity is 26,497 gpd. Based on PUD maximum day demands of 384 gpd per household and a septic return credit of 50 percent, this reservation quantity translates to 130 homes that can be supported by wells and septic tanks without the need for appropriate mitigation.
- The Ecology rule does allow more water to be used if appropriate "mitigation" (e.g., wastewater reuse or aquifer recharge) strategies can be implemented.

- *Scenario 3 – Environmental Restrictions*. This scenario considers the effects of increased critical area buffers, which may result from adoption of more stringent critical area codes and ordinances. Such buffer changes will effectively reduce the amount of buildable land and thereby increase population densities.

- *Scenario 4 – Preservation of Natural Resource-Based Economy*. The 16 water/wastewater management options did not consider economic objectives. Increasing population density in portions of the Nookachamps Basin could harm the commercial forestry and agricultural economies in these areas if the growth is not carefully managed. Scenario 4 examines the effect of providing sufficient buffers between agricultural/forest land and the growth centers, so as provide greater viability for long-term working farms and forests. This would also include consideration of development options for reducing impervious surface and increasing habitat connectivity. This scenario is plausible because:

    - Conflicts between working farms and forests and residential areas are likely if sufficient buffers are not maintained.
    - Land prices for residential development can threaten long-term commercial viability of working farms and forests.
    - A certain land base is necessary to support the infrastructure that makes working farms and forests possible (e.g., for feed stores, machine and implement stores, insurance, etc.) In some cases, small decreases in the land base can rapidly erode this supporting infrastructure.

The four selected water/wastewater management options will be evaluated according to these three watershed management scenarios to determine their ability to accommodate the revised growth patterns and to understand their associated impact upon the Basin's water balance.

Charrette Process

The charrette has emerged as an alternative to conventional planning and approval processes. This process provides an interactive and visual forum to exchange ideas and provide feedback. Charrettes allow a high level of collaboration by providing interactive, on-demand information that is provided in a variety of formats. Charrettes are designed to achieve specific objectives: the design of a new neighborhood, the redevelopment of an undercapitalized thoroughfare, or the revitalization of a watershed to meet the needs of the natural and built environments.

The PUD plans to implement a charrette-style meeting with various stakeholders to further examine the watershed management scenarios described above. This will allow multiple interested parties to comment in an open forum on the ability of the scenarios to meet their specific needs. The PUD will then frame future watershed-based utility planning efforts in the context of the issues and discussions brought forth through the charrette process.