Wyoming Community Viz^{TM} Partnership Phase I Pilot: Aquifer Protection and Community Viz^{TM} in Albany County, Wyoming

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Suggested reference citation for this publication is:

Lieske, S.N., S. Mullen, M. Knapp and J.D. Hamerlinck. 2003. *Wyoming Community Viz™ Partnership Phase I Pilot: Aquifer Protection and Community Viz™ in Albany County, Wyoming.* (Final Report) Laramie, Wyoming: University of Wyoming.

Disclaimer:

The material presented herein resulted from research sponsored by the Wyoming Business Council, the Wyoming Community Foundation and the University of Wyoming through the Wyoming Community Viz™ Partnership. The results presented reflect neither a consensus of opinion nor the views and policies of the Wyoming Business Council, the Wyoming Community Foundation, the Wyoming Community Viz™ Partnership, the University of Wyoming, the governments of Albany County and the City of Laramie or Community Viz™. Explicit findings and implicit interpretations of this document are the sole responsibility of the authors.

Acknowledgements

This report was completed in fulfillment of University of Wyoming Contract # WBC6361 (Principal Investigator: Jeffrey D. Hamerlinck, Wyoming Geographic Information Science Center; Co-Principal Investigator: Diana Hulme, William D. Ruckleshaus Institute of Environment & Natural Resources).

Primary funding for the project was provided by the Wyoming Business Council. Other sponsors of funding included the Wyoming Community Foundation, and the University of Wyoming's William D. Ruckleshaus Institute of Environment & Natural Resources,Department of Agricultural and Applied Economics and Wyoming Geographic Information Science Center.

The authors wish to extend special thanks to Molly Welker, former coordinator of the City of Laramie Water Outreach Office; Mary Randolph, Executive Director of the Wyoming Rural Development Council; Towny Anderson, former Development Director for the Orton Family Foundation; and Debbie Nagel-Smith, the Albany County Assessor.

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Preface

The Wyoming Community Viz™ Partnership was established in 2001 to promote the use of geographic information system-based planning support systems and related decision support technologies in community land-use planning and economic development activities in the State of Wyoming. Partnership members include several state agencies, local governments and several non-government organizations. Partnership coordination is provided by the Wyoming Rural Development Council. Research and technical support is coordinated by the Wyoming Geographic Information Science Center's Spatial Decision Support System Research Program at the University of Wyoming.

The focus of the partnership currently centers on the implementation and use of the Community Viz™ suite of GIS-based planning tools. Community Viz™ was developed by the Orton Family Foundation (Rutland, VT; www.orton.org), a not-for-profit, private operating foundation whose mission is to provide technology-based assistance to rural communities faced with challenging land use planning issues. The Community Viz™ software applications are designed to allow users to combine leading-edge computer and GIS technology with sound planning concepts to assist communities in grappling with such planning issues as increasing population, expanding residential areas, growing demand for public services and requests to adopt unanticipated land-use changes.

Response to these types of planning issues is often made more difficult in rural states like Wyoming because planning resources are consistently limited. The Wyoming Community Viz™ Partnership seeks to increase the quality of the planning process in Wyoming by making Community Viz™ readily available to Wyoming communities. Partnership objectives include building local resources to use the software, creating a strategy to facilitate this use and helping communities incorporate Community Viz™ in their planning process. It is hoped that Community Viz™ can support such planning tasks as: (1) building public understanding and acceptance of planning processes; (2) increasing the predictability of development, planning and approvals processes; (3) facilitating high quality and timely decision-making; (4) using accurate information and the latest proven techniques and alternatives for sound planning processes; and (5) exploring a wide range of public policy options to support and protect a community's own values as its citizens define them.

In June 2002, the Partnership initiated a three-phase plan to promote Community Viz™ based planning support systems in Wyoming. Phase I of the Partnership plan was a "proof of concept" pilot project set in Albany County in southeastern Wyoming. The goal of the project was to demonstrate the application of Community Viz™ to a Wyoming-specific issue (in this case, aquifer protection) and to determine potential challenges for broader adoption in terms of data requirements, computing infrastructure and technological expertise.

The results of the Phase I pilot project are detailed in this report. Efforts are currently underway to secure funding for Phase II of the plan, which expands the use of Community Viz™ into four additional Wyoming communities. Specific Phase II objectives are to expand the type and number of issues addressed by Community Viz™ and increase the use of Community Viz™ in the planning process. As a part of Phase II the Partnership will create a technical assistance network aimed at assisting communities with the technical challenges in applying the software to their planning issues. The third phase will expand the program to more communities in the state, maintain the technical assistance network, and monitor the impact of Community Viz™ on the planning process.

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Executive Summary

The Wyoming Community Viz™ Partnership was established in 2001 to promote the use of geographic information system-based planning support systems and related decision support technologies in community land-use planning and economic development activities in the State of Wyoming. The focus of the partnership currently centers on the implementation and use of the Community Viz™ suite of GIS-based planning tools. In June 2002, the Partnership initiated a three-phase plan to promote Community Viz™ in Wyoming. The process and results of the Phase I pilot project are detailed in this report.

The purpose of the pilot project was to serve as a "proof of concept" in demonstrating how the Community Viz™ software might be incorporated into a small town planning process in Wyoming. In addition, the project served to identify potential challenges for broader adoption of the software in Wyoming, including digital geospatial data requirements, computing infrastructure, and technological expertise.

First developed for business applications in the 1970s, decision support systems (DSSs) are computer-based software applications which integrate database management systems, analytical models, and graphics to improve decision-making processes (Densham 1991). An example of a recent DSS application which bridges the gap between modeling and communication is Community Viz™, developed by the Orton Family Foundation (Rutland, VT). Since its release, Community Viz™ has been utilized in many planning applications from rural growth management (Mullen 2001) to urban redevelopment (Wendt 2002) and watershed modeling (Prisloe and Hughes 2002).

The Wyoming Community Viz™ Partnership Phase I Pilot Project addressed the potential impacts of alternative scenarios on groundwater protection. The project analyzed three possible alternative future land use scenarios in the vicinity of municipal well fields and groundwater recharge areas and their impacts on water quality and related resource indicators.

The study area for the project was focused on the primary groundwater recharge area delineated for the City of Laramie / Albany County, Wyoming's aquifer protection plan.

The Casper Aquifer is the primary groundwater source of drinking water for the City of Laramie. The purpose of the *Casper Aquifer Protection Plan* (Welker 2002) is to protect the recharge area of the Casper Aquifer, located along the western foothills of the Laramie Range mountains bordering the eastern edge of the Laramie city limits. The plan makes clear that not protecting the aquifer is potentially a grave risk for the city and county. It also details both the problem of nitrate contributions from rural residential septic systems and a possible solution.

Community Viz™ was used to develop one current and three possible future land use scenarios for the City of Laramie / Albany County aquifer protection overlay zone. Four scenarios were created for this project: (1) current conditions; (2) continuation of existing trends; (3) aquifer protection; and (4) density shift. Depicted in the *current conditions scenario* are the current land use, subdivisions and ownership patterns in the study area in the year 2000. The *continuation of existing trends scenario* projected current trends through 2050. The *aquifer protection scenario* is based on recommendations found in the Casper Aquifer Protection Plan for an overlay zone designed to protect groundwater from contamination. The *density shift scenario* placed subdivisions completely outside the Aquifer Protection Area just north of current city limits.

In the Scenario Constructor module of Community Viz™ results are measured quantitatively using indicators. Although the emphasis of the pilot project was on groundwater protection, it is recognized that land use decisions rarely are made on a single issue. For this reason a range of indicators encompassing environmental, economic and social concerns were evaluated for each of the four scenarios.

For the *Quality of Water* indicator, the *continuation of existing trends* scenario yielded the worst results at every wellhead. The *aquifer protection* scenario demonstrates significantly better results at the Turner wellhead, while it appears to not solve the long-term problem at the other three wellheads. For the *quantity of water* indicator, results are similar for the three scenarios. Still, there are implications to water consumption based on land use patterns. For the *local tax revenues* indicator, results are similar for the three scenarios. For the *cost of community* services indicator, results are dramatically different for the three scenarios. For the *traffic impacts* indicator results are fairly similar for current conditions, the continuation of existing trends scenario and the density shift scenario. There is, however, a spike in vehicle miles traveled in the aquifer protection scenario. For the *wildlife habitat* indicator, greatest impacts are found in the continuation of existing trends scenario. The *recreation impacts* indicator shows that the continuation of existing trends scenario has the least effect on access to public lands. The *visual impacts* indicator shows that the *aquifer protection* scenario would result in the greatest impacts to viewsheds within the study area. The riparian impacts indicator shows the *continuation of existing trends* scenario would result in the greatest impacts to riparian areas.

There are a number of recommendations that can be made based on the completion of the Phase I pilot project. Some of these recommendations relate specifically to implementation of the *Casper Aquifer Protection Plan*, while others pertain to the future use of Community Viz™ in Wyoming. Indications of sound land use policy can be found among the results; local staff, administrators, decision makers and interested citizens should review this study with the implementation of groundwater protection measures in mind.

In terms of digital geospatial data requirements, we have learned that an accurate and complete digital parcel layer is of primary importance. Of near equal importance is a database linking information on property values, land use and zoning classifications, property tax rate information, and building type to the parcel layer. In order to make use of the visualization capabilities of the software, it is recommended a community obtain high resolution remotely-sensed digital imagery (e.g. digital orthophotographs or satellite imagery) as well as precise locations of features in a community (e.g. building footprints) to assist in rendering three dimensional models of the built environment. Communities must be prepared to obtain or develop other thematic data specific to their project.

In addition to developing a geospatial data infrastructure, communities must invest resources in necessary computer hardware, computer software, professional staff and their training. In conclusion, this project found Community Viz™ to be a valuable tool for addressing planning issues in an objective and quantifiable manner. We recommend the Partnership and others continue to explore the potential for the use of planning support tools in augmenting the local community planning process by developing educational, marketing, and other outreach materials and assisting in securing funding for Community Viz™-assisted planning efforts. Opportunities in other application areas should also be investigated, including economic development, agricultural land preservation, watershed protection, open space planning, and wildlife habitat management.

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Chapter I
Introduction

This report documents the process and results of the Wyoming Community Viz™ Partnership's Phase I Albany County Pilot Project. The purpose of the pilot project was to serve as a "proof of concept" in demonstrating how the Community Viz™ planning support system software might be incorporated into a small town planning process in Wyoming. In addition, the project served to identify potential challenges for broader adoption of this suite of software tools in Wyoming, including digital geospatial data requirements, computing infrastructure and technological expertise. The application focus of the pilot project involved planning issues associated with implementation of a joint city/county aquifer protection plan for the City of Laramie in Albany County in southeastern Wyoming. The project analyzed three possible alternative future land use scenarios in the vicinity of municipal well fields and groundwater recharge areas and their impacts on water quality and related resource indicators.

Decision Support Technologies for Planning Applications

First developed for business applications in the 1970s, decision support systems (DSSs) are computer-based software applications that integrate database management systems, analytical models and graphics to improve decision-making processes (Densham 1991). Spatial decision support systems (SDSSs) are a special type of DSS focused on addressing problems with a spatial component and/or utilizing spatial analysis techniques in their approach (Malczewski 1999). Development of SDSS applications has advanced significantly over the last decade, following the increased accessibility of desktop geographic information system (GIS) technology. Planning Support Systems (PSSs) are a specific type of SDSS which "involve a wide diversity of geo-technology tools …developed to support public or private planning processes (or parts thereof) at any defined spatial scale and within any specific planning context," (Geertman and Stillwell 2003: 5). Typically GIS-based, PSSs are unique in their focus on planning needs and planning process-driven tools (Batty 1995). Unlike complex land use or resource modeling software, PSSs often take the form of a toolbox from which decision-makers can draw for assistance in decision management, providing tools for modeling, analysis and design, as well as communication, visualization and information dissemination functionality (Klosterman 1997; Batty 2003).

CommunityViz™

An example of a recent PSS application that bridges the gap between modeling and communication is Community Viz™, developed by the Orton Family Foundation (Rutland, VT). A modular system built on the ArcView GIS platform (ESRI, Inc.; Redlands, CA), Community Viz™ includes three integrated components: Scenario Constructor, 3D ModelBuilder, and Policy Simulator. Scenario Constructor provides functionality for assessing the potential impacts of specific, proposed land use actions by monitoring change in a series of associated indicators. 3D Modelbuilder allows three-dimensional display of landscape and structure information with real-time movement and object manipulation in a photo-realistic setting. Policy Simulator uses agent-based modeling to forecast probable land use, and demographic and economic changes given alternative governmental and community choices (Kwartler and Bernard 2001).

Since its release, Community Viz™ has been utilized in many planning applications from rural growth management (Mullen 2001) to urban redevelopment (Wendt 2002) and watershed modeling (Prisloe and Hughes 2002). This project focused on the Scenario Constructor component of the software. Scenario Constructor allows quantitative comparison of specific land-use alternatives using a "spatial spreadsheet" that can perform numerical computations on geographic data. "What if…" types of questions can be asked and evaluated by quantitatively and visually comparing different scenarios. Scenarios may be thought of as a group of alternate future conditions which, though all plausible, are each structurally different in form (van der Heiden 1996; Avin and Dembner 2001).

How This Report is Organized

The remainder of this report is organized into three chapters. Chapter II provides an overview of the project and the study area. Chapter III presents both the methods used and results obtained in the project. Chapter IV presents conclusions from the project and recommendations to the Partnership based on what has been learned from the pilot. Appendix A lists the individual participants in the Albany County Pilot Project as well as the members of the Wyoming Community Viz™ Partnership. Details on data sources used in developing the indicators and how the indicators were calculated are provided in Appendix B. Documentation of outreach efforts is provided in Appendix C.

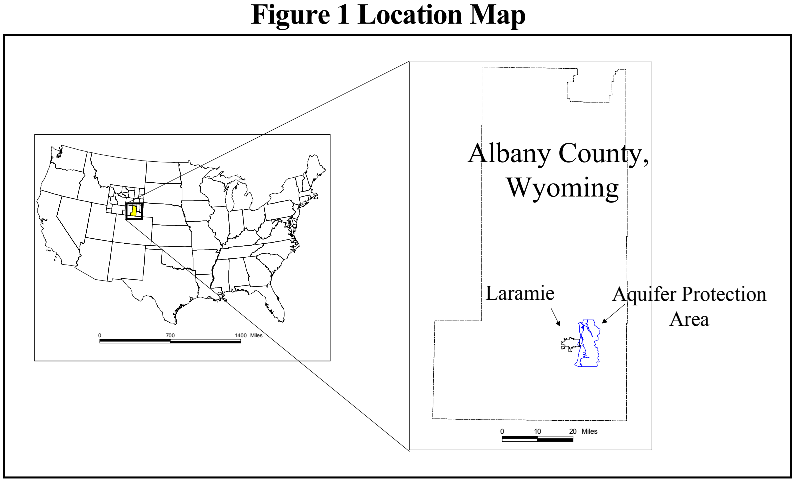
Chapter II
Study Area and Planning Issues

The Wyoming Community Viz^{TM} Partnership Phase I Pilot Project addressed the potential impacts of alternative scenarios on groundwater protection. In this chapter, the regional setting is described. This is followed by an overview of the issues associated with implementation of a local aquifer protection plan under different development conditions. Also introduced are several other land use issues which were evaluated for each scenario. These issues include fiscal impacts, aesthetic impacts, environmental impacts and traffic impacts.

Regional Setting

The study area for the project was focused on the primary groundwater recharge area delineated for the City of Laramie / Albany County, Wyoming's aquifer protection plan. Albany County is located in the high plains region of southeastern Wyoming (Figure 1). Most of the county is located in a cool and arid basin (< 12 inches of precipitation annually) containing the Laramie River watershed, a major tributary to the North Platte River system. The county is flanked on the west by the Medicine Bow Mountains and on the east by the Laramie Range. 27,204 of the county's 31,742 people reside in the city of Laramie (US Census Bureau, 2003), the county seat of government and home to the University of Wyoming. Interstate 80 runs east-west through the county. The Denver metropolitan area is centered 130 miles to the south along the fast growing Front Range region of Colorado.

Figure 1 Location Map



Land Use Impacts on Groundwater Quantity and Quality

The primary issue addressed in this project was land use impacts on groundwater quality. In 2002, the city of Laramie approved the implementation of an overlay zone based on the *Casper Aquifer Protection Plan*. In early 2003, Albany County approved a similar overlay zone. These are continued steps in a 17-year effort to protect the quality of the county population's largest source of drinking water[1].

The Casper Aquifer is the primary groundwater source of drinking water for the City of Laramie. It supplies approximately 50% of the city's drinking water and 100% of the drinking water to rural homeowners living on the Casper Aquifer[2]. Normally, the city supplements its drinking water supply using treated water from the Laramie River. However, in times of drought, all of the city's water needs must be met using groundwater from the Casper Aquifer (Welker 2002).

The purpose of the *Casper Aquifer Protection Plan* is to protect the recharge area of the Casper Aquifer, located along the western foothills of the Laramie Range mountains bordering the eastern edge of the Laramie city limits. The Plan follows requirements defined in the *Wyoming Wellhead Protection Guidance Document* (Wyoming Department of Environmental Quality 1998). Three different aquifer protection zones are delineated in the plan, accompanied by descriptions of known and potential contaminant sources within each zone and associated area-specific management guidelines (Welker 2002).

Groundwater from the Casper Aquifer is obtained through four different well fields. Figure 2 presents the city's well fields and their locations relative to the city limits and to the Casper Aquifer recharge area. All well fields are on fenced property owned and controlled by the City of Laramie. The well fields from north to south are: Spur Ridge, Turner, Pope Springs and Soldier Springs.

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[1] The Albany County Pilot Project is based on the June, 2002 draft of the Casper Aquifer Protection Plan.

[2] In this instance, "Casper" refers to the name of a specific saturated, permeable geologic unit, not the name of the city or county it serves.

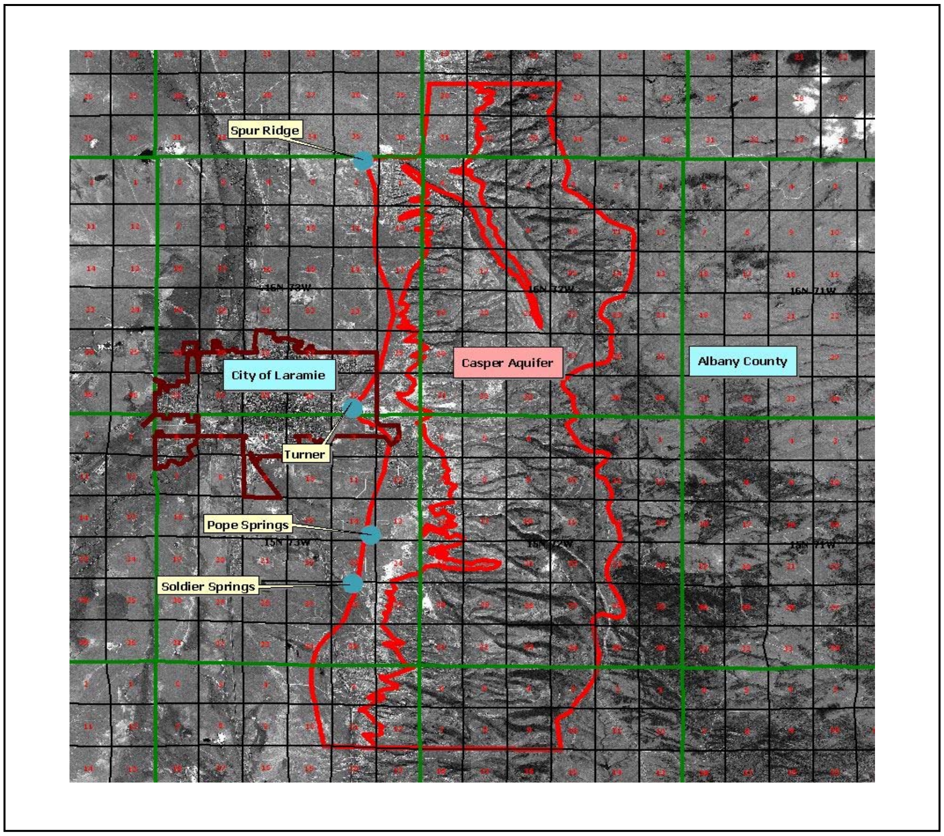


Figure 2 Aquifer delineation and protection zones

The aquifer protection area is divided into three zones (Figure 2). Zone 1 is located around each of the well fields and consists of a protection area with a 100 foot minimum fixed radius around each well. Zone 2, known as the primary protection area because of its greater degree of vulnerability and the greater number of existing wells, is located at the western end of the delineated aquifer protection area. The remainder of the delineated aquifer protection area is zone 3, known as the secondary protection area.

The *Casper Aquifer Protection Plan* makes clear that not protecting the aquifer is potentially a grave risk for the city and county. Once contaminated, aquifers are difficult and expensive to clean. Governments or other responsible parties may have to pay for site-specific studies, remediation and property damage. The cost effective approach is to prevent contamination before it occurs. Perhaps the best way to protect drinking water is through community planning before a source is contaminated.

A critical aspect of maintaining an aquifer is responsible community development. Development over an aquifer should keep the aquifer protection area free from additional contamination sources and free from excessive draw-down. Current development trends in the Laramie area may be putting the quality of its drinking water at risk. The county has for some time been seeing an increase in rural residential development in the recharge area of the aquifer. Residential growth in the Casper Aquifer is happening in the primary recharge zone due to the popularity of rural residences and the suitability of soils for development in this area. These developments are not connected to city water or city sewer. Consequently, each rural residence built in the aquifer recharge area has both a well and a septic system. The potential problems of treating sewage in a septic system in the aquifer recharge area are readily apparent. Of specific concern is an increase of nitrate levels contributed by rural residential septic systems in the groundwater.

The *Casper Aquifer Protection Plan* details both the problem of nitrate contributions from rural residential septic systems and a possible solution. The draft plan recommends an overlay zone with various restrictions within a delineated Aquifer Protection Area (nearly identical to the aquifer recharge area) to help protect the Casper Aquifer from contamination from septic systems.

Chapter III
Methods and Results

Scenario Development

Community Viz™ was used to develop one current and three possible future land use scenarios for the City of Laramie / Albany County aquifer protection overlay zone. Scenarios, from the Community Viz™ perspective, represent different patterns of development and in this case provide a way of quantifying and informing decision makers about the implications of each planning approach on the aquifer recharge area.

Four scenarios were created for this project: (1) current conditions, (2) continuation of existing trends, (3) aquifer protection, and (4) density shift. The current conditions scenario was based on data from the year 2000. The other three scenarios project year 2000 data into the future based on different development patterns. All scenarios reflecting future development were based on an increase of 1,331 new residences (calculated based on growth from 1990 – 2000) and are directly comparable. The increase in the number of new residences remains constant; the difference is in comparing and contrasting development patterns.

The scenarios were based on two critical criteria. First, renewable resources such as groundwater require a long-term view to maintain. Consequently, the planning horizon of the Albany County Pilot Project is 50 years. The scenarios project what the impacts of growth will be based on different development patterns in the year 2050. The second criteria used in creating scenarios was the rate of growth of residences in the delineated aquifer protection area. Albany County Assessor's data showed that residential development within the aquifer protection area increased at an annual rate of 2.5% between 1990 and 2000. The 2.5% growth rate would, over the course of the planning horizon, amount to an increase of 1,331 new residences in the aquifer protection area. This was the number of new parcels that were added to each scenario for future development.

Depicted in the ***current conditions scenario*** are the current land use, subdivisions and ownership patterns in the study area in the year 2000. For a map of current conditions, see Figure 3.

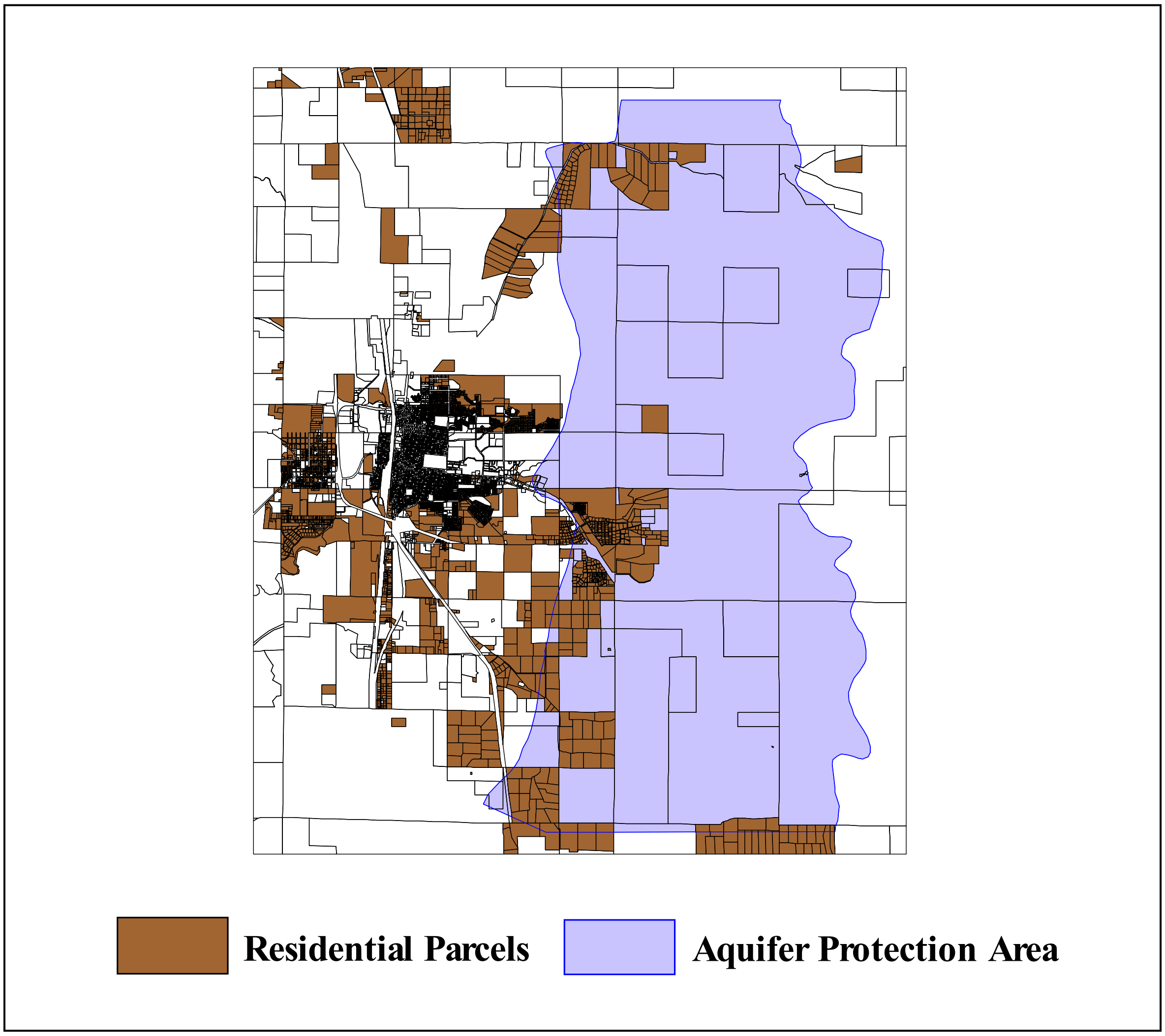


Figure 3 Current Conditions in the year 2000.

The ***continuation of existing trends scenario*** projected current trends through 2050. Development continues on the western edge of the aquifer protection area due to suitability of soils for building, favorable slopes and proximity to town. The map of this scenario (Figure 4) shows the increase in rural subdivisions in Albany County in the study area. Lot sizes in this scenario are based on the Albany County land use regulations:

1. Agricultural minimum lot size is thirty-five (35) acres.
2. Commercial minimum lot size is one (1) acre.
3. Industrial minimum lot size is one (1) acre.
4. Residential minimum lot size is five (5) acres.

In this scenario, proposed subdivisions contain parcels ranging in size from 5 to 40 acres. What are currently state-owned sections have been subdivided in this scenario based on the probability that these sections may be sold within the next 50 years.

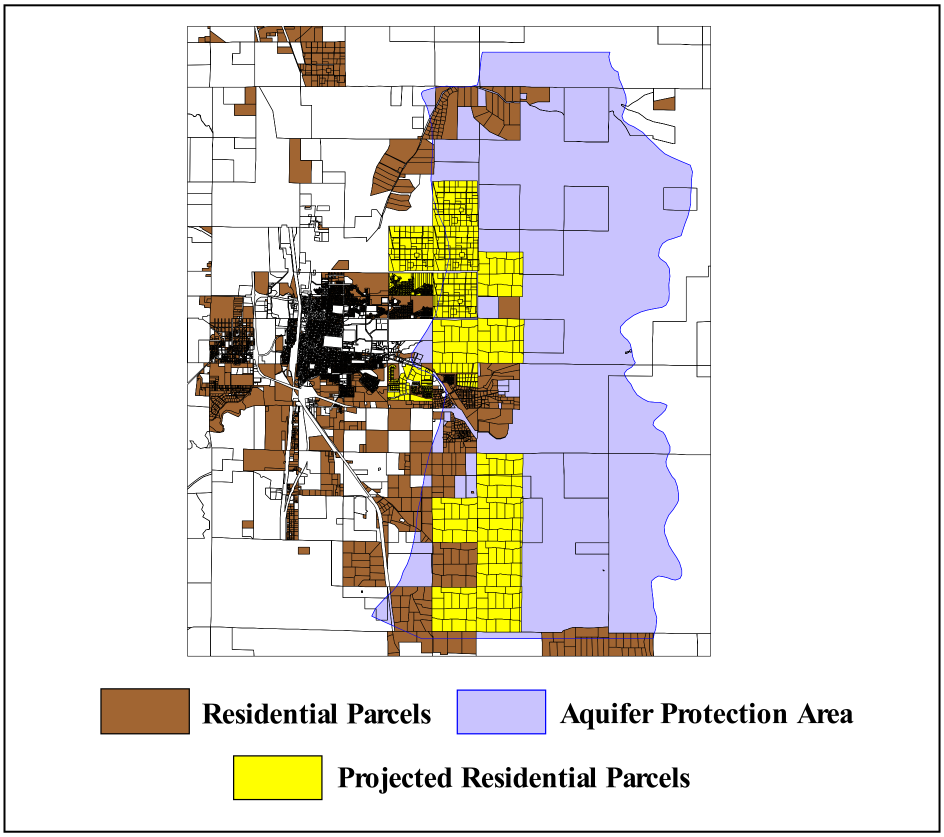


Figure 4 The Continuation of Existing Trends Scenario

The ***aquifer protection scenario*** is a more environmentally conscious approach to planning. The scenario is based on recommendations found in the Casper Aquifer Protection Plan for an overlay zone designed to protect groundwater from contamination (Figure 5).

Development impacts on vulnerable features (such as faults, hydrological features, etc.) are mitigated through careful placement of new residences on the landscape. Based on recommendations in the *Casper Aquifer Protection Plan*, subdivisions near city limits are annexed into the city so they may be connected to city water and sewer. Development is (a) kept 100 feet from recharge features, (b) 100 feet from faults and (c) built on suitable soils using a greater than 2% slope in consideration for the requirements of building mound-type septic systems. These criteria are generally site-specific. Results could be altered with improved site-specific data.

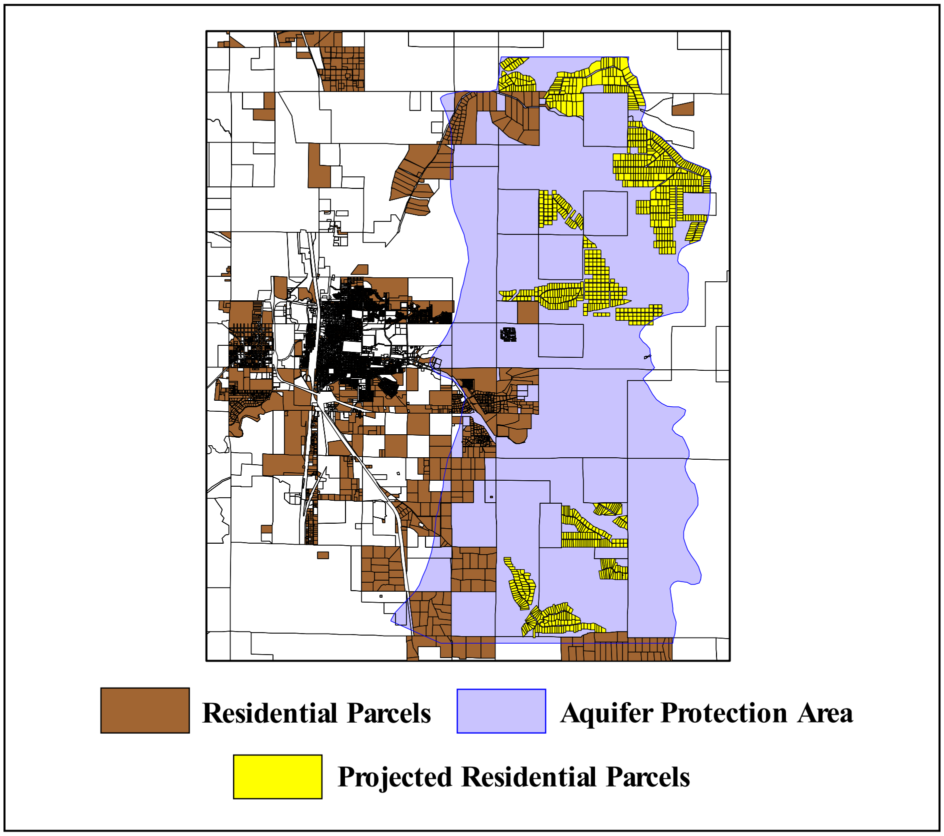
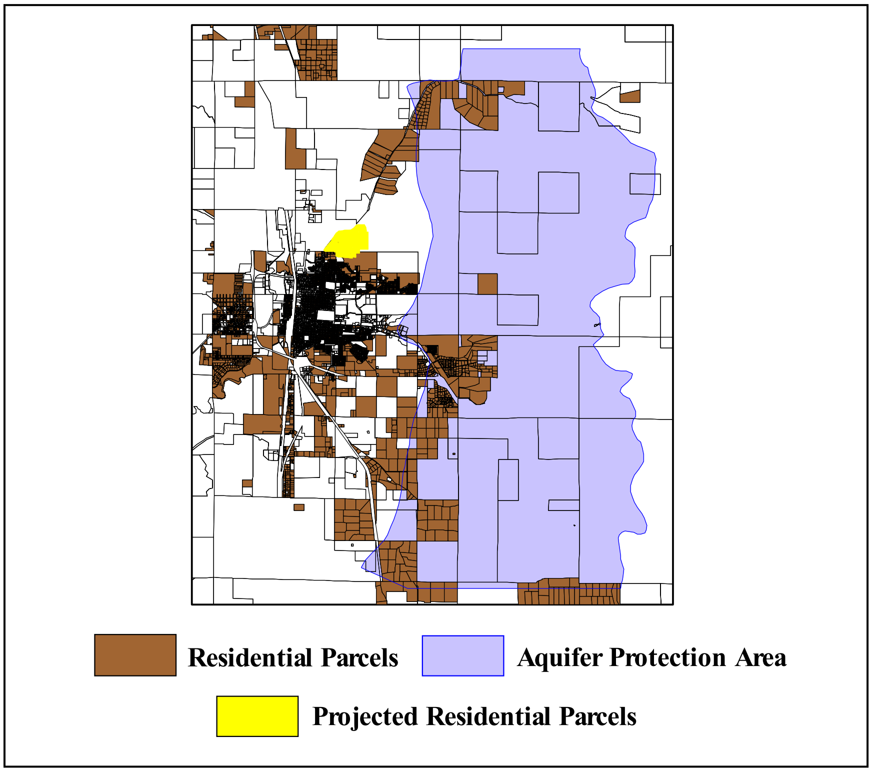


Figure 5 The Aquifer Protection Scenario

In the ***density shift scenario*** (Figure 6) projected subdivisions were placed completely outside the Aquifer Protection Area just north of current city limits. A single landowner owns the majority of the delineated aquifer protection area. Rather than spreading development across the area, the possibility exists of shifting the owner's development rights to just one portion of their land. This type of development is often referred to as cluster development, smart growth or traditional neighborhood design. It is a compact plan that has the same number of housing units as the other scenarios but in a smaller area with limited lot sizes. This results in a higher but very livable density. Such developments take advantage of density, which creates a concentrated demand for city services and amenities including local schools, shopping and places of worship.



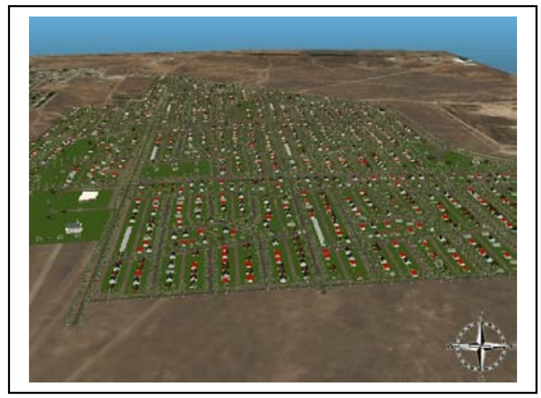


Figure 6 The Density Shift Scenario

Scenario Indicators. In the Scenario Constructor module of Community Viz™ results are measured quantitatively using indicators. Although the emphasis of the pilot project was on groundwater protection, it is recognized that land use decisions rarely are made on a single issue. For this reason a range of indicators were evaluated, encompassing water and other natural resource factors as well as economic and social concerns. Indicators included:

- *Quality of Water* (Nitrate Levels) -- summarizes the pollution implication of nitrates due to septic system failure.
- *Quantity of Water* -- summarizes the water used by the community as measured in gallons per day.
- *Local Tax Revenues* -- summarizes current government revenues and anticipated increases.
- *Cost of Community Services* -- summarizes costs of services.
- *Traffic Impacts* -- indicates the effects on traffic within the community as measured in vehicular miles traveled per day.
- *Wildlife Habitat* -- summarizes the impacts on predicted terrestrial vertebrate species habitat.
- *Recreation Access* -- summarizes access to public recreation lands.
- *Visual Impact* -- summarizes aesthetic impacts.
- *Riparian Area* -- summarizes the impacts on acres of riparian area.

Quality of water summarizes projected increases in nitrate levels based on increases in rural residences for the three scenarios. *Quantity of water* summarizes the water used by the community as measured in gallons. *Local tax revenues* summarizes current government revenues and anticipated increases in revenues. *Cost of community services* summarizes the cost of services the community is paying currently and can expect to pay. *Traffic impacts* measures changes in traffic volume as measured in vehicular miles per day per household. *Wildlife habitat* summarizes the impacts on predicted terrestrial vertebrate species habitat. *Recreation access* compares access to public lands suitable for recreation. *Visual impact* summarizes the visual and aesthetic impacts of the three scenarios. The indicator takes a quantitative approach to visual quality by looking at possible impacts to viewsheds as seen from road networks in the study area. *Riparian area* summarizes impacts on acres of riparian area.

Full details on data sources used in developing the indicators and how the indicators were calculated are provided in appendix B.

Results

In evaluating the results it is important to keep in mind three ideas. First and foremost, the future is a variable that citizens and decision makers control. Second, as previously mentioned, the planning horizon for this study is 50 years. All results were projected to the year 2050. Increases in nitrate levels and changes in other variables will be incremental over the course of the planning horizon and will continue to change as development continues in the years beyond 2050. Finally, the scenarios accommodate the same increases in growth and are directly comparable.

The evaluation of indicators resulted in numerical results specific to each indicator for each scenario. Nearly each indicator was measured using different units. For example, nitrate levels are in parts per million, traffic impacts are in vehicle miles traveled and revenues are in dollars.

Quality of Water. Figures 7a through 7d present nitrate concentrations in parts per million (ppm) at the four wellheads producing water for Laramie residents. The four wellheads are Pope, Soldier, Spur and Turner. Water quality results are similar at all but the Turner wellhead, where the nitrate concentration for the *continuation of existing trends* scenario is significantly higher. The Turner wellhead is located on the eastern edge of Laramie where growth pressure is considerably higher than in areas surrounding the other wellheads. As water movement through water-bearing strata over longer distances has a cleansing affect on water quality, the nitrate model weighs development near wellheads higher than development that is farther away. This suggests buffer areas around each wellhead are very important and activities that occur upslope (east) of these wells need to be closely monitored to protect the water resource.

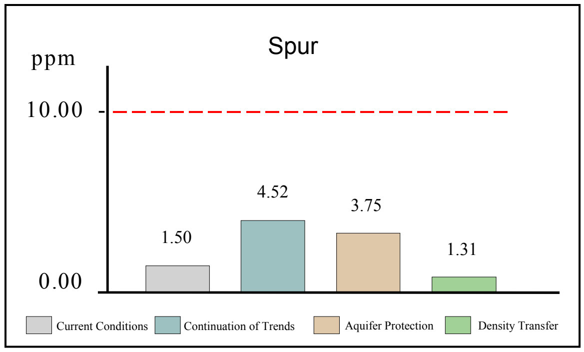


Figure 7a Nitrate Levels at the Spur Wellhead

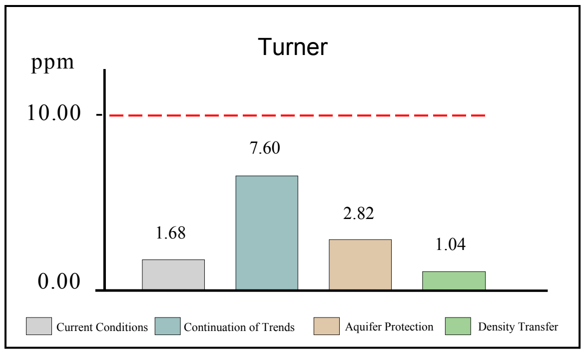


Figure 7b Nitrate Levels at the Turner Wellhead

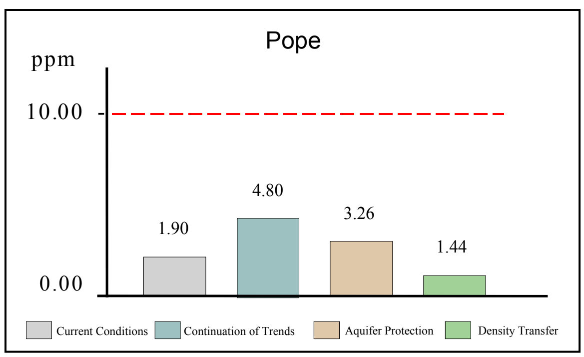


Figure 7c Nitrate Levels at the Pope Wellhead

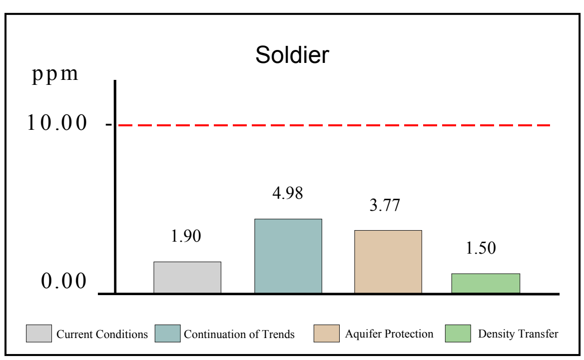


Figure 7d Nitrate Levels at the Soldier Wellhead

The *continuation of existing trends* scenario yielded the worst results at every wellhead. If the long-term value of this water resource is going to be retained, a planned approach to managing the resource will have to be adopted. The United States Environmental Protection Agency defines a nitrate threshold of 10 parts per million where water is unfit for human consumption. Every wellhead is rapidly approaching that threshold within the next fifty years in the *continuation of existing trends* scenario.

The *aquifer protection* scenario demonstrates significantly better results at the Turner wellhead, while it appears to not solve the long-term problem at the other three wellheads. The density shift scenario yielded the best results at all four well heads, yet this scenario presumes that development would not occur anywhere else in the aquifer protection zone and the concentrated development north of Laramie is all on city sewer and water. Cultural preferences suggest this scenario may be more difficult to implement than the others.

The *continuation of existing trends* scenario has expanded the city limits to include proposed development immediately southeast of Laramie known as the Turner Tract area. Under this scenario, if the Turner Tract area was developed using city water and sewer, the development would not contribute to increased nitrate concentrations at the Turner wellhead. However, since the Turner Tract area is located very close to the Turner well field, if this proposed development was not included in the city limits and services were not extended (i.e. these homes were developed using individual wells and septic systems) the impacts to water quality, mainly the nitrate levels, at the Turner well would be significant. Figure 8 depicts the results of excluding this development from city services (by placing them outside the city limits) in terms of nitrate concentrations at the Turner well. The result of this change pushes the level of nitrates above 10 ppm, thus making the water unfit for domestic use. The Turner Tract area does not cover a large area, however the effect this development could have illustrates how vulnerable water quality is to land uses near the city well heads.

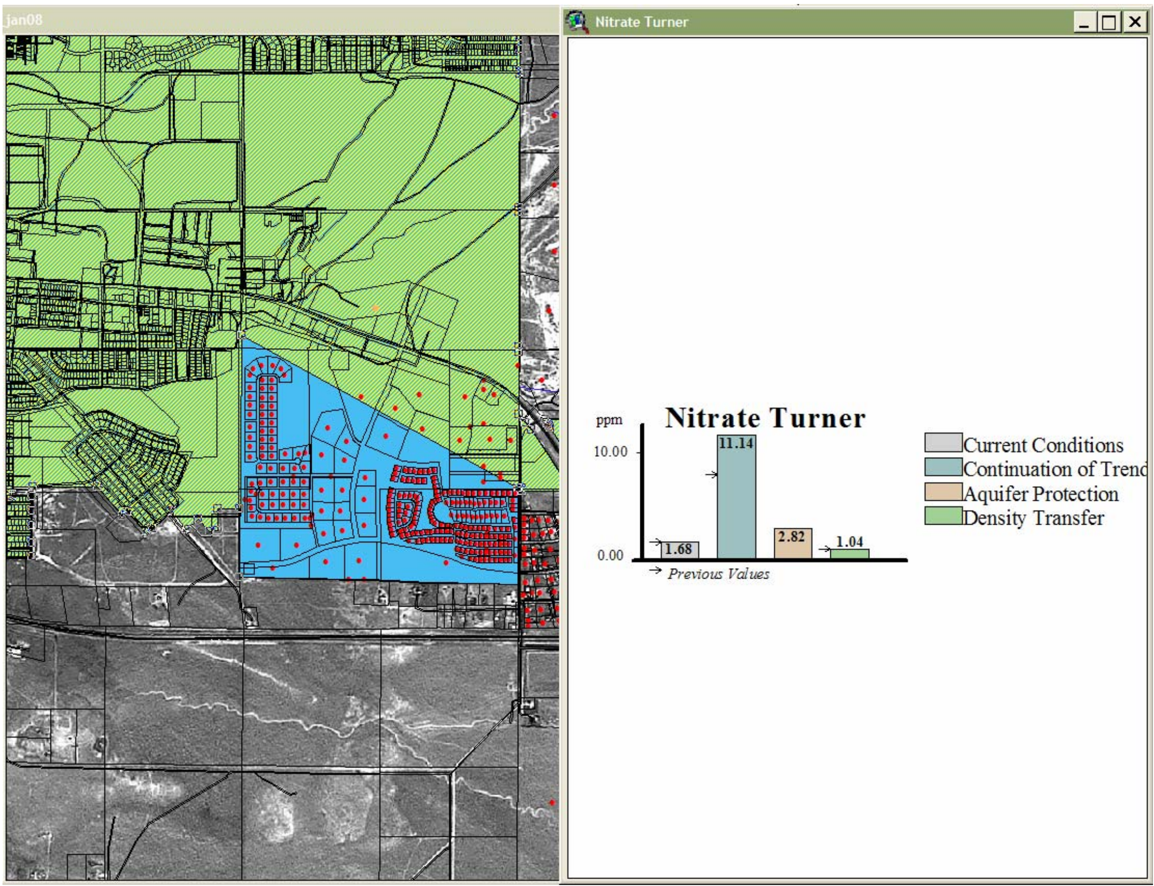


Figure 8 Alternate *continuation of existing trends*

The blue area reflects where city limits were adjusted to not include homes (red dots), thus development contributes to nitrate levels at Turner wellhead. This causes the nitrate levels to jump from 7.6 ppm to 11.14 ppm, significantly above the 10 ppm threshold for human consumption. The water resource is very vulnerable, as this blue area is presently outside the city limits and, based on this study, needs to be included at some point to avoid nitrate contamination of the aquifer.

Quantity of Water. The table below reflects water consumed by area residents in the summer when water usage is at its highest due to watering of lawns and other outdoor watering activities not associated with winter water use.

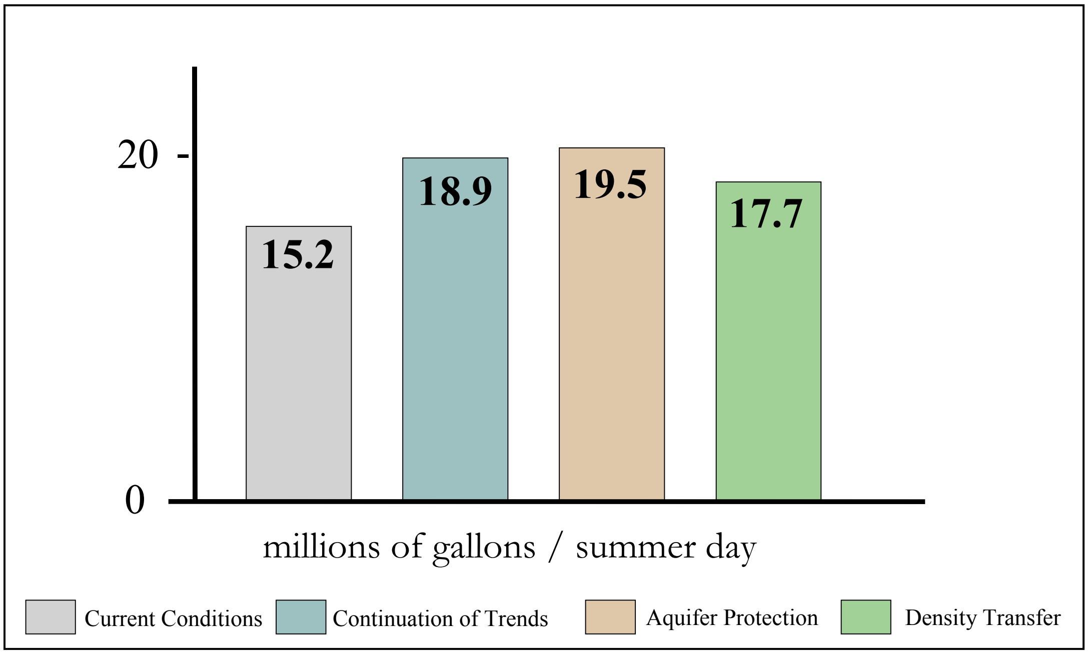


Figure 9 Quantity of Water Consumed

Results are similar for the three scenarios due to the identical increase of 1,331 residences in the study area. Still, there are implications to water consumption based on land use patterns. The large lot sizes (greater than five acres) of the *aquifer protection* scenario result in the greatest increase in water consumption over current conditions. Large lot sizes in the *continuation of existing trends* scenario yield the second largest increase in water consumed over *current conditions*. The *density shift* scenario also shows a significant increase in gallons per day consumed over current conditions, but relatively small lot sizes appear to minimize the impacts of water usage due to the increase in residences. The implication of the water use indicator is that irrigated lot size is a significant factor in determining overall water use for the community.

Local Tax Revenues. The figure below reflects government revenues in 2002 dollars.

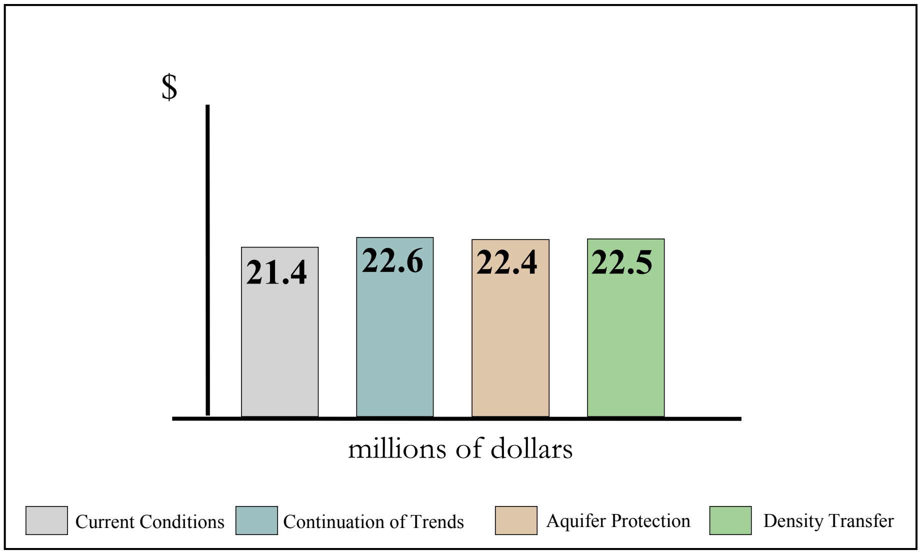


Figure 10 Local Tax Revenues

Results are similar for the three scenarios. As seen with the water consumption indicator, all scenarios address an identical increase of 1,331 residences in the study area. Differences are derived primarily from differences in property values in the type of residences expected in the three different scenarios. The larger lot sizes of the *continuation of existing trends* and *aquifer protection* scenarios imply higher property values (although not necessarily due to structures) based simply on area of land and result in slightly higher anticipated revenues.

Cost of Community Services. The graph below is an aggregation of service costs such as police, fire protection and roads. Values presented in cost of services estimates are in 2002 dollars.

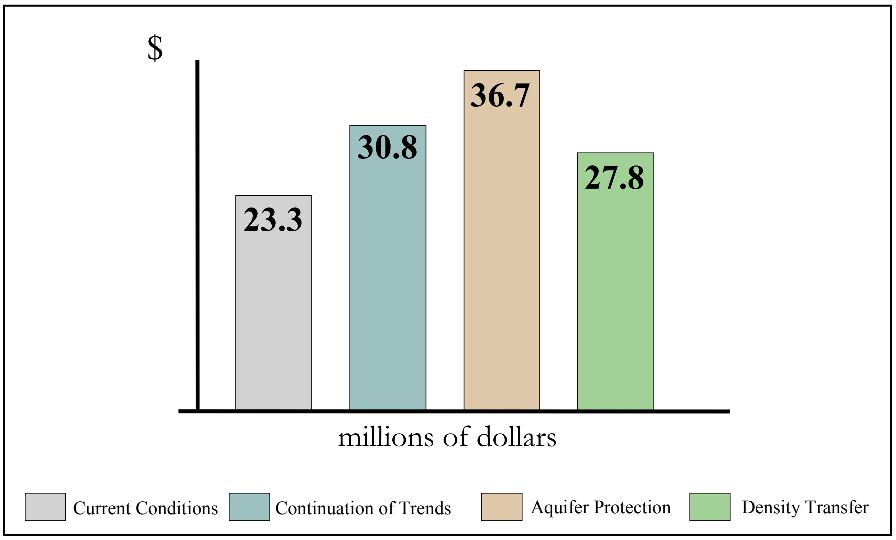


Figure 11 Aggregate Cost of Community Services

Results are dramatically different for the three scenarios--even though all scenarios address an identical increase of 1,331 residences in the study area. Variance is due in large part to the increase in average distance from a new residential parcel to the sources of various services provided in the community. It stands to reason that services such as police, fire and emergency medical as well as many other services will have cost increases associated with providing those services to residences further from town. Providing services farther from town is more expensive than providing those same services within city limits (Coupal 2003).

It is no surprise that the aquifer protection scenario, with new residential parcels built far from currently available services, yields the highest costs of services. The *density shift* scenario with all new parcels located adjacent to current city limits has the lowest costs of services increase. The *continuation of existing trends* scenario falls in between *aquifer protection* and *density shift* in terms of increased cost.

What is surprising is the magnitude of the differences in costs of services between the three scenarios. The *density shift* scenario is the least expensive but still projects an increase of approximately 4.5 million dollars over current expenses. The *continuation of existing trends* scenario projects costs of approximately 7.5 million over *current conditions* and the *aquifer protection* scenario projects costs of approximately 13.4 million dollars over current conditions. It is apparent that land use patterns will significantly affect costs of community services.

Traffic Impacts

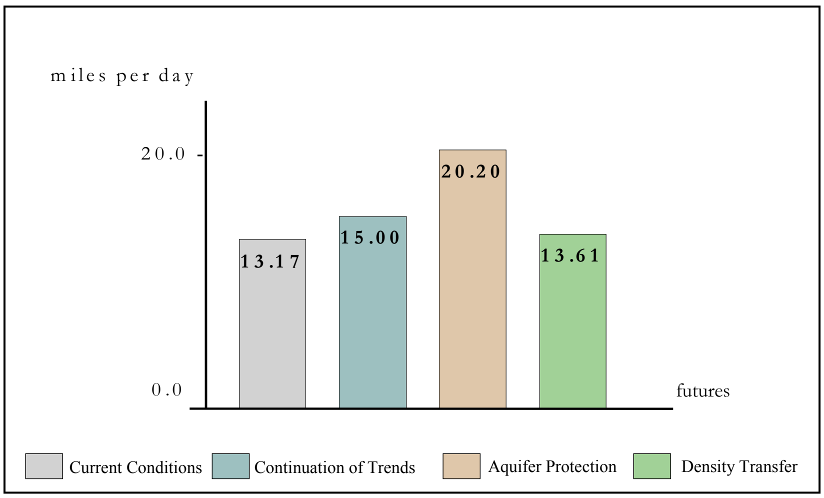


Figure 12 Traffic Impacts (Vehicle Miles Traveled)

Results are fairly similar for current conditions, the continuation of existing trends scenario and the density shift scenario. There is, however, a spike in vehicle miles traveled in the aquifer protection scenario.

Variance in this indicator is due exclusively to increases in average distance from a new residential parcel to destinations for a person's daily travel (work, school, shopping etc . . .). As would be expected, the density shift scenario with all new parcels located adjacent to current city limits has the smallest increase in vehicle miles traveled. The continuation of existing trends, with new residential parcels generally located at the eastern edge of town shows a moderate increase in daily vehicle miles traveled. The aquifer protection scenario, with development intentionally placed farther from the eastern edge of town (to protect the aquifer) demonstrates a substantial increase in daily vehicle miles traveled.

Wildlife Habitat. Figure 13 summarizes impacts to areas with greater than average predicted numbers of terrestrial vertebrate species, i.e. higher quality wildlife habitat. The chart shows impacts to wildlife habitat in acres. Higher numbers indicate greater impacts to wildlife habitat.

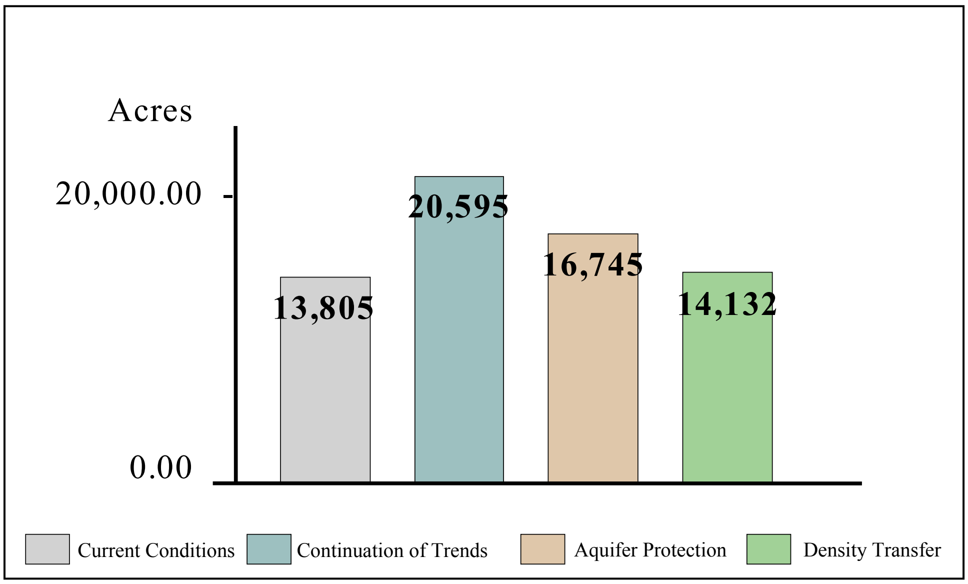


Figure 13 Wildlife Habitat

Results are significantly different for the three scenarios. Greatest impacts to wildlife habitat are found in the continuation of existing trends scenario. Most new residential development found in this scenario occurs where the Casper Formation subducts beneath the Sherman Granite. This is the area where city wells are located along with numerous natural springs. The presence of water indicates higher quality wildlife habitat. As the goal of the *aquifer protection* scenario is to protect theses resources, impacts on wildlife habitat from the *aquifer protection* scenario are significantly less than in the *continuation of existing trends* scenario. Still, development can be accommodated with the least impact to wildlife habitat resources with the *density shift* scenario. The limited lot sizes and relatively dense development will have a minimum impact on wildlife within the study area.

Recreation Access. Figure 14 presents average distance to open space via trails. The indicator shows that the continuation of existing trends scenario has the least effect on access to public lands. The greatest effect on recreation access is the density shift scenario, primarily because parcels are located relatively far from public lands, not because of any access restrictions inherent in the scenario.

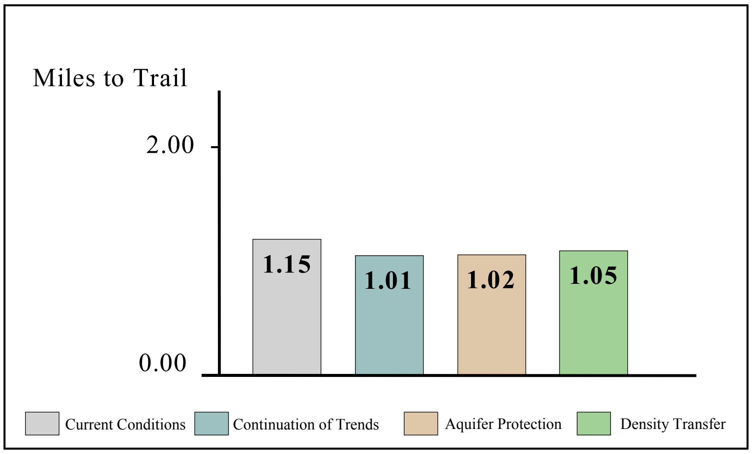


Figure 14 Recreation Access

Visual Impact. Figure 15 demonstrates relative levels of visual impacts. Values in the chart are unitless and therefore relative. Lower numbers indicate less visual impact and higher numbers indicate greater visual impacts of the different scenarios.

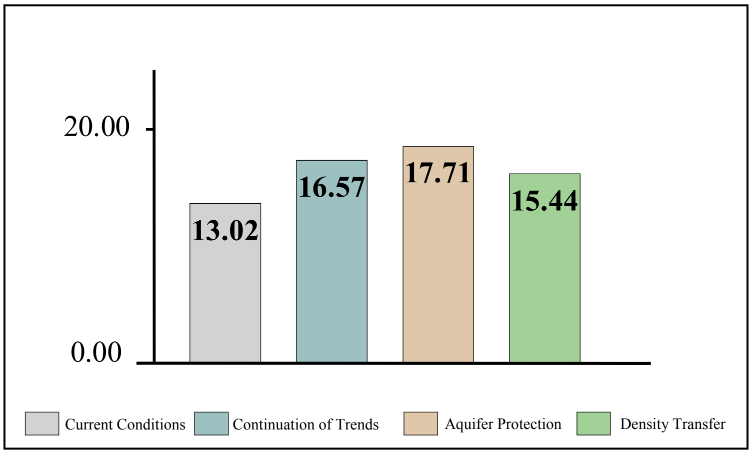


Figure 15 Visual Impact

The *aquifer protection* scenario would result in the greatest impacts to viewsheds within the study area. New development in the aquifer protection area is fairly dispersed and slightly elevated over current development or development proposed in the other two scenarios. Consequently, new development in the *aquifer protection* scenario can be seen from more places and has a greater visual impact.

In comparison to the *aquifer protection* scenario, new development in the *continuation of existing trends* scenario is both lower in elevation and more condensed; hence it has less of a visual impact. The *density shift* scenario, with higher density's and a more compact development has the least visual impact of the scenarios.

Riparian Area. Figure 16 shows the area of currently existing riparian area that would be compromised in each scenario. Larger numbers indicate greater acreages of riparian area one impacted per scenario.

The *density shift* scenario has absolutely no impact on riparian areas above and beyond what has already been impacted by currently existing development. Impacts on riparian areas from the *aquifer* *protection* scenario are also minimal as development is generally higher in elevation than the majority of riparian areas found in the study area. The *continuation of existing trends* scenario would result in the greatest impacts to riparian areas. New development in the *continuation of existing trends* scenario occurs in the area where we find our city wells. This is due to the numerous natural springs in these areas which consequently impacts wildlife habitat associated with these riparian zones than would be found when development is regulated as shown in the other two futures. This is an indication that regulations and planning in the placement of future development is necessary and supports what is shown in the proposed aquifer overlay zone keeping development away from natural riparian zones.

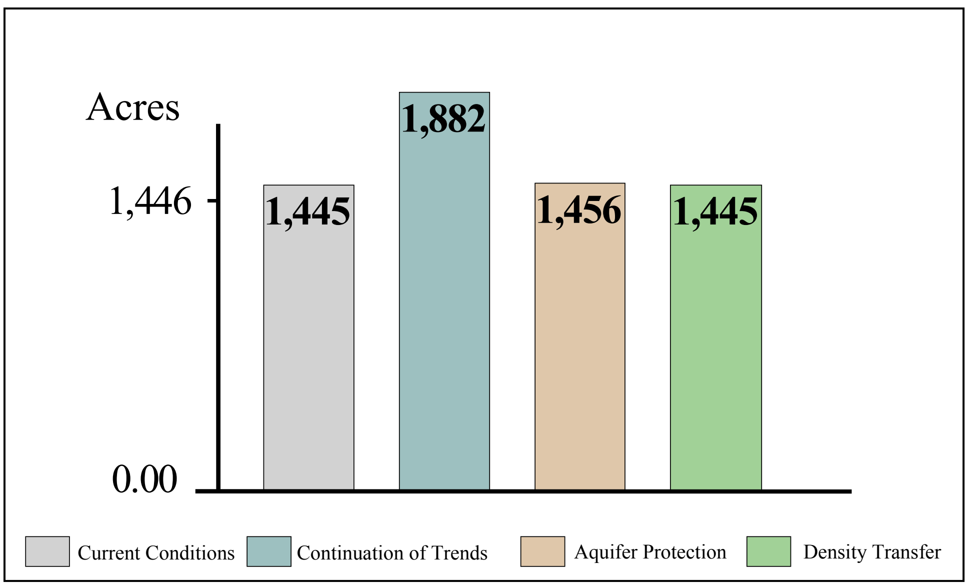


Figure 16 Riparian Area Impacts

Summary. The best way to compare scenarios is by comparing the results from each indicator and determining which scenario leads to the largest number of desirable outcomes. In order to allow for such an overview, the following matrix (Figure 17) summarizes outcomes for each indicator. Green is used to identify the scenario with the most favorable results. Red depicts least favorable performance, and yellow indicates a mid-level. In some instances there were minimal differences between most and least favorable.

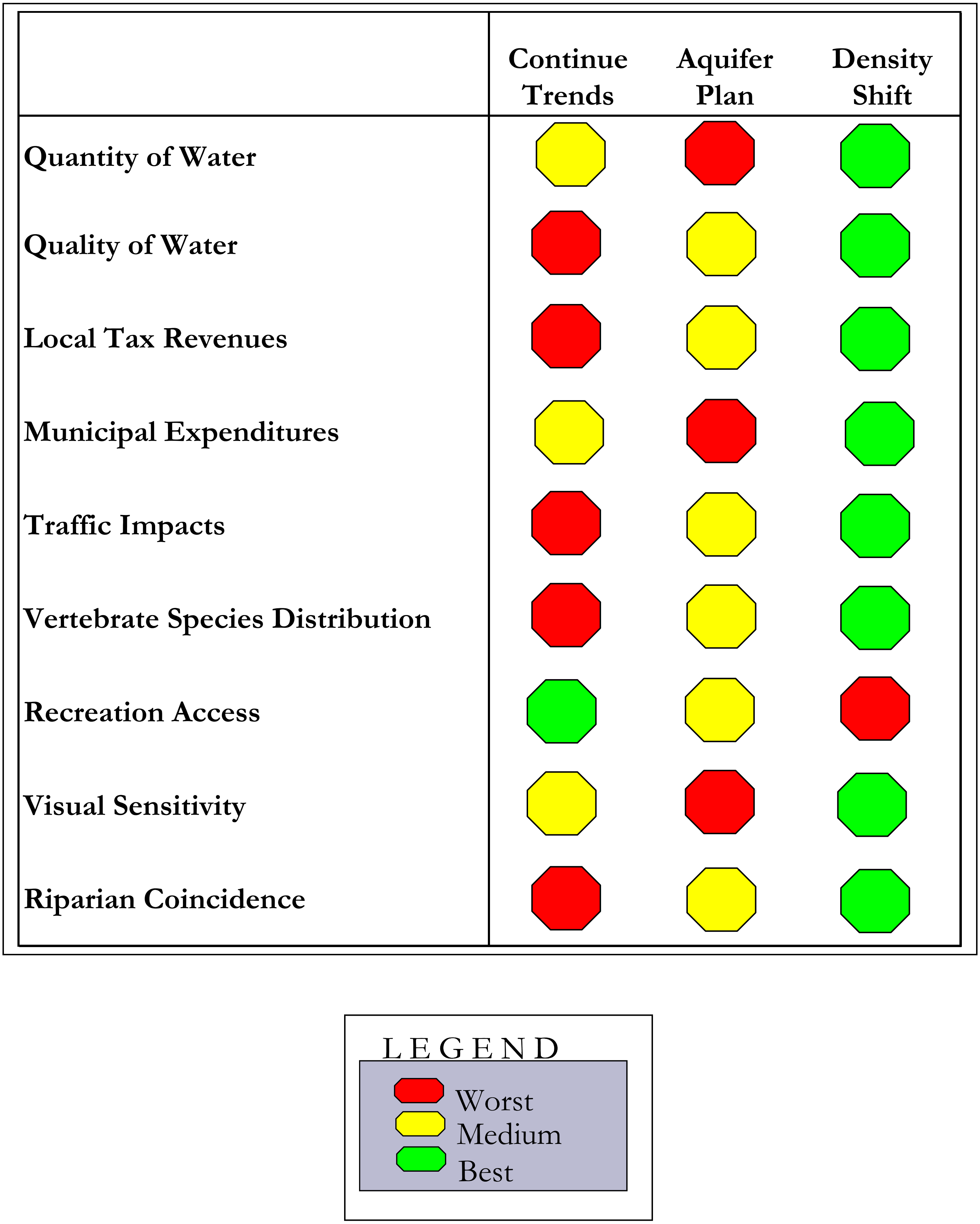


Figure 17 Indicator Summary Matrix

Chapter IV
Conclusions and Recommendations

There are a number of recommendations that can be made based on the completion of the Phase I pilot project. Some of these recommendations relate specifically to implementation of the *Casper Aquifer Protection Plan*, while others pertain to the future use of Community Viz™ in Wyoming.

Conditions for completion of the project were nearly optimal in terms of geographic information systems expertise, existing digital data and geographic proximity of the participants. Still, the project took twice the length of time to complete as originally anticipated. There were several reasons for this, including the time required to properly define and refine the indicators in the Community Viz™ software environment. Other reasons included the need to fine-tune the digital parcel layer, and the overall learning curve required to use Community Viz™ regardless of prior geographic information systems experience.

In terms of this project's impact on planning activities in the city and county, it is not our intention to prescribe discrete land use policy. Yet, indications of sound land use policy can be found among the results. The scenarios explored were selected, in part, because they reflect significantly different approaches to land use planning and noticeably varied land use patterns. There are other legitimate alternatives to these scenarios which the community may wish to explore. Local staff, administrators, decision makers and interested citizens should review this study with the implementation of groundwater protection measures in mind. It is recommended that a discussion involving the feasibility of each scenario be conducted to determine if the assumptions underlying the scenarios were realistic. For example, the major landowner in the aquifer protection area may conclude that shifting density to the northern edge of Laramie isn't in their best interest, even with a density bonus consideration. This discussion will inform any decision about potential land use policy recommendations in the aquifer protection area.

This project utilized the Scenario Constructor and Sitebuilder 3-D modules of Community Viz™. The project did not use the Community Viz™ Policy Simulator forecasting tool. However, the University of Wyoming team members are conducting research on a small, unfunded, agent based modeling experiment involving this application.

To guide the future use of Community Viz™ in Wyoming we offer the following recommendations. We hope the Partnership will consider these ideas as they move forward with future Community Viz™ activities.

In terms of digital geospatial data requirements, we have learned that an accurate and complete digital parcel layer is of primary importance. Of near equal importance is a database linking information on property values, land use and zoning classifications, property tax rate information, and building type to the parcel layer. In order to make use of the visualization capabilities of the software, it is recommended a community obtain high resolution remotely-sensed digital imagery (e.g. digital orthophotographs or satellite imagery) as well as precise locations of features in a community (e.g. building footprints) to assist in rendering three dimensional models of the built environment. Communities must be prepared to obtain or develop other thematic data specific to their project. For example, a project involving the protection of agricultural lands would require land productivity ratings or a habitat conservation project would require the predicted distribution of certain animal species.

In addition to developing a geospatial data infrastructure, communities should be prepared to invest resources in necessary computer hardware, computer software, professional staff and their training.[3] Such an investment must be accompanied by a strong commitment to integrate planning support system technologies such as Community Viz™ into their planning process. It is hoped the demonstration of such a commitment can be leveraged by The Partnership through such mechanisms as seed grant programs, technical assistance and support services.

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[3] More information on technical specifications is available from Community Viz™ at their website, www.communityviz.com.

We recommend the Partnership continue to support and build capacity for its current supporting infrastructure. When communities first begin using Community Viz^{TM}, they will benefit from outside assistance and expertise available from Partnership members, Community Viz^{TM}, or other planning or geographic information systems consulting firms. Resources available at the University of Wyoming include the Wyoming Natural Resources Data Clearinghouse, a statewide geospatial data repository hosted by the Wyoming Geographic Information Science Center (WyGISC). Data available include statewide coverages of elevation, soils, roads, vegetation, wildlife habitat, cultural features and census demographics. WyGISC also maintains a state-of-the-art computer training facility with multiple seats of Community Viz^{TM} and supporting Environmental Systems Research Institute, Inc.(ESRI) software applications. The William D. Ruckleshaus Institute of Environment and Natural Resources can provide valuable assistance with policy development, public processes and provides resources on land resource management issues through the Wyoming Open Spaces Initiative and other natural resource and environmental programs.

In conclusion, this project found Community Viz^{TM} to be a valuable tool for addressing planning issues in an objective and quantifiable manner. We recommend the Partnership and others continue to explore the potential for the use of planning support tools in augmenting the local community planning process by developing educational, marketing and other outreach materials and assisting in securing funding for Community Viz^{TM} assisted planning efforts. Opportunities in other application areas should also be investigated, including economic development, agricultural land preservation, watershed protection, open space planning and wildlife habitat management.

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Appendix A
Contributors

Pilot Project Participants

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Katy Mays, Project Coordinator, Ruckleshaus Institute, University of Wyoming

Steve Mullen, Senior Associate, Community Viz™

Partnership Members *(as of July 2002)*

This partnership became known as the Wyoming Community Viz™ Partnership and consists of the following organizations:

- The Wyoming Business Council
- The Wyoming Rural Development Council
- The Wyoming Community Foundation
- The University of Wyoming
- Community Viz™ / The Orton Family Foundation
- The Wyoming Chapter of The Nature Conservancy and,
- Numerous Wyoming Communities

Appendix B
Procedures & Data

An indicator is a scenario-based computation. It is defined via the Scenario View Properties window (Orton Family Foundation 2002). Indicators allow direct quantitative assessment of differences between scenarios. From the Community Viz™ Scenario Constructor version 1.3 User Manual the description of an Indicator is:

> In the Scenario Analysis process, the consequences of alternatives are evaluated by monitoring the effect of changes on the Scenario Indicators. An Indicator is a measured or computed value. Indicators must have targets that represent specific Scenario goals (e.g. average walking time to transit stops should be less than 10 minutes). In Scenario Constructor, Indicator results are recomputed automatically as Scenario alternatives are proposed (Orton Family Foundation 2002).

Water Quality. Because the Albany County Pilot Project is looking at development alternatives in an environmentally sensitive area, and the primary concern is aquifer contamination by nitrates, the quality of water indicator is the most important indicator used in this project.

The primary data source in determining current conditions for the water quality indicator was the City of Laramie's "2001 Drinking Water Quality Report". The report contains the following chart from which we based our assessment of current conditions:

Table 1: Inorganic Constituents

Constituent	Sample Site	Violation	Amount	MCL,	MCLG,	Likely Source
		Yes/No	*Detected, ppm*	*ppm*	*ppm*	*Contamination*
Nitrate (As Nitrogen)	*Turner*	*No*	*1.7*	*10*	*10*	*Run-off from fertilizer use; leachate from septic tanks; erosion of natural deposits; Sewage*
	Pope-Soldier	*No*	*1.9*			
	Spur	*No*	*1.5*			
	Surface Source	*No*	*<1.10*			

The report explains the problem with excess levels of nitrate in drinking water:

> Nitrates in drinking water at levels above 10 ppm are a health risk for infants less than 6 months of age. High nitrate levels in drinking water can cause Blue Baby Syndrome. Nitrate levels may rise quickly for short periods of time because of rainfall or agricultural activity (City of Laramie 2002).

This project did not use the nitrate model presented in the *Casper Aquifer Protection Plan*. Instead, expertise on the City of Laramie Environmental Advisory Committee was used in the development of a new model which based nitrate concentrations at wellheads on both model contributions of current septic systems and distance from individual septic systems to wellheads. This has been implemented using the following procedure for nitrate concentration calculations:

1. As separate fields in **Septic2.shp** (the septic system computer file), calculate the inverse of the distance (1/ distance) from each septic system to each wellfield.
2. Using ArcView's Field/Statistics and the fields created in step one, get the sum of the inverse distances from all septic systems to each well:
3. As separate fields in **Septic2.shp**, calculate the contribution of NO to each well from each septic system using the equation:

[Dist_Turner Inverse] * (1.7/0.0344283239)

Where 1.7 is the known concentration of nitrates at the Turner wellfield 2002 and 0.0344283239 was calculated in step two. The idea of using the reciprocal of the distance from a septic system to a wellfield is that septic systems closer to a given well are going to impact that well more than systems located farther away from that well.

4. Estimates of NO are found in indicators. For the futures, calculate the centroid for each new parcel. Assume these centroids are new septic systems.
5. In order to have the Nitrate indicator be sensitive to changes in the city limits—i.e. the city expands water and sewer and eliminates septic systems a new field was added to **Septic2.shp**. The new field is a boolean "City Limits".

Environmental Advisory Committee expertise corroborated the constraints put on development in the aquifer protection scenario and the hypothetical use of mound septic systems in the scenario as a technological fix to the problem soils that are largely unsuitable for development within the delineated aquifer protection area..

Water Quantity. The Water Quantity indicator and supporting calculations are based on data published by the City of Laramie in June of 2002 in their document, *2001 Drinking Water Quality Report*. The report indicates Laramie water consumption of 12.6 million gallons per day in the summer and 5.5 million gallons per day in the winter (City of Laramie 2002).

Calculating water quantity involves the following steps:

1. The first step was to define the variable "WaterPerPersonPerDay". The value of 202.2 gallons is equal to 5.5 million gallons per day winter usage divided by a city population of 27,204.

2. The second variable used is "Peop/Parcel". It is defined as 3.896 for the study area. It is based on a study area population of 27,204 for the city, a study area population of 1,724 for the included area of the county lying outside the city limits and a total of 7,425 residential parcels in the study area:

3. The third variable is "Wat/AcRes" or water consumed per day per residential acre. The value of 2,864.7 gallons per acre is based on an additional usage of 7.1 million gallons in the city of Laramie in the summer months (12.6 million gallons summer - 5.5 million gallons in the winter) divided by 2,478.45 acres of residential property in the study area.

4. The final variable is "Irrigated area per residential parcel outside the city limits." Initial value is 0.75 acres per residential parcel and this can be adjusted with a slider bar.

5. Based on the defined variables, the field "WatUsePersons" in the file **Parcelscviz2.shp** is calculated by multiplying &Peop/Parcel& * &WaterPerPersonPerDay&. Also calculated in the file **Parcelscviz2.shp** is the field "WatUseAc", or water use per acre. Different calculations are need based on whether the parcel is inside or outside the city limits. For parcels within the city limits "WatUseAc", is calculated by multiplying the variable &Wat/AcRes& by the acre of each parcel using the formula: &Wat/AcRes& * ([Area] / 43560). For parcels outside the city limits "WatUseAc", is calculated by multiplying the variable &Wat/AcRes& by the variable Irrigated/res parcel city= "false". So, "WatUseAc" is calculated using the formula:

```
X.IIf (
([City Limits] = true), &Wat/AcRes& * ([Area] / 43560),
([City Limits] = false), &Wat/AcRes& * &Irrigated / res parcel city = _false_&, 0)
```

Note that "WatUseAc" is calculated for all parcels. The data is only meaningful for residential parcels, so be sure when using these values to select for classcodei = "R". The indicator *Water Use, Total* is the sum of "WatUsePersons" where classcodei = "R and "WatUseAc" where classcodei = "R". Results are reported in the indicator *Water Use, Total* which is calculated by summing "WatUsePersons" and "WatUseAc" for residential parcels using the following formula:

Local Tax Revenue. The Indicator Local Tax Revenue can be broken down into three parts: property tax, sales tax and lodging tax. Supporting indicators are: *Tax_Property_Total* and *Tax_Sales_Total*, These are summed to created the Indicator *Revenues Total*. Estimates for current (2002) conditions are as follows:

Tax_Property_Total = $ 9,439,327
Tax_Sales_Total = $ 11,969,262.14
Revenues Total = $ 21,408,589

According to the Albany County Assessors records for tax year 2002 total assessed valuation for the incorporated area of the City of Laramie is $115,470,159 for total taxes of 8,306,923.24. Intersecting **Parcelscviz2.shp** with the Laramie zoning shapefile in order to determine city limits and summing property taxes for the city produces a result of $8,306,960.58—extremely close to the actual data the difference can be explained in dollar rounding. Taxes for the rest of the district (which our study area is a part of) are 4,351,987.84. In order to develop estimates of property taxes paid for properties in the three futures (properties that do not exist at this time) it is necessary to estimate both land values and building values for those properties. Assessed values for new parcels are estimated in the field "TaxValCompute". Estimated Assessed value is based on three variables (mean land value, mean home value and average lot size), both in and out of the city limits:

	Within City Limits	Outside City Limits
Mean land value	$ 20,968	$ 27584
Mean home value	$ 97,915	$ 101,408
Avg lot size	25359 ft / 43560 ft/ac	558017 ft / 43560 ft/ac
	0.582 acres	12.8 acres
Land value / acre	$36,017	$ 2,153.27

These numbers are reflected in the following variables:

Tax-CountResHomVal = $ 101,408
Tax-CountResLandVal/Acre = $ 2153.27
Tax-TownResHomeVal = $ 97,915
Tax-TownResLandVal/Acre = $ 36,017

All variables are used in the calculation of the field “TaxValCompute” in the file Parcelscviz2.shp. The formula determines, for each parcel, an estimated assessed value based on the above variables. The formula is as follows:

X.IIf (
([City Limits] = True), &Tax-TownResHomeVal& + (&Tax-TownResLandVal/acre& * [Area] / 43560),
([City Limits] = False), &Tax-CountResHomeVal& + (&Tax-CountResLandVal/Acre& *
[Area] / 43560),0)

To derive the indicator in the current conditions scenario, the “assessed value” field in **Parcelscviz2.shp** is summed where Future = “False”. To derive the indicator in the futures, the “assessed value” field in **Parcelscviz2.shp** is summed where Future = “False” and added to this is the sum of “TaxValueCompute” where Future = “True” using the formula:

X.Sum ([** Parcelscviz2:Assess_val], ([** Parcelscviz2: Future] = false)) + X.Sum ([** Parcelscviz2: TaxValCompute], ([** Parcelscviz2: Future] = true))

Tax_Sales_Total is calculated based on the FY 2002 Sales and Use Tax distribution report published by the Wyoming Department of Revenue. Included in the data are Sales and Use Tax under the General Purpose Option, sales and use tax under the Specific purpose option, state sales tax and state use tax. Numbers were divided by the number of households in the city and in the area of the county (from 2000 census data) included in the study area to obtain a number for sales tax per household.

The variables “Households City” and “Households County” are based on 2000 census data and stay the same for all scenarios. These numbers are used in calculating the variable “Sales Tax per Household” for the study area. They are based on 773 residential parcels outside city limits) from Qvizparclip1.shp and2.23 people per household in Albany County, Wyoming from U.S. Census 2000 Table DP-1 Profile of Demographic Characteristics: 2000 Albany County, WYSales Tax FY 2002 per household in the study area. There are:

13, 269 households in the county
11,336 households in the city
773 households located in the study area, lying outside the city.
So, 11,336 + 773 households in the study area = 12109

12,109 / 13269 = 0.9125782 % of county households are in the study area.

0.9125782 * Sales Tax FY 2002 (13,115,901.50) = $11,969,285.78 Sales Tax FY 2002 which can be attributed to the study area. This calculates as $11,969,285.78 / 12109 = $988.46 in sales tax per household in the study area.

For the scenarios, additional households are determined by querying "Parcelscviz2.shp" for parcels where "Future = True" and "Classcodei = "R". These are counted and added to the 12,109 households in current conditions. This new value is multiplied by $988.46 in sales tax per household for each parcel. These values are then summed to determine the indicator *Tax_Sales_Total.*

Cost of Community Services. The cost of community services indicator is based on data obtained in, *City of Laramie, Wyoming Operations Equipment Capital Improvement Plan. Annual Budget, July 1, 2001 – June 30, 2002.* Expenses looked at in the Albany County Community Viz Pilot are:

Administrative
Aggregate / Total
Community Services
Fire Department
General Fund
Police Department
Public Works
Solid Waste
Wastewater
Water Fund

Each of the above expense categories are used in creating two variables. The first is "Expense_Variable_Name". The second variable is "Expense Variable Name per unit" The unit is "Expense Distribution", a field in the **parcelscviz2.shp** file. Expense distribution is the linear distance to the parcel from the **LaramieCenter.shp** point file multiplied by the estimated population of that parcel.

Population is based on data from the U.S. Census Bureau (US Census Bureau) on persons per household in the City of Laramie and Albany County. For non-residential parcels persons per household is defined as "1". This has the advantage of a commercial entity contributing to the community's expense, but lacks a more sophisticated weighting because of lack of data. All values for Expenses are in dollars.

Indicators used in developing costs of community services totals:

Expense Administrative
Expense Community Services
Expense Fire Department
Expense General Fund
Expense Police Department
Expense Public Works
Expense Solid Waste
Expense Total
Expense Wastewater
Expense Water Fund

These indicators are calculated by multiplying the "Expense Variable Name per unit" by the new expense distributions found in the modified **parcelscviz2.shp** files found in each of the three futures.

Vehicle Miles Traveled. Traffic Impacts are quantified using the Indicator *Vehicle Miles Traveled*. Variables in support of this indicator show the number of trips per day from a household to everyday destinations. Data were provided by Steve Mullen at Community Viz™.

The variables are:

Variable	Value
TripCivic	1 trip
TripEntert (entertainment)	1 trip
TripSchool	4 trips
TripWork	2 trips
TripShopping	2 trips

The final indicator, *Vehicle Miles Traveled*, is supported by calculations in four other indicators. This indicator calculates the average trip distance from residential parcels (classcodei="R") to civic, entertainment, school and work destinations. The indicators are:

TripDistEntert
TripDistCivic
TripDistSchool
TripDistShopping
TripDistWork

Formulas for all four indicators are nearly identical. As an example, the following is the formula for *TripDistWork*:

((X.Mean ([** Parcelscviz2: DistWork], ([** Parcelscviz2: Classcodei] = "R"))) * &TripWork&) / 5280

This is where the distance to work is calculated from every parcel to a representative work location, represented by a point in the centroid of each parcel with in the study area. Similar values are calculated in the **Parcelscviz2.shp** file for distance to civic, entertainment and school. Data are recorded in the fields: DistCivic, DistEntert, DistSchool, DistShop and DistWork.

Distances are calculated from every parcel to point locations representing Civic, Entertainment, school and work in the **destinations2.shp** file. Also included in this file is a representative shopping location. In calculating the indicator these values are selected for residential parcels, multiplied by the aforementioned variables which indicate trips per day, divided by 5280 to obtain a value in miles and averaged. The indicator ""Vehicle Miles Traveled" is a summation of the indicators *TripDistEntert*, *TripDistCivic*, *TripDistSchool* and *TripDistWork* using the following formula:

!TirpDistEntert! + !TripDistCivic! + !TripDistSchool! + !TripDistWork!

Wildlife Habitat. The wildlife habitat indicator addresses habitat impacts to predicted terrestrial vertebrate species distributions under different development alternatives. The variable "HabThresh" is the average habitat value for residential parcels under current conditions 2003 based on **Vertmodel1box.shp**. The value is 110. It is used to calculate the field "AveHabVal" in **Parcelscviz2.shp** using the formula:

X.GetFromClosest ([Vertmodel1box:All_rich])

The field “AveHabVal” is used in calculating another field in **Parcelscviz2.shp**. The field “HabThreshCalc” is: X.IIf (([AveHabVal] >= &HabThresh&), 1, 0). It is a boolean field with a value of either 1 or 0.

The initial indicator is called *HabImpactRe*s. It’s the area of predicted terrestrial vertebrate species habitat that is better than the average. Formula:

(X.Sum ([** Parcelscviz2:Area_Feet], ([** Parcelscviz2:Classcodei] = "R") And
([**Parcelscviz2:HabThreshCalc] = 1)))/43560

From the metadata, the data in **Vertmodel1box.shp** are described as follows:

> This dataset contains the predicted distributions of 445 terrestrial vertebrate species in Wyoming, created in a GIS modeling process using species habitat association rules in combination with species geographic range.
>
> The purpose of the vertebrate species maps developed for gap analysis is to provide more precise information about the current distribution of individual native species within their general ranges than is generally available from published range maps. Range maps, which rely only on the location of specimens, do not include information on the ecological conditions that favor the presence of the species. Habitat features, such as vegetation, can enhance traditional approaches despite some limitations (Scott et al. 1993). Using both point locality records and habitat conditions, these predicted distributions provide better estimates about the actual amount of habitat area and the nature of its configuration.

Besides gap analysis, the predicted terrestrial vertebrate species distributions may be used to answer a wide variety of management, planning, and research questions relating to individual species or groups of species.

Recreation Access. The Recreation Access indicator quantifies the average distance to recreational access from residential parcels. Values are calculated from the file **traillink.shp**. The **traillink.shp** file was developed from the 1995 TIGER roads file for Albany County and modified for each scenario to show access from residential parcels to public lands.

The indicator *RecAccessTrailDistance* is calculated using the formula:

X.Mean ([** Parcelscviz2:RecAccessDist], ([** Parcelscviz2:Classcodei] = "R"))

The field “RecAccessDist” measures straight-line distance to closest feature in **traillink.shp** the result will be in Miles and is calculated using the formula:

X.MinDistance ([Traillink:]) * #Miles per Foot#

Visual Impact. The visual impact indicator quantifies the abstract concept that different development patterns will be of different aesthetic qualities. As the conventional wisdom is that in Wyoming we value our open spaces, we based our qualitative assessment of development aesthetics on how much new development can be seen from common observation points. The analysis is based on a series of points (1/4 mile apart in the file visualquality2.shp) along major roads (quartermile2.shp) Arcview’s Spatial Analyst was used to create a grid (vizquality100) indicating how many points can see a particular cell on the map. The scale was changed from “1 to 62” to “1 to 100” so it could be understood more intuitively. The field “AveVisValRes” in Parcelscviz2.shp finds the Average Grid Value for each parcel from theme 'Vizquality100' using the formula:

X.GridMean([Vizquality100:Value])

Visual impact is evaluated with the *Frequency Scene Index* indicator. It is the Average value from attribute AveVisValRes in theme ** Parcelscviz2 where Classcodei = "A” OR Classcodei = "R" using the formula:

X.Mean ([** Parcelscviz2:AveVisValRes], ([** Parcelscviz2:Classcodei] = "R") Or ([** Parcelscviz2:Classcodei] = "A"))

The bigger the number, the more visual impact development has. The lower the number the less visual impact a development has, helping maintain our expansive views and open spaces.

Riparian Area. The field Riparian Area in Parcelscviz2.shp measures overlaps with features in Riparianall2. The result is measured in Acres. It is calculated using the equation:

X.OverlapArea ([** Ripclean:]) * #Acres per Sq Foot#.

The indicator *ResRiparianImpact* calculated using the equation:

X.Sum ([** Parcelscviz2:RiparianArea], ([** Parcelscviz2:Classcodei] = "R")).

The field "RiparianArea" is a measure of overlap with features in Ripclean.shp. The result is measured in Acres: X.OverlapArea ([** Ripclean:]) * #Acres per Sq Foot#

The Data

Note that the double asterisk symbol (**) denotes an automated theme in Community Viz^{TM}. The following themes are used in all scenarios:

Delinesp: is a polyline file which shows zones 2 and 3 of the delineated aquifer protection area. The file coincides with the delineation presented in the June, 2002 Draft of the Casper Aquifer Protection Plan. Delinesp was provided by the Albany County Assessor's Office.

**** ParcelCviz2.shp** is based on the parcel shapefile from the Albany County Assessor's Office. The county wide coverage was clipped using "**1box.shp**" to coincide with the pilot project study area. The file links to the Assessors2002.mdb file via the geopin field. Both the parcel file and associated database contain 2002 data. City Limits: the city limits shapefile was produced by dissolving the various polygons in the County Assessor's office city zoning file into one polygon.

Destinations.shp was created by for the project in order to assess distances for the vehicle miles traveled indicator.

Laramie.sid is a compressed 1 meter satellite image produced by Space Imaging. The imagery was purchased by Albany County and should not be used by parties other than the county or groups / individuals working with Albany County on a specific project.

**** Septic2.shp** was created using Xtools from **Parcelscviz2.shp**. Only parcels outside the city limits that are located on the Casper aquifer were used to generate the file. The shapefile was modified to demonstrate locations of septic systems based on different land use patterns and is thus slightly different in each scenario.

Buildings.shp shows building footprints for structures in and near downtown Laramie. The file was provided by the Albany County Assessor's Office.

Vertmodel1box.shp was obtained from the website of the Wyoming Geographic Information Science Center. It was clipped to the study area. The original file is called **vert_q6.e00** and the metadata is called "vertmodel".

Traillink.shp was derived from the U.S. Census Bureau TIGER road file for Albany County. The shapefile was modified to show access based on different land use patterns and is thus slightly different in each scenario.

Lazoneu.shp shows zoning within Laramie's city limits. It was obtained from Albany County.

****Citylimits.shp** was created from **Lazoneu.shp** using Xtools.

Subdiv.shp shows subdivisions outside the city limits. It was obtained from Albany County.

Wellfields.shp is a point file showing the location of Laramie's four wellfields. It was obtained from Albany County.

**** Roadsgood2.shp** was derived from the U.S. Census Bureau TIGER roads file.

**** Roads2.shp** was derived from the U.S. Census Bureau TIGER roads file.

Hydrobuff.shp is a polygon file created by buffering a 1:100,000 hydrography layer available from the Wyoming Geographic Information Science Center

Public.shp was created from **Parcelcviz2.shp** where the field "classcodei" = "X" for exempt.

Lasewer.shp shows sewer/water lines within the city. The file was obtained from the Albany County Assessor's Office.

Delinesppoly.shp was created from **Delinesp.shp** using Xtools.

Quarry.shp was obtained from the Albany County Assessor's Office. It was not used in this project.

Ripclean.shp was created by Community Viz. It was derived from a 1:100,000 hydrography file available through the Wyoming Geographic Information Science Center.

Laramie center.shp was created by the Project and indicates the approximate geographic center of activity in the city and study area.

Laramiekn.shp shows natural gas lines in the city. It was obtained from the Albany County Assessor's Office.

New_aerial.tif is a mosaic of 5 meter satellite imagery from Space Imaging. Images provided by Albany County.

Slope is a GRID created using ArcView's Spatial Analyst extension from a 30m DEM of the study area. The DEM was downloaded from the website from the Wyoming Geographic Information Science Center and clipped to the study area using Spatial Analyst.

Faults_500Kclip.shp was obtained from the webiste of the Wyoming Geographic Information Science Center.

Vizqualty 100 is a GRID created with **quartemile.shp** and **visualquality.shp** and a digital evalvation model with using spatial analyst's calculate viewshed functionality.

1box.shp is an arbitrary boundary created by to delineate the study area boundaries.

The Following are themes are unique to the **current conditions** scenario:

**** Services.shp** was created by Community Viz™ to demonstrate automatic updates for distances to and costs of services for a hypothetical new subdivision. Moving the subdivision engages the automatic update features.

**** 1subone.shp** is the hypothetical subdivision linked to **Services.shp**.

Parcelcntrs2.shp was created using Xtools and parcelscviz2 in order to have point locations for 3-D models.

**** Blockreal.shp** contains foot prints for buildings in downtown Laramie that are not included in Buildings.shp. This file can be linked to imagery in a 3-D model for a very realistic of one of the blocks of downtown Laramie.

**** Pline1.shp** contains the same building footprints as **Blockreal.shp**. It was created by Community Viz.

**** Mainpt.shp** is used with blockreal.shp in the creation of the blockreal visualization. It was created by Community Viz.

**** 3dpnt** is used with blockreal.shp in the creation of the blockreal visualization. It was created by Community Viz.

Trees.shp shows representative trees which could exist in downtown Laramie. The file is used to enhance 3-D visualizations.

Railroadclip1.shp was created from 1995 TIGER files and clipped to the study area. The purpose is to enhance 3-D visualizations by draping a texture on the polylines.

Transit stops.shp was created for the project using information from the University of Wyoming brochure entitled, "Transpark: Come ride with us." The file was created in order to enhance 3-D visualizations and facilitate future transportion modeling.

Wells.shp is a polygon file containing locations of the wells.

Nwtin1 is a TIN created using ArcView's Spatial Analyst extension from a 30m DEM of the study area. The DEM was downloaded from the website of the Wyoming Geographic Information Science Center and clipped to the study area using Spatial Analyst.

The Following are themes are unique to the **continuation of existing** trends scenario:

****Citylimits2.shp** is a copy of **citylimits.shp**. Its sole purpose is to allow for a quick adjustment of nitrate levels with a modification of the city limits (interpreted as a change in available services) for sewer/ water.

The following are unique themes to the **aquifer protection** trends scenario:

**** Aquifer Protection Scenario.shp**, are the parcels added to **Parcelscviz2.shp** to create the parcel map for this scenario.

Aquiferparcelcenters.shp, are the centroids from **Aquifer Protection Scenario.shp** used to add to the septic2 file and in estimating nitrate levels for this scenario.

Traillinkclip2.shp is the **traillink.shp** file clipped to exclude the areas included in the parcels unique to this scenario.

Aquifer Protection Scenario Roads.shp was created for the project to indicate where roads may go to access parcels unique to this scenario.

The Following are themes are unique to the **density shift** trends scenario:

SBMparcels.shp was created by Community Viz as the anticipated residential growth for the Density Shift scenario.

Appendix C
Outreach

The following presentations have been made or are scheduled to inform the citizens of Wyoming and others of the success of Phase I of the Partnership's plan and the potential for using in the state:

January 17, 2003. A project update was presented for local planners, the water coordinator and the city financial manager in Laramie.

January 30, 2003. A project update was presented to regional representatives of the Wyoming Business Council at their meeting in Riverton, Wyoming.

February 11, 2003. A project update was presented to the Partnership. Invited guests included the City of Cheyenne Planning Department, Joe Evans of the Wyoming County Commissioners Association, and Jay Grabow, the Director of Planning and Economic Development for Carbon County, Wyoming.

April 7, 2003. Mike Knapp of the Albany County Assessor's Office presented results of phase I to the Albany County Planner, the Laramie City Planner and the City of Laramie Planning and Zoning Commission and members of the Albany County Planning and Zoning Commission.

April 10, 2003. An overview of the project was presented to the Energy, Environment & Natural Resources Committee of the Wyoming Association of Municipalities at their meeting in Thermopolis.

April 10, 2003. An overview of the project was presented to the Board of Directors of the Wyoming Planning Association.

April 14, 2003. An overview of the project was presented to the Wyoming Rural Development Council Board of Directors.

May 8, 2003. The project was presented to the Open Spaces Advisory Committee of the Ruckleshaus Institute Advisory Board.

Scheduled for July 10, 2003 is a presentation at the Environmental Systems Research Institute (ESRI) International User Conference in San Diego, California.

Tentatively scheduled for July 24, 2003 is a presentation to the community of Story, Wyoming in support of their efforts to develop a comprehensive plan.

Scheduled for August 6, 2003 is a presentation to the Sheridan County Planning & Zoning Commission.

Tentatively scheduled for August of 2003 is a presentation at the Western Planner Resources Conference in Las Vegas, Nevada.

Scheduled for September 11, 2003 is a presentation to the Wyoming Planning Association at their Fall Conference in Cheyenne, Wyoming.

Tentatively scheduled for October of 2003 is a presentation at the "GIS in the Rockies" conference in Denver, Colorado.

Scheduled for December 11, 2003 is a presentation at the Tools for Community Design and Decision Making, Working Session V in San Francisco, California.