Casper Aquifer Protection Plan

Prepared by Wittman Hydro Planning Associates
May 2008

Acknowledgements

The Casper Aquifer Protection Plan (CAPP) was originally generated through the hard work and dedication from various groups and City and County staff members. The Environmental Advisory Committee and Subcommittee members spent endless volunteer hours devoted to completing the original CAPP. The original CAPP was invaluable in the generation of this document. The hard work of previous volunteers, City and County staff, and government officials made the revision of the CAPP straight-forward and pleasant.

Numerous interested citizens provided their opinions and insights into protecting the Casper Aquifer. Thanks to the following individuals who met with Wittman Hydro Planning Associates, Inc. (WHPA), the Laramie Community Development Department, and Albany County Planning Department to discuss the revision of the CAPP: Terry Haugen, Linda Cope, Tony Hoch, Diana Hulme, Scott Lieske, Murray Schroeder, Mitch Edwards, Phil Nicholas, Doug Samuelson, Tom Del Vecchio, Andy MacClugage, Bob Kersey, Gary Linford, John Evans, Allen Frank, Cheri Frank, Tim Chesnut, and Jerry Schmidt.

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Disclaimer: The GIS data used to create the maps within the CAPP were from existing digital data provided by the City of Laramie and Albany County and were not field verified by WHPA.

All pictures appearing in the Casper Aquifer Protection Plan were purchased, taken by Wittman Hydro Planning Associates or provided by the City of Laramie and Albany County.

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Executive Summary

The Casper Aquifer Protection Plan (CAPP) is an aquifer protection program for the City of Laramie and Albany County, Wyoming. The purpose of the CAPP is to protect the recharge area of the Casper Aquifer which supplies all of the water to approximately 400 rural residences in Albany County and on an annual basis approximately 60% of Laramie's water supply.

The CAPP satisfies the following five requirements for approval by Wyoming Department of Environmental Quality (WDEQ).

- **Step 1:** Formation of a community planning team that includes members of the public to initiate, lead, and oversee the development and implementation of the CAPP.
- **Step 2**: Delineation of the aquifer protection area that represents the surface and subsurface area that recharges the Casper Aquifer.
- **Step 3:** Development of a Contaminant Source Inventory that identifies the location of potential sources of contamination.
- **Step 4:** Development and implementation of a Contaminant Management Plan.
- **Step 5:** Development of a Contingency Plan that identifies alternative public water supplies and emergency response if contamination occurs.

Community Planning Team

The first step in creating the CAPP was to establish a community planning team comprised of stakeholders, government representatives, utility representatives, and technical advisors. The City of Laramie and Albany County will continue to use the Environmental Advisory Committee (EAC) to serve as the community planning team. The EAC acts in an advisory role for updating and implementing the CAPP.

Delineation

The Casper Aquifer Protection Area encompasses approximately 72 square miles that lie east of the City of Laramie and extends to the crest of the Laramie Range. The north and south boundaries are approximately 5 and 6 miles north and south, respectively, of Laramie city limits. Delineation of the Casper Aquifer Protection Area (CAPA) was based on the hydrogeologic setting and vulnerability mapping both of which contribute to defining risks to the drinking water source.

The following factors increase the vulnerability of the Casper Aquifer to contamination from land uses.

- Recharge into the Casper Aquifer system occurs rapidly as snowmelt and runoff infiltrates into porous sandstones and fractures that occur in drainages and on the land surface.
- There is continuous residential and commercial development pressure east of Laramie where the Casper Aquifer is recharged. Development in this area increases the risk of contamination in two ways:

    1. **New contamination sources** – Homes and businesses are new sources of potential contamination to the aquifer (volatile organic compounds from fuels and solvents, nutrient fertilizers and pesticides from lawn care, nitrates and pathogens from septic leachate).
    2. **New contamination pathways** – New wells and excavation which weaken the integrity of the confining layer may provide a direct conduit to the Casper Aquifer or reduce the hydraulic barrier provided by the Satanka Shale that overlies the Casper Aquifer.

- Unknown quantities of hazardous substances are transported along Interstate 80 (I-80) and I-80 transects the Casper Aquifer recharge area.
- There is the potential for the rapid transport of contaminants in the saturated zone due to a steep hydraulic gradient and enhanced aquifer permeability from fractures, joints, and dissolution features.
- The recharge area of the Casper Aquifer is in close physical proximity to withdrawal points for Albany County and City of Laramie residents.
- There are characteristics of the Casper Aquifer which may render the aquifer more susceptible to contamination and include: drainages, fractures, faults, folds, dissolution cavities, exposed sandstone, shallow depth to groundwater, and thin soils.

The western boundary of the CAPA was extended to the west of the previous boundary. The previous western boundary of the CAPA was calculated to be the line where at least 75 feet of Satanka Shale was overlying the Casper Aquifer. The boundary was extended to the west primarily on section, quarter-section, and quarter-quarter section lines to provide continuous protection between Zones 1 and 2, provide an additional buffer to the calculated 75 foot line because there are known places where the line was inaccurate, and to provide easier implementation.

Contaminant Source Inventory

The contaminant source inventory identifies potential contaminant sources that may threaten the Casper Aquifer. Within the CAPA the potential contaminant sources include transportation corridors, residential land use, abandoned wells, underground and aboveground storage tanks, stormwater and urban runoff, commercial land use, limestone quarries, agricultural land use, and other miscellaneous uses.

Contaminant Management Plan

The contaminant management plan presents a set of management strategies for the potential contaminant sources identified in the contaminant source inventory. Management strategies may include both regulatory and non-regulatory approaches. The following general approaches are recommended for managing potential contaminant sources in the CAPA.

1. Implement a groundwater monitoring program throughout the CAPA.
2. Adopt the amended aquifer protection overlay zoning regulations.
3. Conduct the East Laramie/Albany County Wastewater Feasibility Study.
4. Fund a joint City/County staff position that will be responsible for implementing the CAPP.
5. Establish an education and outreach program.
6. Use best management practices to protect the Casper Aquifer.
7. Continue providing a household hazardous waste disposal program.
8. Numerous recommendations for specific contaminant sources.

Contingency Plan

The final chapter in the CAPP lays out a contingency plan in the event of groundwater contamination that impacts the City of Laramie's ability to provide an adequate quantity of safe drinking water to the public. Three scenarios were analyzed to determine impacts to the City's water supply. It is recommended that a full-scale emergency response exercise be conducted to test the contingency plan and initiate a study to determine mitigation measures for Interstate-80.

CHAPTER 1

INTRODUCTION

PURPOSE

The primary purpose of the Casper Aquifer Protection Plan (CAPP) is to reduce the possibility of contaminating the Casper Aquifer which supplies the City of Laramie and Albany County residents with drinking water.

WELLHEAD PROTECTION PLAN OVERVIEW

In 1986, Amendments to the Safe Drinking Water Act (SDWA) established the Wellhead Protection (WHP) Program. Under these Amendments, each state was called upon to develop and submit to the U.S. Environmental Protection Agency (EPA) for approval a plan to protect groundwater that supplies wells, wellfields, springs, and tunnels that in turn provide drinking water to the general public. The minimum elements that states must address in their WHP plans are also specified in the SDWA.

In 1996, the SDWA was again amended to increase protection of drinking water in the United States (U.S.). The 1996 amendments established the need for consumer confidence reports, source water assessment programs for surface water and groundwater, operator certification, strengthening protection from microbial contaminants and disinfection byproducts, and cost-benefit analysis of each new standard proposed by the EPA (EPA, 2007). Wellhead protection is now included as part of the source water assessment guidelines established in the 1996 Amendments.

On September 18, 1997, Wyoming became the 46th state to have an EPA-approved WHP Program. Wyoming's WHP plan adopts the systematic and logical proactive approach to protecting drinking water supplies that has been established under the SDWA Amendments of 1986 and 1996. The elements of Wyoming's WHP plan are described in *Wyoming's Wellhead Protection Program Guidance Document* Version 3.1, dated June 1998. This document is intended to serve as a guideline to communities, public water systems, and others required to develop WHP plans that meet the minimum criteria for approval by the Wyoming Department of Environmental Quality (WDEQ) and the EPA. The criteria include the following five steps.

- **Step 1:** Formation of a community planning team that includes members of the public to initiate, lead, and oversee the development and implementation of the local WHP plan.
- **Step 2:** Delineation of local Wellhead Protection Areas that represent the surface and subsurface area surrounding a well or wellfield through which contaminants are reasonably likely to move toward and reach the well or wellfield.
- **Step 3:** Development of a Contaminant Source Inventory that identifies the location of potential sources of contamination.
- **Step 4:** Development and implementation of a Contaminant Source Management Plan.
- **Step 5:** Development of a Contingency Plan that identifies alternative public water supplies and emergency response if contamination occurs.

Aquifer:
A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells, springs, and drain tunnels.

Wellhead Protection Versus Aquifer Protection

Wellhead Protection Areas

The delineation of a wellhead protection area is an important means of directly and immediately protecting the public water supply (Witten and Horsley, 1995). As defined in the 1986 Federal SDWA Amendments, a wellhead protection area is "the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." Pumping wells within an aquifer modify the natural movement of groundwater by drawing water to the well. Wellhead protection areas are those land areas that contribute groundwater (and potential contaminants) to the pumping wells. In this sense, wellhead protection areas are subsets of a larger aquifer system. Wellhead protection areas are intended to protect municipal wells and do not provide protection to individual residential wells.

Aquifer Protection Areas

The 1996 SDWA Amendments promote source water or "aquifer" protection. Aquifer protection will usually encompass a larger area than wellhead protection, and thus provides even greater safety for public water supplies and individual residential wells (Figure 1-1). By protecting a larger portion of the aquifer, it is expected that groundwater available to all users will be protected from contamination over the long-term. In the case of the Casper Aquifer, Albany County residential wells and City of Laramie municipal wells are protected rather than just municipal wells.

The protection of an aquifer requires an understanding of the extent of both the aquifer and its overlying and upgradient lands from which its water is derived (Witten and Horsley, 1995). The delineation of an aquifer protection area is independent of the effects of pumping wells and is more directly related to natural hydrologic flow patterns. Both surface water and groundwater flow conditions must be considered when delineating an aquifer protection area.

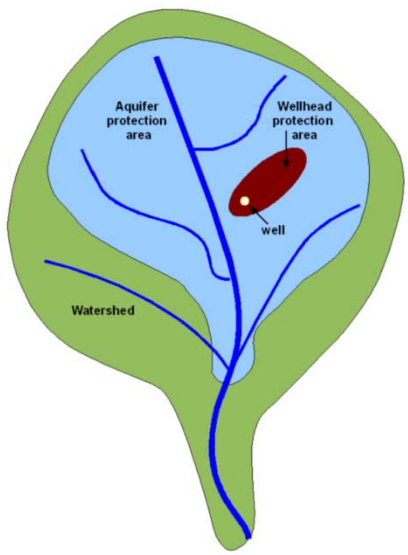


FIGURE 1-1. THE DIFFERENCE BETWEEN A WELLHEAD PROTECTION AREA AND AN AQUIFER PROTECTION AREA. ADAPTED FROM WITTEN AND HORSLEY (1995).

CASPER AQUIFER PROTECTION PLAN BACKGROUND

INTRODUCTION TO THE CASPER AQUIFER

Public drinking water supplies have always influenced the location and development of communities by defining and directing growth. Historically, the location of a good source of drinking water was a key factor in determining the location of towns and cities. Safe drinking water is essential to the quality of community life because of the link between public health and the quality of the public water supply.

About half of the U.S. population and about 75 percent of Wyoming residents depend on groundwater for their primary source of drinking water. Groundwater is derived from rain and snow infiltrating through the soil, and from surface water (drainages, streams, rivers, and lakes) that recharge aquifers. An aquifer is a saturated, permeable geologic unit that can transmit groundwater for specific purposes. Aquifers may be localized or underlie several towns or counties. The Casper Aquifer underlies several counties and provides water to both municipalities and individual residences.

The Casper Aquifer consists of approximately 700 feet of interbedded sandstone and limestone. Due to the highly faulted, fractured, and folded nature of the Casper Aquifer and natural drainages, a contaminant introduced at the ground surface might easily enter the aquifer system and move rapidly away from the entry point. Once contaminated, aquifers are difficult and expensive to remediate and municipalities or responsible parties may have to pay for site studies, remediation, and property damage. One example is from Jacksonville, North Carolina, where the design and implementation costs for groundwater remediation alone were $2.2 million. This did not include the cost of assessment or the cost for operation and maintenance (State Coalition for Remediation of Drycleaners, 2007). The most cost-effective approach is to prevent aquifer contamination, rather than attempting to remedy contamination after it occurs. In the case of individual residences using the Casper Aquifer as a drinking water source, remediation of the individual well would most likely be too expensive for the homeowner to bear.

The Casper Aquifer supplies approximately 60% (Figure 1-2) of the City of Laramie's drinking water and 100% to the rural homeowners that reside within the Casper Aquifer recharge area. The City also uses treated water from the Laramie River to supply drinking water to the community (Figure 1-2).

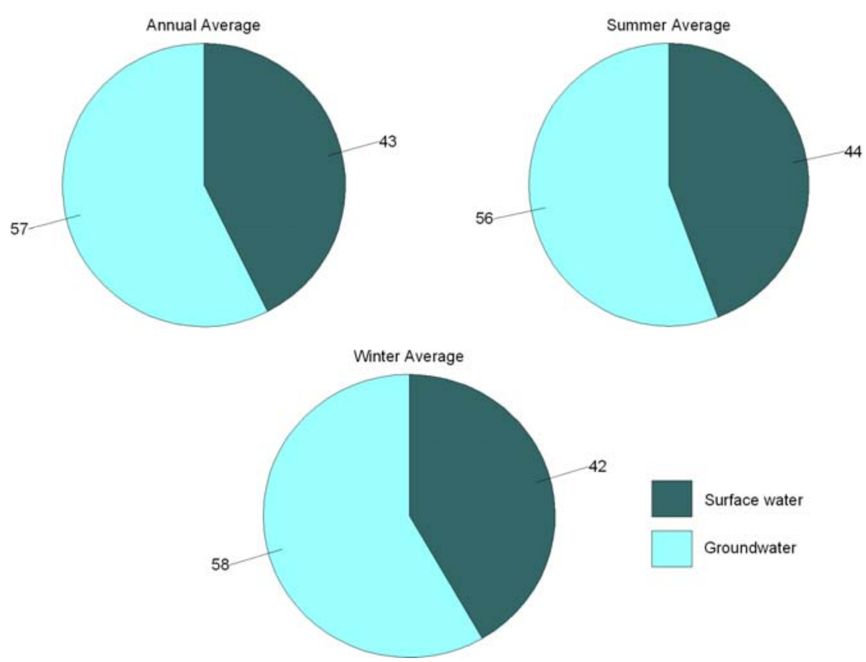


Figure 1-2. The percentage of groundwater and surface water used by the City of Laramie for drinking water. *Note: Averages are taken from 2001 to 2006 production data. Summer months = June, July, and August. Winter months = December, January, and February.*

Figure 1-3 shows the location of City wellfields relative to the city limits and to the Casper Aquifer Protection Area (CAPA). The wellfields from north to south are called: Spur, Turner, Pope Springs, and Soldier Springs. Wells at the Soldier Springs Wellfield, Spur No. 1 well, and Turner No. 2 well are all on fenced property owned and controlled by the City of Laramie. The wells at Pope Springs are located on City property but are not fenced. Spur No. 2 well and Turner No. 1 wells are also located on City property but only a small area around the wellheads is fenced. Technical information for the City's water-supply wells are on file at the City Utility Division office and include copies of the well permits and statements of completion on file with the Wyoming State Engineer's Office (WSEO), water-quality data, and other relevant information. This information is summarized throughout the CAPP.

History of Aquifer Protection in Albany County

The City of Laramie was successful in obtaining a grant from the EPA in 1993 to develop a WHP Plan. Western Water Consultants, Inc. (WWC) of Laramie developed the initial approach to delineating WHP areas for the City's municipal wellfields at Turner, Pope, and Soldier Springs. The delineations were based on hydrogeologic mapping and time-of-travel contours defined by major faults and assumed hydraulic behavior of faults and folds (WWC, 1993). The EPA grant required development of a WHP ordinance, and a draft was completed in late 1996 (City of Laramie, 1996). Citizens voiced numerous concerns at that time, based upon (1) the prescriptive nature of the ordinance, (2) the dependence of the 1993 WHP areas upon the location of identified faults, and (3) the exclusion of limestone quarries from the WHP area.

In 1997, as a result of citizen concerns and challenges to the proposed WHP ordinance, the Laramie City Council and Albany County Commissioners instructed the Environmental Advisory Committee (EAC) to develop an aquifer protection program for the Casper Aquifer. An aquifer protection program provides a higher level of protection for the City's public water supply and Albany County residents within the Casper Aquifer recharge area by including a larger portion of the aquifer resource, rather than focusing only on the municipal wellfields. The first version of the CAPP was a voluntary, non-regulatory approach to the protecting the Casper Aquifer from contamination.

Residents throughout Albany County recognize the Casper Aquifer as a valuable natural resource. In a phone survey conducted by Fairbank, Maslin, Maullin & Associates (2007), 80% of Albany County residents strongly agreed that "Albany County should guide development to protect natural resources such as groundwater, floodplains, wetlands, and crucial wildlife habitat." In 2007, Albany County and the City of Laramie hired Wittman Hydro Planning Associates, Inc. (WHPA) to update the CAPP and revise the existing ordinance to ensure protection of the Casper Aquifer. Local citizens were met with to ensure that voices from all perspectives were heard. The updated CAPP and ordinance reflect both local concerns and recent scientific information.

The CAPP has been developed to address each of the five steps outlined in Wyoming's WHP guidance document. The content and organization of the CAPP are as follows:

- Chapter 2 describes the formation and function of the volunteer community planning team.
- Chapter 3 describes the delineation of the Casper Aquifer Protection Area (CAPA).
- Chapter 4 presents the inventory of contaminant sources within the CAPA.
- Chapter 5 presents the Contaminant Management Plan.
- Chapter 6 presents the Contingency Plan.

Revising and Updating the CAPP

Because WHP plans are dynamic and evolving, it is understood that the CAPP may be subject to periodic change to make it more useful to the community. The Wyoming WHP Program Guidance Document requires that a local Wellhead Protection Plan (i.e. CAPP) be reviewed and, if necessary, updated every two years. Due to the need to update the CAPP and the limited availability of volunteers to complete the task, Albany County and the City of Laramie decided to hire water resource consultants to complete the 2008 update. In the future, the County and City will determine the most efficient and effective way to update the CAPP and may use any combination of County and City staff, consultants, and volunteers.

The CAPP will be modified, if necessary, based upon research conducted on the Casper Aquifer, changes in potential contaminants, risks posed by contaminants, changes in management strategies, and updates to the contingency plan. Significant technical changes to the delineation of the Casper Aquifer Protection Area boundaries will be reviewed and approved by three Wyoming licensed professional engineers or geologists. A new delineation map will be developed if changes are significant, otherwise changes to the delineation map will be annotated or appended.

Following this guideline, revisions to the CAPP should be made when new information is available concerning:

- Hydrologic characteristics of the Casper Aquifer;
- Changes in water supply or pumping volumes;
- Planning or development of new water supplies;
- Changes in potential contaminant sources or the threat posed by potential contaminants;

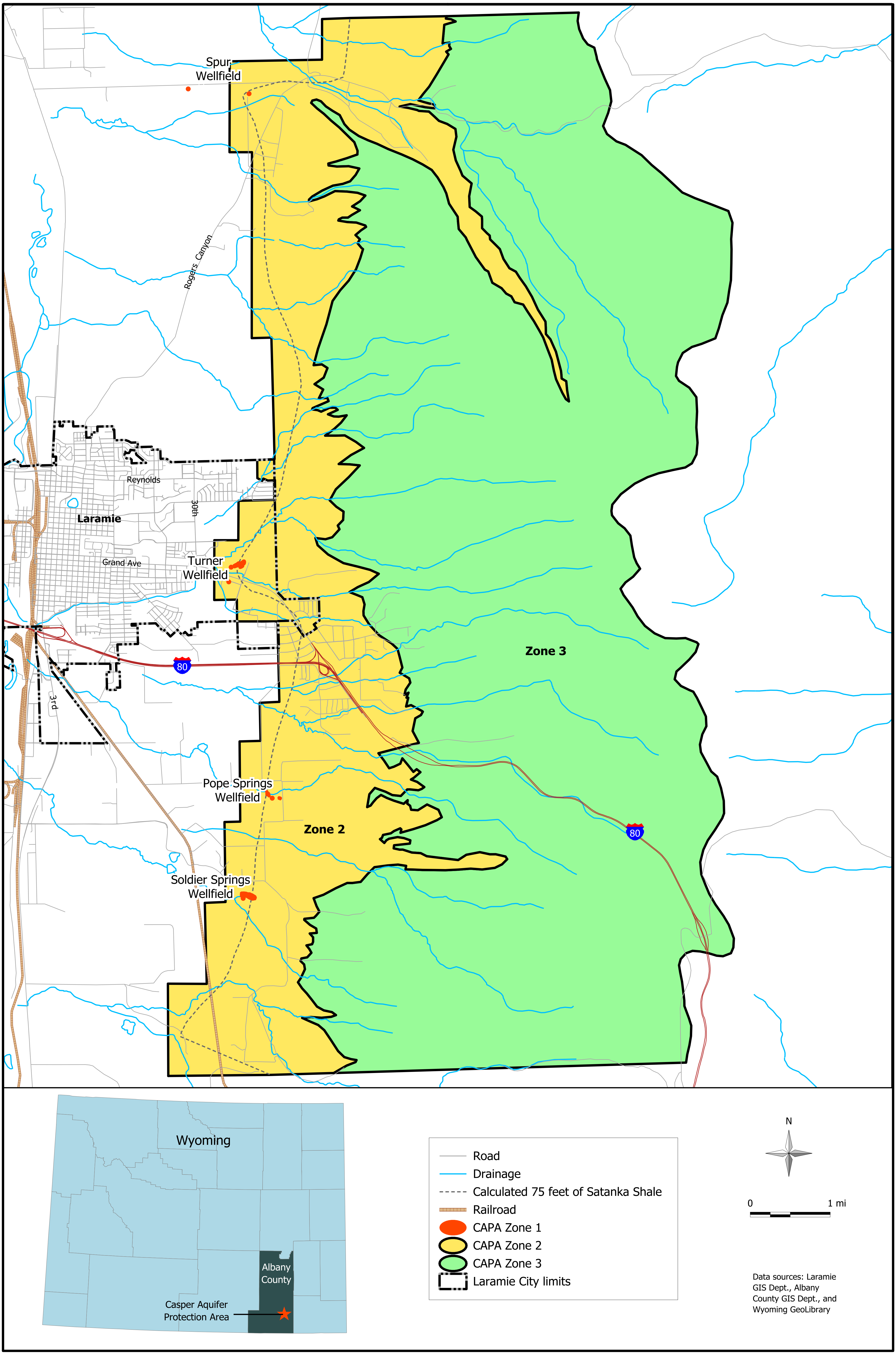


Figure 1-3. Location of Casper Aquifer Protection Area (CAPA).

- New management strategies;
- Contingency planning.

The amended ordinance and resolution should be passed that are a reflection of some of the recommendations found in the CAPP. Amending the ordinance or resolution does not require the CAPP to be revised. The approved ordinance will simply be placed in the appropriate appendix.

The City of Laramie and Albany County will draft a letter every two years advising WDEQ and anyone else who has a copy of the CAPP of all changes in the plan. Updated pages will be sent, as appropriate, and posted to the City's website.

The revised CAPP will be presented to the Albany County Planning Department, City of Laramie Community Development Department, Albany County Planning and Zoning Commission, City of Laramie Planning Commission, the Board of County Commissioners, and the Laramie City Council. The County and City staff will provide recommendations for acceptance or denial to the Albany County Planning and Zoning Commission and Laramie Planning Commission, respectively. The Albany County Planning and Zoning Commission and Laramie Planning Commission will provide a recommendation to the respective County Commissioners and Laramie City Council. The County Commissioners and City Council will then approve or deny the revised CAPP.

CHAPTER 2

COMMUNITY PLANNING TEAM

This chapter describes Step 1 of the five-step process: the formation of a community planning team. In addition, this chapter describes past activities performed by the community planning team.

COMMUNITY PLANNING TEAM OVERVIEW

The main characteristic of a successful local aquifer protection plan is recognition of the importance of public participation in both the development and implementation of the plan. By forming a community planning team, stakeholders and other interested parties have the opportunity to be involved in the development and implementation of the local aquifer protection plan.

Wyoming's Wellhead Protection (WHP) guidance document presents a list of entities and individuals who should be considered when developing a community planning team. The list includes:

- City, County, or Tribal Council/Commission representatives;
- Public Water System (PWS) operator(s);
- Private, commercial, and industrial interest representatives;
- Residential interest representatives; and
- Technical, legal, and regulatory advisors.

HISTORY OF THE COMMUNITY PLANNING TEAM

In 1997, the Laramie City Council and Albany County Commissioners charged the Environmental Advisory Committee (EAC) with developing the first version of the Casper Aquifer Protection Plan (CAPP). The EAC was a volunteer group of Albany County citizens concerned and interested in environmental issues pertinent to the County (Appendix A).

The EAC created five subcommittees to address the steps required in Wyoming's WHP guidance document. The subcommittees include the Public

Education Subcommittee; Technical Review Subcommittee; Contaminant Source Inventory Subcommittee; Contingency Planning Subcommittee, and Aquifer Area Management Subcommittee.

The EAC meetings were held once a month at various times and locations in Laramie. Subcommittee meetings were held as needed at the direction of the EAC. Meeting agendas and informational packets were organized by the EAC chairperson. All minutes from EAC and committee meetings are on file at the City Community Development Department. A City Council liaison, City Public Works Department staff, and County Commissioner were invited to attend all EAC meetings. All meetings were open to the public.

After the initial CAPP was completed and submitted to the Wyoming Department of Environmental Quality (WDEQ) in 2002, the City/County Water Outreach Coordinator (WOC), a Public Works Department employee, was responsible for implementing the CAPP. The WDEQ reviewed the original document and requested that some revisions be completed before the plan was accepted by the State. The general categories of requested changes are listed below.

1. Include a delineation of Zone 1 and faults in Zone 2.
2. Expand the discussion of potential sources of contamination.
3. Clarify the water shortage contingency plan.

All changes to the original plan were written either by or in cooperation with EAC members and the Water Outreach Coordinator, in response to WDEQ comments. These changes were part of the revised CAPP dated November 2006 that was submitted to the WDEQ for review and approval. The revised CAPP was approved by the WDEQ on July 3, 2007 (Appendix B).

Due to continuing community concern regarding the potential impacts of development to the Casper Aquifer in the Casper Aquifer Protection Area (CAPA), the City of Laramie and Albany County jointly hired Wittman Hydro Planning Associates, Inc. (WHPA) in September 2007 to review and update the CAPP and associated ordinances. Version 3.0 of the CAPP was completed by WHPA with input provided by City and County Planning Departments, concerned citizens, and the Technical Advisory Committee (TAC). The TAC was a group of interested individuals including landowners, professionals, and City and County government representatives. The EAC was included as a representative on the TAC but chose to otherwise be uninvolved due to their lack of expertise on the subject. The concerned citizens were incorporated by meeting with several individuals at the beginning of the update so that WHPA could understand the issues surrounding the CAPP and associated regulations. The concerned citizens and TAC members are listed in the acknowledgments.

After approval by the local governments, CAPP Version 3.0 will be submitted to WDEQ. A WDEQ approved wellhead protection plan may provide the following benefits.

- Recognition of Laramie and Albany County as exemplary in protecting water.
- Water-quality monitoring waivers from the EPA.
- State Revolving Loan Funds which provide support to source water protection efforts.

History of Community Outreach and Educational Activities

Historically, the Utility Division Manager and the EAC have been involved in outreach and educational activities that promoted the importance of protecting and conserving our groundwater resources. Following is a list of these activities.

- Six different brochures relating to the Laramie Regional Drinking Water Protection Program (LRDWPP), water conservation, septic system maintenance and the household hazardous waste collection (HHWC) program were distributed throughout the community.
- A LRDWPP logo was designed and used on all outreach material.
- T-shirts and hats were printed to promote the HHWC program.
- Bookmarks with a list of ten ways to conserve water and to protect groundwater were distributed to school-aged children at the Albany County Public Library.
- A site-specific Laramie-area poster showing the aquifer recharge area and information about the Casper Aquifer was designed and distributed throughout the community and schools.
- A tri-fold poster board describing the LRDWPP and water conservation programs was displayed in City Hall, the Albany County Courthouse, and the Albany County Public Library and at various venues throughout the community.
- The EAC purchased a groundwater model which simulates the Casper Aquifer and shows how the aquifer could be potentially contaminated by wells, septic systems and/or a hazardous material spill on Interstate 80.
- The EAC promoted the LRDWPP during National Drinking Water Week, Earth Day celebrations at the University of Wyoming (UW), the City Summer Safety Fair, the Agriculture Expo

Community Night, and through a mini-water festival at the local "Freedom Has A Birthday" Celebration on the 4th of July.

- Several workshops were held to promote water-wise landscaping principles and on water quality and septic system maintenance. A water-wise landscaped garden was planted at the Albany County Public Library in 2001.
- Newsletters about the LRDWPP have been mailed out to the community in the City's utility bills and in the annual consumer confidence report that is mailed to over 16,000 households. A citizen survey about our drinking water supplies was mailed with the consumer confidence report in 1999.
- Two public-service-announcement videos, shown on the local cable television channel, highlight the need to protect and conserve our drinking water. The videos were developed in cooperation with the UW Broadcasting Class and the UW Television Department.
- From 1998-2002 38 press releases were published in local papers relating to groundwater protection and the CAPP. Appendix C includes a list of the specific press releases.
- Over 30 presentations were given to local service organizations (e.g., Kiwanis, Lions, Rotary, Soroptomist, the League of Women Voters), to elementary schools, to various University of Wyoming natural resource and geology classes and to the City Council, County Planning and Zoning Commission, City Planning Commission, and to the Albany County Board of Commissioners.
- The EAC participated in the Annual Children's Water Festival in Casper, WY (1999-2001).

Groundwater Guardian Program

In the past, the EAC was a member of the National Groundwater Foundation that oversees a "Groundwater Guardian" program. The mission of the Groundwater Guardian program is to support, recognize, and connect communities protecting groundwater. The program is designed to empower local citizens and communities to take voluntary steps toward protecting their groundwater resources. Contaminated groundwater is extremely expensive and difficult to remediate; therefore prevention is the logical alternative. The City of Laramie was designated a Groundwater Guardian community in 2000 and 2001 because of the EAC's proactive approach to developing an aquifer protection program and educating the community about the importance of protecting its groundwater resource.

It is recommended that the City of Laramie and Albany County re-join the National Groundwater Foundation. The Foundation provides resources that support all aspects of the CAPP and protection of municipal and domestic wells.

Future Work of the EAC and City/County Staff

It is recommended that the City and County jointly appoint one staff person to implement the CAPP. Since the position of the Water Outreach Coordinator has been vacant, little or no work has been done to implement the CAPP due to a lack of a dedicated staff person to the project. Using one staff person to oversee the implementation of the CAPP will allow coordination between the City and County governments and ensure that one person is ultimately responsible for implementation. The assigned staff will become the primary contact for all CAPP duties such as educational outreach, public/agency inquiries, implementation, periodic plan updates, staff review of site-specific investigations, assisting Planning staff with land development proposal reviews, coordination of consultants hired to review site-specific investigations, and oversee studies related to the CAPP. In the event that the assigned staff is unavailable, the secondary contact is the City of Laramie Community Development Department. In the future, the EAC will continue to serve as the community planning team that will advise and support the work of the assigned staff and implementation of the CAPP.

Throughout the rest of this document are recommendations that should guide the City/County staff and the EAC through the implementation process. It is imperative that the EAC and City/County staff continue to work with the stakeholders, local government officials, local experts, and the University of Wyoming. Utilizing all resources the community has to offer will provide complete implementation and greater assurance that the community will accept and adopt the CAPP.

CHAPTER 3

DELINEATION OF THE CASPER AQUIFER PROTECTION AREA

This chapter describes Step 2 of the five-step process: identify land areas that contribute water to public drinking water supplies and that should have some level of protection. Delineation of the protection area has been conducted using the broader approach of aquifer protection rather than the more restrictive concept of wellhead protection.

INTRODUCTION

CASPER AQUIFER PROTECTION CONSIDERATIONS

Approximately 60 percent of the City of Laramie and all of the South of Laramie Water and Sewer District drinking water supplies are derived from wells completed in Casper Aquifer. Residents that live east of the Laramie municipal service area also rely on groundwater from the Casper Aquifer for 100 percent of their drinking water supplies.

The Casper Aquifer is vulnerable to contamination for the following reasons:

1. Recharge into the Casper Aquifer system occurs rapidly as snowmelt and runoff infiltrates into porous sandstones and fractures that occur in drainages and the land surface.
2. There is continuous residential and commercial development pressure east of Laramie where the Casper Aquifer is recharged. Development in this area increases the risk of contamination in two ways:

    - **New contamination sources** – Homes and businesses are new sources of potential contamination to the aquifer (volatile organic compounds from fuels and solvents, nutrient fertilizers and pesticides from lawn care, nitrate nitrogen, and pathogens from septic leachate).
    - **New contamination pathways** – New wells and excavations which weaken the integrity of the confining layer may provide a direct conduit to the Casper Aquifer or reduce the hydraulic barrier

provided by the Satanka Shale that overlies the Casper Aquifer.

3. Unknown quantities of hazardous substances are transported along Interstate 80 (I-80) and I-80 transects the Casper Aquifer recharge area.
4. The fractures and drainages found throughout the CAPA allow for the rapid transmission of contaminants from the surface into and throughout the aquifer.
5. The recharge area of the Casper Aquifer is in close physical proximity to withdrawal points for Albany County and City of Laramie residents.
6. There are characteristics of the Casper Aquifer which may render the aquifer more susceptible to contamination and include: drainages, fractures, faults, folds, dissolution cavities, exposed sandstone, shallow depth to groundwater, and thin soils.

History of the Delineation of the Casper Aquifer Protection Area

In 1993, the City of Laramie obtained a grant from the U.S. Environmental Protection Agency (EPA) to develop a wellhead protection (WHP) plan. Western Water Consultants (WWC) of Laramie developed the initial approach to delineating WHP areas for the City's municipal wellfields (Spur, Turner, Pope Springs, and Soldier Springs). The delineations were based on hydrogeologic mapping and time-of-travel contours defined by major faults and assumed hydraulic behavior of faults and folds (WWC, 1993). Citizens voiced concern at that time about the dependence of the WHP areas upon the location of identified faults.

As a result of citizen concerns, in 1997, the Laramie City Council and Albany County Commissioners instructed the Laramie/Albany County Environmental Advisory Committee (EAC) to develop an aquifer protection program, rather than a WHP program. An aquifer protection program provides a higher level of safety for public water supplies because it includes the entire aquifer resource and groundwater users in the vicinity of the City of Laramie, rather than focusing solely on the municipal wellfields.

In 1998, the first delineation of the Casper Aquifer Protection Area (CAPA) was developed by the EAC Technical Review Subcommittee. The subcommittee was comprised of engineers, geologists, hydrogeologists, and one citizen at-large. The subcommittee developed consensus regarding a delineation method, and a delineation report was signed by the Technical Review Subcommittee members on July 25, 1999. The boundary of the CAPA was delineated as follows: the eastern boundary was the ridge of the Laramie Mountains, the northern boundary was north of the Spur Anticline, the southern boundary was south of the Simpson Springs Anticline, and the western boundary was calculated from a dip formula where it was estimated that 75-feet of Satanka Shale would be overlying the Casper Aquifer. The delineation report, which was to become Chapter 3 of the CAPP, was presented at a joint work session of the Albany County Commissioners and the Laramie City Council. On January 4, 2000, both governing bodies approved the delineation through Joint Resolution N. 2000-02 which was needed before work could proceed on remaining chapters of the CAPP. A copy of the resolution is contained in Appendix D and a copy of the delineation report (Version 1.0) is contained in Appendix E to preserve the integrity of the initial delineation effort.

The delineation report (Version 1.0) was submitted to the Wyoming Department of Environmental Quality (WDEQ) for preliminary approval. WDEQ staff identified three deficiencies in the delineation that needed to be addressed.

- The lack of a Zone 1 protection area for each municipal production well;
- Differentiation of a Zone 2 and Zone 3 protection area, and the basis for the north and south boundaries of the CAPA which did not comply with criteria stated in the WHP Guidance Document; and
- The lack of a higher level of protection for faults and other vulnerable features.

These three deficiencies were addressed in Version 2.0 of the delineation report. A copy of the Version 2.0 delineation report is contained in Appendix E. In July 2007, the WDEQ reviewed and approved the CAPP.

In 2008, the CAPP was updated by Wittman Hydro Planning Associates, Inc (WHPA). The west boundary of Zone 2 was modified and Version 3.0 is presented in this chapter. The western boundary of the CAPA was straightened and moved to the west. The western boundary was changed to reflect the fact that there are known places where there is less than 75 feet of Satanka Shale overlying the Casper Aquifer along the calculated line (depicted in Figure 1-3 as the 75 feet of Satanka Shale). At Soldier No. 1 well there is 41 feet of Satanka Shale but the calculated 75 feet line is to the east of Soldier No. 1. At Turner No. 2 well, there is 74 feet of Satanka Shale so the calculated 75 feet line should coincide with Turner No. 2 yet the calculated line is east of Turner No. 2. At Spur No. 1 well there is 54 feet of Satanka Shale and yet the calculated 75 feet line is very near that well when the actual line should be further to the west of the Spur No. 1. Since there are known areas where the calculated line is inaccurate, it was decided that the western boundary should be moved to ensure that at least 75 feet of Satanka Shale was overlying the Casper Aquifer. Additionally, the western boundary was moved to ensure continuous protection between Zones 1 and 2. In previous delineations there was a gap of protection between Zones 1 and 2. Finally, the line was straightened and moved primarily to section, quarter section, and quarter-quarter section lines to provide for easier implementation of the CAPP.

Geology and Hydrogeology of the Laramie Area

The basic geology of an area is described by the structure and stratigraphy of the rocks. Structure refers to the distribution of rock units on the ground surface and in the subsurface. This distribution is determined by the original processes of rock formation and by later events that move and deform the rock. Stratigraphy refers to the composition and sequence of the rock units. Together, structure and stratigraphy define the framework of earth materials that control the occurrence and movement of groundwater.

Structural Setting

Regional Setting

The City of Laramie and the wells and springs serving the City are located within the Laramie structural basin. The basin is a broad, north-plunging, asymmetrical syncline that is bounded on the west by the Medicine Bow Mountains, on the east by the Laramie Range, and on the south by the Front Range. To the north the Laramie basin is bounded by a series of anticlines.

Local Setting

The Laramie Range, which bounds the Laramie basin on the east, lies immediately east of the Laramie City limits. The range was uplifted by compressional forces during the Laramide orogeny between 75 and 50 million years ago. In the Laramie area, this uplift resulted in generally uniform stratigraphic dips of between 3 and 5 degrees to the west, with the rocks striking nearly north-south. However, the uplift was not entirely uniform and faults and folds locally interrupt the dip regime (Lundy, 1978).

Faults

There are two fault types in the Laramie area. The apparent oldest set of faults is the reverse faults and monoclines, which were associated with the compression and uplift of the Laramie Range. There are also normal faults, with associated folds, which were formed by extensional stress. Lundy (1978) and Ver Ploeg (1995, 1996, and 1998) have mapped the locations of faults in the Laramie area. Ver Ploeg continues to map local faults through the efforts of the Wyoming State Geological Survey.

In most cases, the faults and folds observed in the Casper Formation do not propagate vertically through the entire thickness of the overlying Satanka Shale. Exceptions are the Sherman Hill and Laramie faults, in which offset lithologies indicate shearing through the entire thickness of the Satanka Shale.

Reverse Faults

The Horse Creek, Red Hills, and Laramie faults are all reverse faults. Lundy (1978) also indicates that the Spur and Pilot Hill monoclines are cored by reverse faults. The reverse faults tend to have north to northwest trends and are steeply dipping. Ver Ploeg (1995) has documented right-lateral strike-slip motion on the Red Hills Fault. These reverse faults were the result of northeasterly compressional stresses (Ver Ploeg, 1998). The offset along the fault planes range up to 250 feet and most of the faults have upward offset on the west side of the structure (Lundy, 1978). Folding of the sedimentary rocks extends away from the fault plane on the Horse Creek reverse fault a distance of less than 50 feet (Lundy, 1978). The width of the deformation associated with the fault reportedly increases in some areas but no widths are provided.

Normal Faults

Several major normal faults are mapped in the Laramie area. These faults include the Lincoln, Soldier, Pope, Sherman Hills, Quarry, Jackrabbit, City Springs and Spur faults. These major normal faults trend northeast to east-west. The faults were probably the result of relaxation of the compressional stresses that formed the reverse faults (Ver Ploeg, 1998).

Numerous minor unnamed faults are mapped in the Laramie area. Other unmapped faults may exist that have small displacements and/or are covered by Quaternary alluvial and colluvial deposits. There are no apparent trends in the orientation of the minor faults.

Displacement across the normal faults ranges from a few inches to as much as 200 feet (Lundy, 1978); most of the faults have downward displacement on the south block (Ver Ploeg, 1998). The dips on the fault plane of the normal faults are steep, ranging from 60 to 80 degrees (Lundy, 1978). Lundy (1978) reports that rocks adjacent to the faults are folded in zones tens of feet wide and offsets on the folds are approximately the same as the offset on the faults.

FOLDS

Folding in the Laramie area predominantly occurs as east-west trending, west-plunging anticlines and monoclines. The Simpson Springs Anticline and the Spur Anticline are examples of east-west trending folds in the Laramie area. There are also numerous folds mapped by Lundy (1978) and Ver Ploeg (1998) that are associated with faults. These structural features include the Horse Creek, Jackrabbit, Spur, Soldier, and Quarry monoclines.

SPECIFIC STRUCTURAL FEATURES

As early as 1947 the potential role of faults and folds in supplying groundwater to historic springs and municipal wellfields in the Laramie area was recognized (Morgan, 1947; Huntoon, 1976). The occurrence of springs and the large water production at the municipal wellfields are believed to be related to a particular fault, fold or fault/fold system. The discussion that follows provides a cursory overview of the faults and folds associated with the historic springs (City Springs, Pope Springs, and Soldier Springs) and municipal wellfields in the Laramie area.

The City Springs Fault is a normal fault with downward relative displacement on the northwest side of the fault. The fault trends northeast-southwest and has measured stratigraphic displacements of between 20 and 150 feet (Lundy, 1978). The Spur Fault is a northeast-southwest trending normal fault. Displacement along the Spur Fault ranges from 50 to 200 feet, with the downward relative displacement being on the northwest side of the fault (Lundy, 1978). The Spur Fault intercepts the City Springs Fault approximately one mile northeast of the City Springs. Jackrabbit Fault is an east-west trending fault that grades eastward into a monocline. Downward displacement on the fault is to the south and ranges from 30 to 80 feet (Lundy, 1978). Jackrabbit and City Springs faults intersect approximately two miles northeast of the City Springs. The Quarry Fault is an east-west trending normal fault that occurs in conjunction with a monocline (Lundy, 1978). The displacement of the fault is downward to the south and has a maximum displacement of 60 feet (Lundy, 1978). The western terminus of the Quarry and City Springs faults converge in the vicinity of City Springs.

The Pope Wellfield is located near the west end of the Pope Fault. The stratigraphic displacement is up on the north side of the fault. The total displacement of the Pope Fault has not been measured.

The Soldier Fault is an east-west trending normal fault that grades into a monocline at its east end. The fault has a measured displacement of 40 feet downward on the northern side of the structure (Lundy, 1978).

The Spur Anticline trends northwest to southeast and has a northwest plunge. Dips on the north side of the anticline range from 30 to 50°, while the dips on the south side vary from 4 to 10° (WWC, 1997b). The anticline is cored by a high-angle reverse fault and has a stratigraphic displacement of up to 250 feet (Lundy, 1978). This structural feature was targeted by the City during development of the Spur Wellfield.

Stratigraphy

Several geologic formations or units are present in the Laramie area. A formation is a lithologically distinctive rock unit that is large enough to be mapped. Formations and units pertinent to the delineation of the CAPA include the sequence from the Sherman Granite upwards to the Satanka Shale (Figure 3-1). The following section provides a summary of these units.

Precambrian Rocks

The Precambrian Sherman Granite is a coarsely-crystalline igneous rock that is exposed east of the crest of the Laramie Range (Figure 3-2). The Sherman Granite was formed by the slow cooling of magma (liquid rock) and is a large mass of interlocking minerals. Other Precambrian rocks in the Laramie area include granite, gneiss, anorthosite and gabbro which are intruded by the Sherman Granite. These igneous and metamorphic rocks are distinctly different than the overlying formations which are layered sedimentary rocks derived from chemical precipitation and the deposition of detrital material.

Fountain Formation

The Pennsylvanian Fountain Formation is an irregularly distributed sedimentary rock that is thin (less than 50 feet thick) to absent in the Laramie area (Lundy, 1978). The Fountain Formation is composed of continental, arkosic sandstone with minor amounts of siltstone. Where present, the Fountain Formation unconformably overlies the Precambrian rocks. Because the unit is not locally continuous, the Fountain Formation is included with the overlying Casper Aquifer in subsequent discussions in this chapter.

Casper Formation

The Pennsylvanian-Permian Casper Formation unconformably overlies the Fountain Formation, where the Fountain is present or the Precambrian rocks where the Fountain is absent. The Casper Formation is approximately 700 feet thick and is composed of marine and eolian sandstones interbedded with marine limestone and minor amounts of shale (Figure 3-1). Sandstone comprises approximately 85% of the total thickness with limestone comprising most of the remaining lithology. The Casper Formation is informally

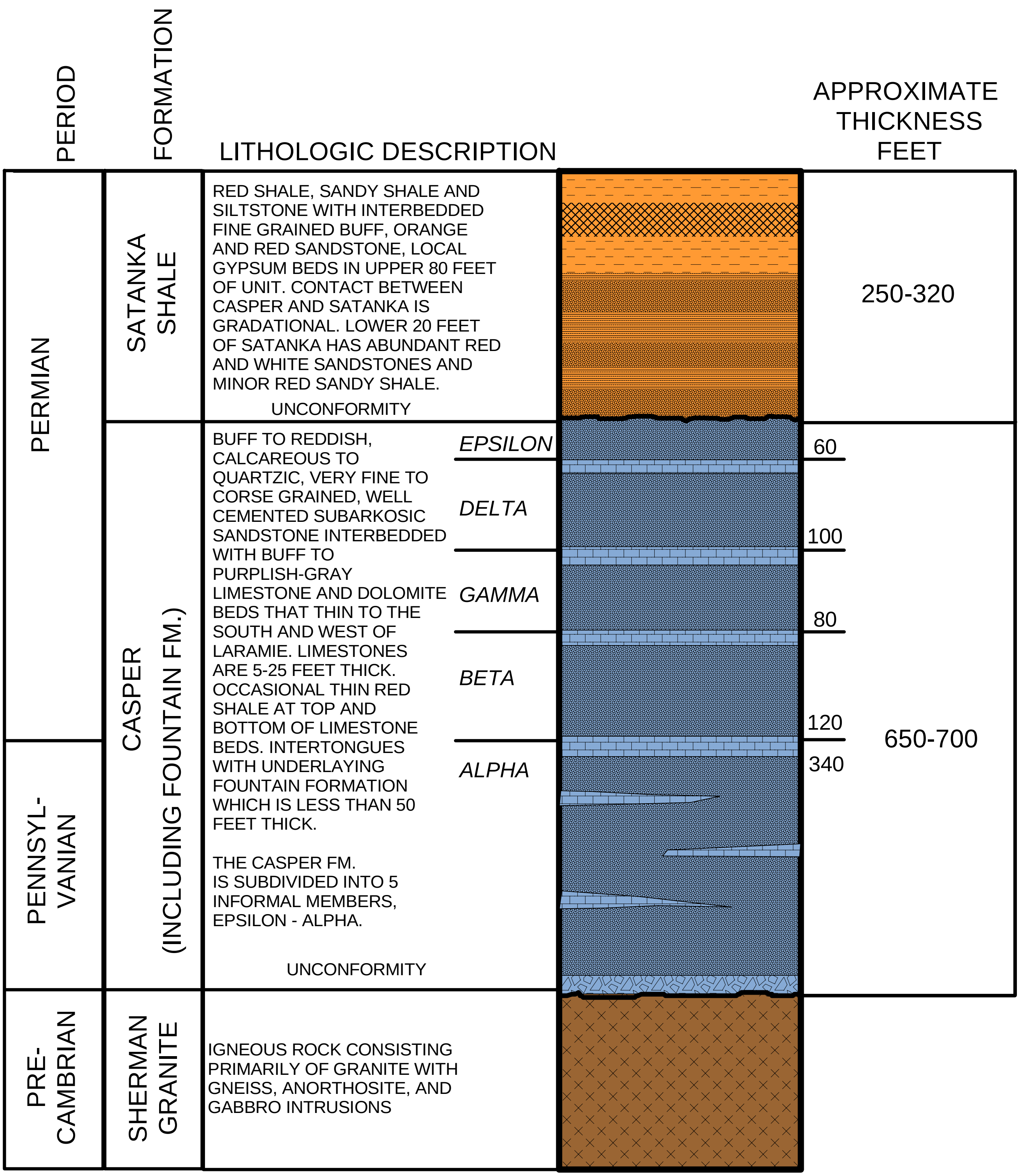


Figure 3-1 Stratigraphic Column of Units Relevant to Casper Aquifer Protection Area Deliniation

Casper Aquifer Protection Program
Adapted from: WWC (1997)
Ver Ploeg (1995)

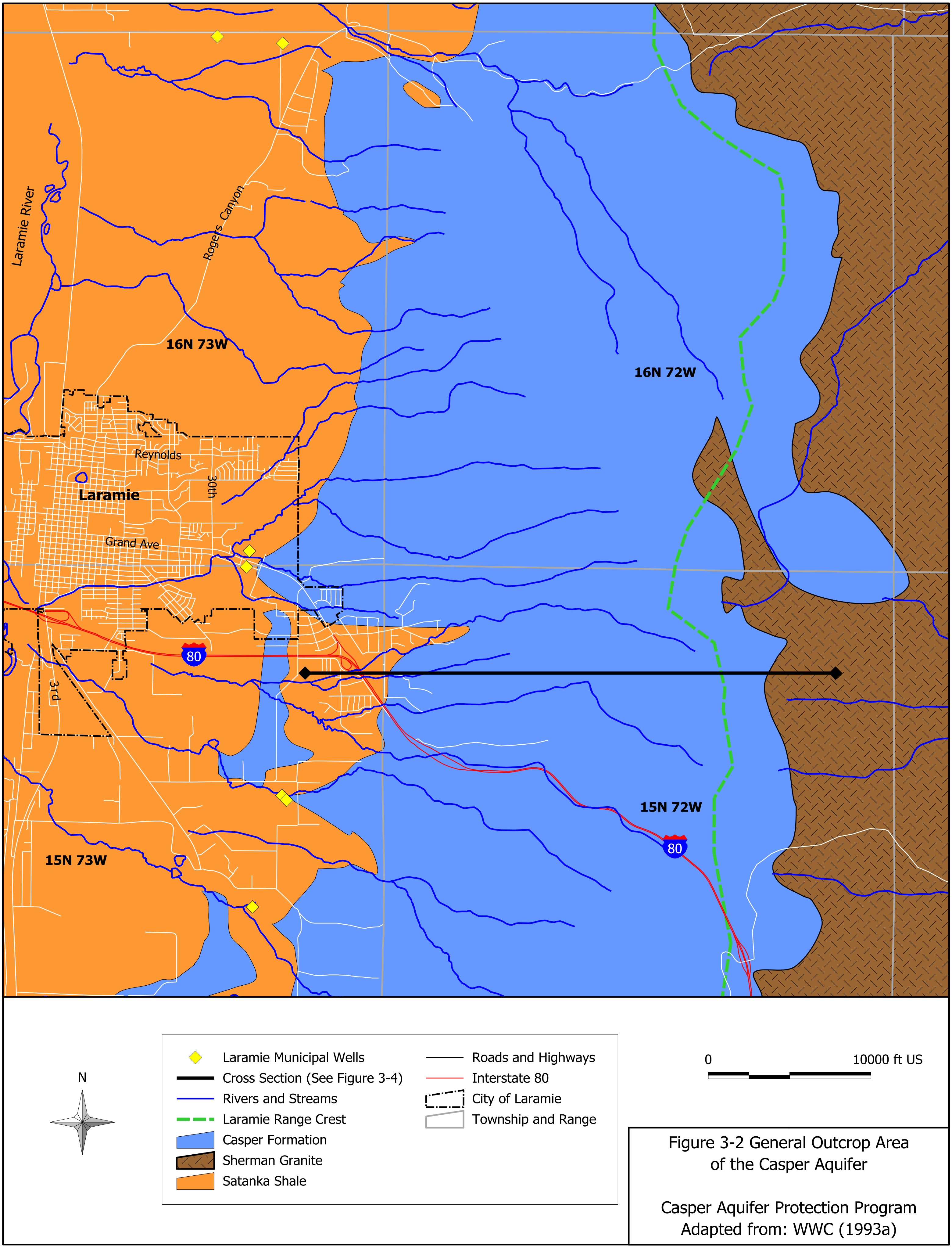


Figure 3-2 General Outcrop Area of the Casper Aquifer

Casper Aquifer Protection Program
Adapted from: WWC (1993a)

subdivided, from bottom to the top, into five members designated alpha, beta, gamma, delta, and epsilon, each of which consists of a sandstone layer bounded at the top by a regionally continuous limestone (Lundy, 1978). The Casper Formation is exposed on the west flank of the Laramie Range, east of the City of Laramie (Figure 3-2).

Satanka Shale

The Permian Satanka Shale unconformably overlies the Casper Formation and is predominantly red shale with interbedded siltstone and sandstone layers. The Satanka Shale is approximately 250 to 320 feet thick in the Laramie area. The lower 20 to 30 feet of the Satanka Shale has several red and white sandstone beds that are lithologically similar to sandstones of the underlying Casper Formation. The Satanka Shale is exposed along the western foothills of the Laramie Range and near the eastern corporate limits of the City of Laramie.

Hydrostratigraphy

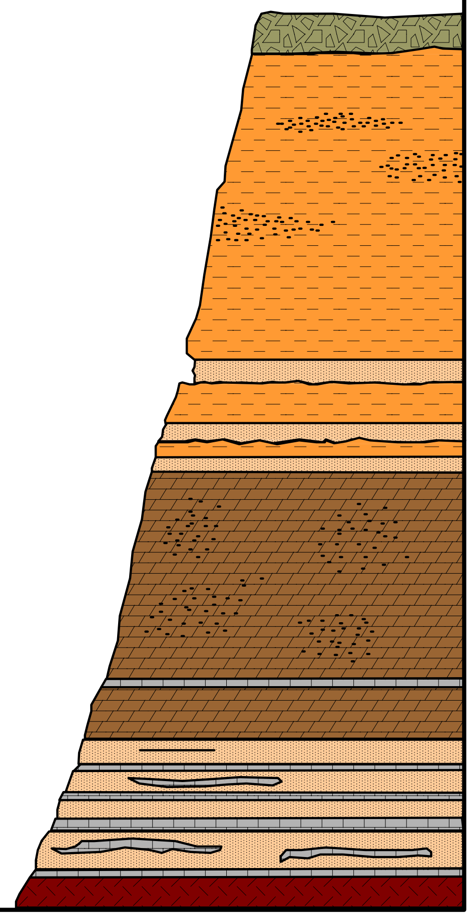
The stratigraphy of an area can be further defined in relation to the ability of a formation(s) to store and transmit groundwater. Terms such as aquifer, aquitard, aquiclude, and confining layer (see Glossary) are used to describe and define the hydrostratigraphy. The classical definition of aquifer is "a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells and springs." In strict terms, the Casper Aquifer is comprised of the water saturated portion of the Casper Formation, and does not include any portion of the overlying Satanka Shale, underlying Sherman Granite, or unsaturated portions of the Casper Formation. However, this distinction is too restrictive; if any portion of the Casper Formation is saturated, that area of the surface or subsurface occurrence of the Casper Formation will be referred to as the Casper Aquifer. In essence, for the remainder of this chapter, there will be no distinction between the Casper Formation and the Casper Aquifer; the Casper Aquifer will be used herein to describe the surface exposure, lithology, structure, and hydraulic properties of the Casper Formation.

Aquitard:
The less-permeable beds in a stratigraphic sequence that tend to restrict or impede groundwater flow relative to the more permeable beds that serve as aquifers.

Figure 3-3 provides a general description of the geologic formations present in the Laramie area. The following sections provide a detailed description of the hydraulic role of the primary water-bearing geologic units used in the delineation of the CAPA.

Sherman Granite

Unaltered Sherman Granite has practically no intergranular or intercrystalline permeability. Like most crystalline rocks, permeability within the Sherman Granite is limited to areas where the granite is extensively weathered and/or fractured by faults and joints (Richter, 1981). Groundwater movement within the Sherman Granite is typified by conduit flow. Many domestic wells obtain drinking water from the granite, but well yields are typically small and depend

Age	Formation	Thickness (feet)	Water Supply	Lithology
QUATERNARY	ALLUVIUM	0-45	Contains small amounts of water.	
CRETACEOUS	UNDIVIDED	6500	Water yield depends on lithology. Majority of section is shale, and yields no water or small amounts of highly mineralized water. Some sandstones, notably in the Frontier formation and the Masaverde Group, yield good water supplies to wells.	
	CLOVERLY	115-236	Sands contain highly mineralized water.	
JURASSIC	MORRISON	135-220	Highly mineralized but potable water.	
	SUNDANCE	0-200	Contains water, but limited areal extent.	
TRIASSIC	CHUGWATER	1100-1200	Sulfate-rich water. Used for irrigation water and for stock watering north and south of Laramie.	
PERMIAN	FORELLE	9-25	Yields little or no water.	
	SATANKA	230-300	Sulfate-rich water used for stock watering.	
	CASPER	500-700	Most important aquifer in area. Supplies water to wells and large springs on west flank of Laramie Rng.	
PENNSYLVANIAN	FOUNTAIN	20-50	Included in "Casper Aquifer."	
PRECAMBRIAN	UNDIVIDED		Yields small amounts of water.	

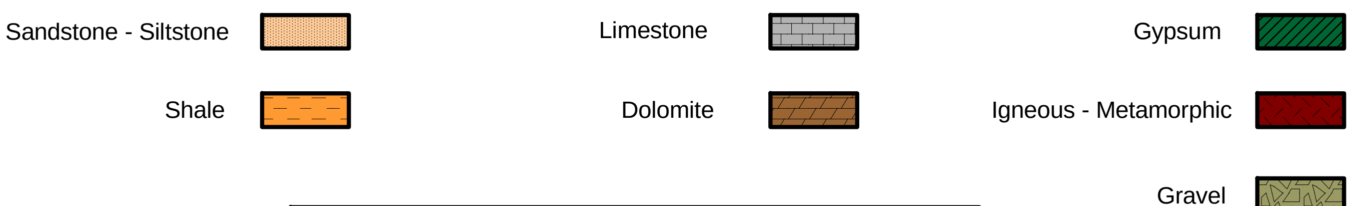


Figure 3-3 Hydrogeologic General Characteristics Of Laramine Area Formations

Casper Aquifer Protection Program
Source: Thompson (1979)

on the permeability of the fractures. Short-term pump tests of wells completed in the Sherman Granite indicate marginal to no yield, where the rocks are not fractured, and a maximum yield of approximately 20 gallons per minute (gpm) occurs in weathered or fractured granite (Wyoming State Engineer Office records, various).

To date, there has not been a systematic study of the hydrogeology of the Sherman Granite and its hydraulic relationship to the overlying Casper Aquifer. Because of the much lower permeability and limited storage capacity of fractures in the Sherman Granite compared to the sandstones of the Casper Aquifer, the Sherman Granite is designated herein as the lower confining unit of the Casper Aquifer.

However, if faults in the Casper Aquifer are continuous between the two units, there may be some hydraulic connection between them. Preliminary chemical analyses of strontium concentrations and isotopic ratios from groundwater within the Casper Aquifer suggest there may be some mixing of groundwaters of the Sherman Granite and the Casper Aquifer (Frost and Toner, 1996). It is reasonable to assume that the hydraulic contribution from the Sherman Granite to the Casper Aquifer is minor due to the impermeable nature of unfractured crystalline rock and the limited storage capacity of fractures. Therefore, the Sherman Granite is characterized as an aquitard or aquiclude (see Glossary).

Satanka Shale

The hydraulic relationship between the Satanka Shale and the underlying Casper Aquifer is a critical element in the delineation of the CAPA. The hydrogeology of the Satanka Shale has not been studied in detail, but observations made during studies of the Casper Aquifer provide some data regarding the hydraulic relationship between the Satanka Shale and the underlying Casper Aquifer (Lundy, 1978; Huntoon and Lundy, 1979; WWC, 1993, 1994, 1997a, b; and Weston, 1995).

Taken in its entirety, the Satanka Shale is a regional confining layer overlying the Casper Aquifer. However, permeable sandstones in the Satanka Shale provide water to many domestic and stock wells in the Laramie area. In general, the 300 feet of interbedded shale, siltstone, and sandstone of the Satanka Shale hydraulically isolates the Casper Aquifer from overlying aquifer units.

The hydraulic head in the Casper Aquifer is typically 20 to 40 feet greater than the head in the permeable layers within the Satanka Shale. The Casper Aquifer is confined where overlain by a sufficient thickness of the Satanka Shale (JMM, 1989; WWC 1993, 1994, 1997a, b; and Weston, 1995). Hydraulic separation between the Casper Aquifer and permeable layers in the Satanka Shale has been documented during pumping tests conducted at the Spur Wellfield, LaPrele Park Prospect, and the Turner Wellfield, where no observable head declines occurred in the monitored intervals in the Satanka Shale as the Casper Aquifer was pumped (WWC, 1993, 1996, 1997a,b).

Important for the delineation of the CAPA is the fact that interconnected fractures in the lower 50 feet of the Satanka Shale can be permeable. In contrast to the general observations described above, groundwater from the Casper Aquifer flows upward through the lower 50 feet of the Satanka Shale at City Springs, Pope Springs, Soldier Springs, and Simpson Springs. In addition, water quality in the lower-most sandstones of the Satanka Shale is very similar to water quality of the Casper Aquifer (WWC, 1994). Consequently, it is assumed that the lower 50 feet of the Satanka Shale is in hydraulic communication with the Casper Aquifer.

Casper Aquifer

The Casper Aquifer is the hydrogeologic unit that provides the sole source of groundwater to the drinking water wells used by the City of Laramie and the main source of water for domestic wells east of Laramie. Sandstones in the Casper Aquifer have large permeabilities compared to the overlying and underlying geologic units. The Sherman Granite provides an effective lower confining layer for the Casper Aquifer and the low permeability shales of the Satanka Shale provide an effective upper confining layer, where there is a sufficient thickness.

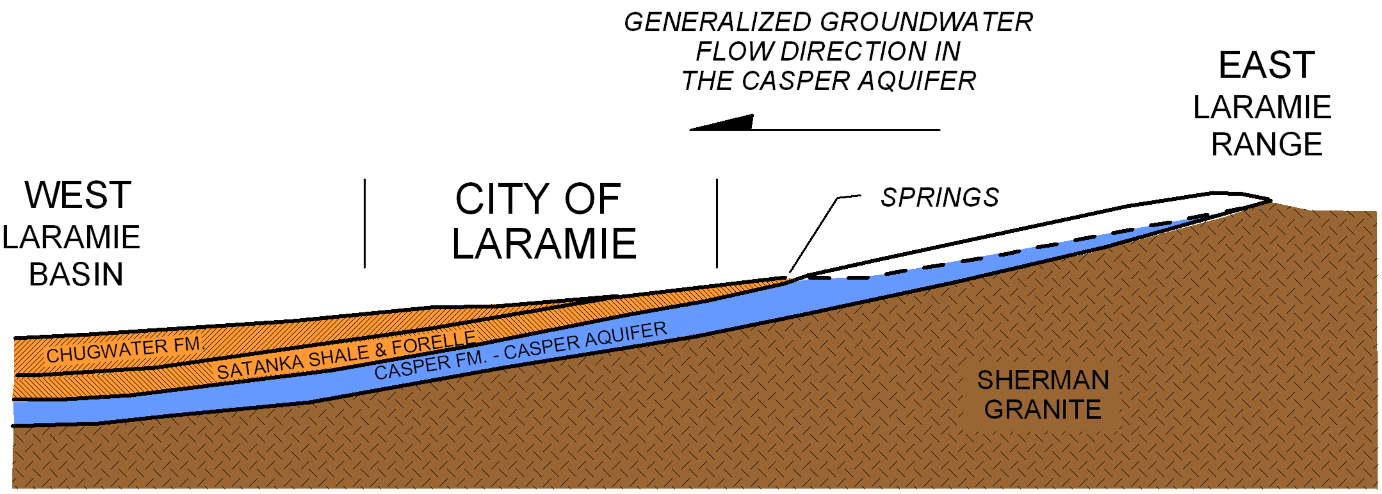
Hydrogeology of the Casper Aquifer

An expanded discussion of the hydrogeology of the Casper Aquifer is provided in the following sections.

Extent of the Casper Aquifer

Regionally, the Casper Aquifer occurs along the margins and in the subsurface of the Laramie basin. The Casper Aquifer extends approximately 50 miles north-northwest of Laramie before it is interrupted by a thrust fault. To the south of Laramie, the Casper Aquifer extends past the Wyoming-Colorado border, a distance of at least 21 miles.

In the vicinity of Laramie, the Casper Aquifer occurs both at the ground surface and in the subsurface. The ground surface exposure of the Casper Aquifer occurs in a four to five mile wide, north-south trending band on the west flank of the Laramie Range (Figure 3-2). As the sedimentary rocks dip 4º to the west, the Casper Aquifer is covered by the Satanka Shale and gets more deeply buried by overlying lithology as one proceeds to the west (Figure 3-4). Near the western city limits of Laramie, the depth to the top of the Casper Aquifer is



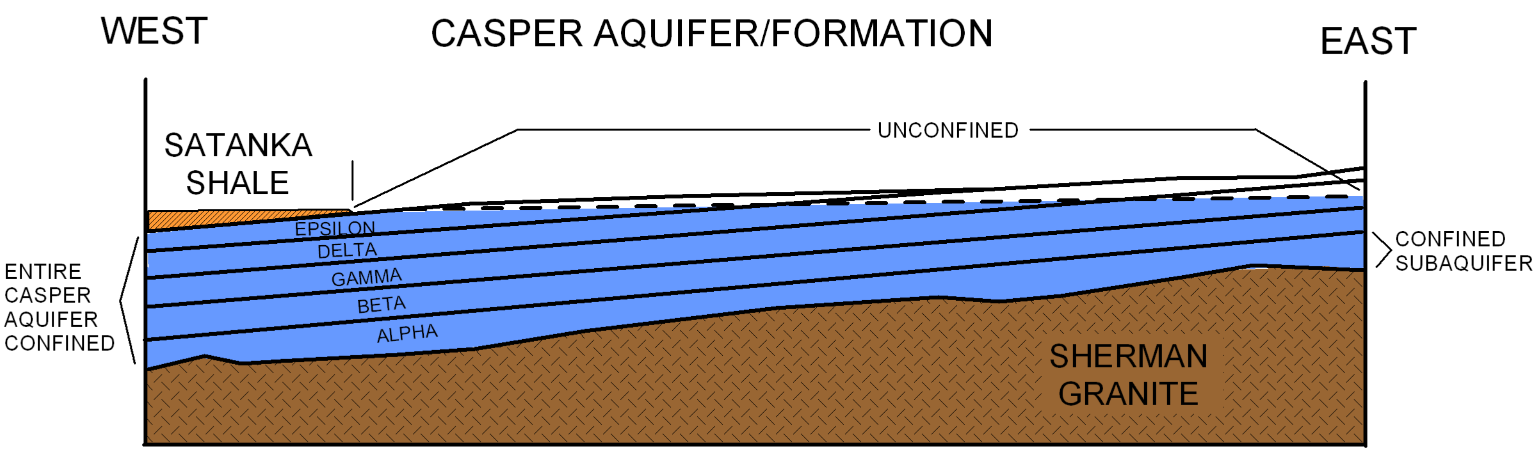
EXPLANATION

NOT TO SCALE

SATURATED CASPER FORMATION

UNSATURATED CASPER FORMATION

GENERALIZED CROSS-SECTION THROUGH THE VICINITY OF LARAMIE, WYOMING.
(SEE FIGURE 3-2 FOR CROSS-SECTON ORIENTATION)



EXPLANATION

NOT TO SCALE

WATER TABLE SURFACE
(UNCONFINED AT THAT LOCATION)

SATURATED SANDSTONE IN CASPER FM.

LIMESTONE AQUITARD

UNSATURATED SANDSTONE IN CASPER FM.

GENERALIZED CROSS-SECTION SHOWING CONFINED AND UNCONFINED CONDITIONS IN THE CASPER AQUIFER.

Figure 3-4 General Schematic Cross-Sections

Casper Aquifer Protection Program
Adapted from: WWC (1993)

approximately 1,500 feet. Based on water quality considerations, the west boundary of the Casper Aquifer can be defined by the 1,000 milligrams per liter (mg/L) total dissolved solids (TDS) contour mapped by Richter (1981). This water quality contour is approximately nine miles west of Laramie City limits. TDS refer to the sum of any minerals, salts, metals, cations or anions dissolved in water. When water has TDS concentrations greater than 1,000 mg/L, the water is generally unsuitable for drinking water purposes and is definitely not suitable for municipal use.

SATURATED THICKNESS OF THE CASPER AQUIFER

The saturated thickness of the Casper Aquifer varies significantly where the Casper Aquifer is exposed along the west flank of the Laramie Range. As shown in Figure 3-4, the saturated thickness is nearly zero at the crest of the Laramie Range and gradually increases westward towards the contact of the Casper Aquifer and Satanka Shale. While the entire thickness of the Casper Formation is not saturated on the flank of the Laramie Range, there is some thickness of the Casper Formation that is saturated throughout the outcrop, hence the Casper Aquifer. Deep canyons and elevated regions along the west flank of the Laramie Range result in irregular saturated thicknesses.

A short distance west of the contact between the Casper Aquifer and the Satanka Shale, the Casper Aquifer attains its maximum saturated thickness of 600 to 700 feet, as dictated by the total thickness of the Casper Formation. West of the contact, as the Casper Aquifer dips to the west and is confined by the overlying Satanka Shale, the Casper Formation is fully saturated and the Casper Aquifer maintains its maximum saturated thickness.

MEDIA TYPE AND GROUNDWATER FLOW CHARACTERISTICS OF THE CASPER AQUIFER

The Casper Aquifer is comprised of two media types; porous sandstone and fractured sandstone and limestone. Groundwater flow in the sandstone and limestone includes both porous and conduit flow. Porous flow occurs within the permeable unfractured sandstone. Conduit flow occurs in both the sandstone and limestone where permeability has been enhanced by fractures and/or dissolution.

Porous flow refers to the flow of water through the pore space between individual sand grains and interstitial cement of a sandstone. The intergranular permeability of the sandstones in the five members of the Casper Aquifer is variable; the greatest permeability occurs in the epsilon and delta members and the lowest permeability in the alpha member. The variation is due to the well sorted and less cemented nature of the epsilon and delta members compared to the greater abundance of very fine sand and silt and the calcite cement that fills the pore spaces in the lower sandstone members (e.g. alpha).

Intergranular permeability is responsible for providing water to wells on the order of 1 to 100 gpm.

Conduit flow refers to the flow of water through cavities or fractures associated with dissolution, faults, folds, joints, and partings along bedding planes. The permeability of cavities and fractures is typically orders of magnitude greater than intergranular permeability. Conduit flow systems are capable of yielding large quantities of water to wells, as demonstrated by the Laramie municipal water supply wells and associated springs. Production from the municipal wells that penetrate the fractured Casper Aquifer is on the order of 1,500 to 2,500 gpm. These high-yield wells intersect fractures associated with faults, folds, and bedding planes that have deformed the Casper Aquifer. At the Spur and Turner wellfields, where the rocks have been extensively fractured, the upper and lower members of the Casper Aquifer are hydraulically connected with each other through a vertical fracture network.

Direct evidence exists of the presence and highly permeable nature of fractures in the Casper Aquifer at Laramie's wellfields. In the course of numerous water supply investigations, downhole camera surveys have been performed in wells at the Spur, Turner, and Pope wellfields. Videos of open hole completions in the Casper Aquifer at wells TW-1, 1941 Turner No. 1, 1941 Turner No. 2, and Turner No. 2 (WWC, 1995; WWC, 1996; Wyoming Groundwater, 2004) demonstrate the presence of fractures in the subsurface of the Casper Aquifer. A salt tracer test conducted at the Turner No. 1 well demonstrated how rapidly groundwater can travel through fractures (WWC, 1993). The peak concentration of a dissolved salt water plume traveled a distance of 147 feet in 12 minutes before arriving at the pumping well (Turner No. 1).

In 2004, the temporary removal of the turbine pump from the City's Turner No. 2 well provided an opportunity to perform a downhole camera survey of the well casing and open hole. The camera survey allowed a visual inspection of approximately 250 feet of lithology within the epsilon, delta, and gamma members of the Casper Aquifer. Large horizontal openings and fractures were observed in the sandstones immediately above or below a limestone layer, and vertical fractures were observed in limestone (Wyoming Groundwater, 2004). It is reasonable to believe that production from the Turner No. 2 well (i.e., 1,400 gpm) is primarily from the observed cracks, fractures, and openings in the sandstones, and that the horizontal fractures may extend some distance beyond the wellbore to hydraulically connect the well with other fractures networks and porous sandstones within the Casper Aquifer.

Porosity of the Casper Aquifer

The intergranular porosity of the rocks comprising the Casper Aquifer varies significantly. Lundy (1978) reports that the porosity of the well-cemented sandstones are approximately 22 percent, while the porosity of the epsilon sandstone ranges from 15 to 30 percent. The average porosity of the sandstones is 19 percent according to Lundy (1978). No porosity values are available for the limestones within the Casper Aquifer. The porosity is extremely low where the limestones are not fractured but secondary porosity does exist where they are fractured. WWC (1993) estimates that the average effective porosity of the fractures within the Casper Aquifer is 0.02 percent. Although fracture networks represent a very small percentage of whole rock porosity, interconnected fracture networks are capable of transmitting large quantities of water (see Table 3-1).

Hydraulic Conductivity, Transmissivity, and Storativity of the Casper Aquifer

Pump testing of wells completed in the Casper Aquifer in the Laramie area demonstrates that there are significant variations in the permeabilities of the sandstones comprising the Casper Aquifer. The most striking variation in permeabilities within the Casper Aquifer are observed when comparing unfractured versus fractured aquifer media. Table 3-1 shows the hydraulic conductivity and transmissivities reported in Lundy (1978).

Table 3-1. Hydraulic conductivity and transmissivity of the Casper Aquifer. ***Data source: Lundy, 1978.***

	HYDRAULIC CONDUCTIVITY (FEET PER DAY)	TRANSMISSIVITY (GALLONS PER DAY PER FOOT)
Epsilon member	1.3 to 2.6	600 to 970
Gamma member	1.5	435
Aggregate members (alpha through epsilon)	0.21 to 0.32	900 to 1,390
Aggregate members (gamma through epsilon)	0.11 to 0.13	315 to 375
Unfractured areas	0.10 to 2.6	135 to 970
Fractured areas	17 to 40	82,300 to 195,000

Testing of the Spur Wells by WWC (1997b) indicates that the transmissivity of the Casper Aquifer varies with direction (i.e. anisotrophic). Directional transmissivity values varied from 140,000 to 640,000 gallons per day/foot (gpd/ft). All of the reported transmissivities were calculated from drawdowns in monitoring wells located close to the Spur Anticline. Pump tests conducted at the 1941 Turner No. 1 well yielded a hydraulic conductivity of 14 feet per day (transmissivity = 68,100 gpd/ft) (WWC, 1993). At both the Spur and Turner Wellfields, the drawdown was shown to be highly anisotropic, with the greatest drawdown occurring parallel to the geologic structure. The testing indicates that the greatest permeability occurs along the Spur Anticline and that the permeability decreases significantly short distances from the structure.

Storage coefficients for the Casper Aquifer are highly variable. Those reported by Lundy (1978) range from 0.001 to 0.006, which indicates the aquifer is confined to slightly leaky. Pump test data at the Spur Wellfield indicate that the storage coefficient varies from 0.01 to 0.0091 (WWC, 1997b). However, the storage coefficient for the wells changed significantly with time during pumping, which may be the result of the effects of partial penetration or from varying degrees of interconnection via fracture systems. A storage coefficient was calculated by WWC from barometric efficiency data collected from the Spur Wellfield. The resulting storage coefficient was 0.0005, which indicates that the aquifer is confined at that location (WWC, 1997b). The fact that the static water level in the Spur wells is significantly above the top of the Casper Aquifer also provides evidence that the aquifer is confined at that location.

The enhancement of permeability from fractures associated with the faults and folds in the Casper Aquifer cannot be determined with certainty; some structures may enhance aquifer permeability while others may reduce permeability. However, it has been clearly shown that aquifer permeability is enhanced in the area of the municipal wellfields, all of which are associated with one or more structural features. Although the effects that each structure has on aquifer permeability are not known, it is important to recognize the hydraulic complexity imparted to the Casper Aquifer by geologic structures such as faults and folds.

Recharge of the Casper Aquifer

Recharge refers to the replenishment of the Casper Aquifer by the infiltration of water through unsaturated rock to an underlying saturated zone. The average annual recharge to the Casper Aquifer is estimated to be 1.4 inches per year (Lundy, 1978). The Casper Aquifer is recharged primarily by the infiltration of precipitation (rainfall and snow melt) through the porous sandstones exposed on the west flank of the Laramie Range. This process occurs to some degree wherever the Casper Aquifer is exposed at the surface. Consequently, the entire surface exposure of the Casper Aquifer is assumed to be the recharge area.

The infiltration of surface water from rainfall and snow melt into Casper Aquifer sandstones is quite remarkable as observed by Beckwith (1937) and Lundy (1978). For example, following a spring snow storm, Beckwith observed 3 to 4 cubic feet per second of stream flow infiltrate into sandstones over the course of a few hundred feet. Lundy also observed the rapid infiltration of overland flow into gamma sandstone exposures during a rain storm. During recent field work, Karl Taboga has observed the rapid infiltration of overland flow from snow melt into sandstones exposed in upland drainages. Infiltration into the subsurface is enhanced by fractures, joints, and bedding planes exposed at the surface, particularly in drainage channels eroded along fracture zones. The ability of exposed sandstones in drainage channels to absorb surface water is illustrated by the fact that surface water rarely flows out of the drainages that dissect the west flank of the range. It is assumed that the vast majority of recharge to the Casper Aquifer occurs in drainages.

In October-November 2005, a 30-day pump test was conducted at the Brow #2 well located 0.6 miles southeast of Simpson Springs (CBMA, 2006). The test provided a unique opportunity to observe the rapid infiltration of surface water through the unsaturated zone and into saturated sandstone of the Casper Aquifer. The Brow #2 well is spudded on the delta member and has a depth to water of 68 feet. Water from Brow #2 was discharged to the ground surface approximately 600 feet west of the well which corresponds to the west edge of the delta member exposure. Approximately 1,200 minutes (0.83 days) into the pump test, the rate of drawdown in Brow #2 declined and was followed by a brief rise in water level. Apparently, in less than a day, pump test water discharged to the ground surface had infiltrated through approximately 50 feet of unsaturated material and was recycling through the aquifer to the Brow #2 well.

The most direct evidence of the occurrence and timing of recharge to the Casper Aquifer is the rise of water levels in wells. Recharge of the Casper Aquifer from major late-winter/early spring precipitation events is clearly documented in the Huntoon No. 1 and Huntoon No. 2 monitoring wells located in the Sherman Hill Estates and Valley View residential subdivisions, respectively. These wells have been used exclusively for water level monitoring since 1977-78. In 1983, the head in the Casper Aquifer at these wells increased 22 to 25 feet in response to above-average precipitation (snow) in March and April. The 1983 recharge event caused noticeable head increases throughout the Casper Aquifer along the west slope of the Laramie Range as evidenced by above-average discharge at City Springs, Soldier Springs, and high water levels in the Pope wells from 1983 to 1990 (WWC, 1996).

From September 2003 through 2006 on a monthly basis, Karl Taboga has monitored approximately 50 water wells on the west flank of the Laramie Range. Upland wells located at the higher elevation of the Laramie Range experienced a pronounced water level rise of 5 to 17 feet following the melt-off of a snow storm in April 2005. The upland wells are located in areas where snowpack is greatest and persistent, and during snowmelt periods the water level in these wells rise. Head increases in the upland wells occur on the order of days to weeks following the precipitation event which illustrates that water can flow rapidly through the unsaturated zone. A rainfall event in September 2004 produced a water level rise of approximately 1 foot in these upland wells.

Rapid infiltration and groundwater flow in the Casper Aquifer is supported by groundwater age dating data using tritium (Toner, 2000). The presence of tritium in groundwater samples indicates that the groundwater was exposed at the surface subsequent to the 1950's. Tritium was detected in groundwater samples from the Casper Aquifer collected from sites east of Third Street. This indicates that the groundwater in the Casper Aquifer east of Third Street has been recharged within the past several decades.

Snowfall is the most important form of precipitation for recharging the Casper Aquifer. As stated by Huntoon and Lundy (1979), “Most recharge to the Casper Aquifer occurs in March and April when monthly precipitation is above average and the ground has thawed. Recharge rates are negligible in the fall and winter due to frozen ground conditions.” Rainfall in the summer does not appear to provide an appreciable amount of recharge to the Casper Aquifer. Summer rainfall flows quickly down the drainages and evapotranspiration by vegetation is at maximum. Precipitation stored and applied to the ground surface as a slowly melting snowpack during the diurnal freeze-thaw period of March-April appears to be the most effective mechanism for recharge to the Casper Aquifer.

To summarize, the Casper Aquifer is a responsive hydrogeologic system due to the mountain flank exposure of porous sandstones with superimposed fracture permeability from bedding planes, faults, folds, and monoclines. In the upland recharge area, water infiltrates through the unsaturated zone days to weeks after the occurrence of snow melt in March and April. Above-average snowfall in March and April can cause rapid and long-term head increases as demonstrated in the Huntoon monitoring wells after the 1983 recharge event.

Potentiometric Surface of the Casper Aquifer

Potentiometric surface maps indicate the hydraulic gradient and the general direction of groundwater flow in a confined aquifer. Published potentiometric surface maps indicate that groundwater in the Casper Aquifer in the vicinity of Laramie generally flows from east to west, from areas of high elevation at the crest of the Laramie Range toward lower elevations within the Laramie basin (Lundy, 1978; Thompson, 1979; WWC, 1997a,b and 2006). The hydraulic gradient has a slight northwest component between Simpson Springs and City Springs (Thompson 1979) and is altered locally to a more radial pattern in the vicinity of the City’s municipal wellfields and the springs, which discharge large quantities of water from the Casper Aquifer. Flow patterns are also locally altered to some degree by the permeability imparted by fracturing associated with some faults and folds.

The hydraulic gradient ranges from a high of approximately 400 feet per mile, on the west flank of the Laramie Range where the saturated thickness of the Casper Aquifer is variable, to 25 feet per mile, where the aquifer attains its maximum saturated thickness west of the Satanka Shale contact (Lundy, 1978).

Confining Conditions of the Casper Aquifer

As discussed previously, the Satanka Shale serves as the upper confining layer for the Casper Aquifer. The lower 50 feet of the Satanka Shale is comprised of well-cemented sandstone and sandy shale. The brittle nature of that interval and the lithologic similarity to the underlying Casper Formation results in some mixing of groundwater from those units, especially in fractured areas. Where the Satanka Shale has a thickness greater than 50 feet, low permeability shaley strata provide vertical confinement, with the degree of confinement increasing with greater thicknesses of the Satanka Shale. Evidence of confinement includes the discharge of groundwater at Simpson, Soldier, Pope, and City Springs. Additionally, differences in hydraulic head of up to 30 feet were observed at the Spur Wellfield, with the head in the Casper Aquifer being greater than the head in the Satanka Shale (WWC, 1997b).

East of the contact between the Casper Formation and the Satanka Shale, where the Casper Aquifer is exposed at the ground surface and is not confined by the Satanka Shale, the Casper Aquifer is a combination of confined, semi-confined, and unconfined conditions as illustrated in Figure 3-4. The limestones that separate the sandstones generally have negligible permeability and serve as local confining layers that define subaquifers within the Casper Aquifer. Therefore, the informal members, designated in descending order as the epsilon, delta, gamma, beta, and alpha members each comprise subaquifers within the Casper Aquifer (Figures 3-1 and 3-4). However, pump tests reveal that the confining ability of the limestones are compromised where vertical fractures from faults and folds have created hydraulic connection between the members (WWC, 1996 and 1997b). This hydraulic integration of the members appears to occur, at a minimum, in the vicinity of the City wellfields. Vertical fractures in the limestone layers were observed in downhole camera surveys of the open hole interval of the Turner No. 2 municipal well and in the 1941 Turner No. 1 and 1941 Turner No. 2 wells.

Vulnerability of the Casper Aquifer

Several features of the Casper Aquifer render the aquifer potentially vulnerable to contamination. Throughout much of the surface exposure of the Casper Aquifer some protection is provided to the aquifer by overlying soils, low permeability limestones, and several tens to hundreds of feet of unsaturated rock. However, there are characteristics that may compromise the natural protection which include: drainages, faults, fractures, folds, dissolution features, exposed sandstone, thin soils, and shallow depth to groundwater. The following paragraphs describe the reasons these features increase exposure of the Casper Aquifer to contamination.

Drainages

Most of the recharge to the Casper Aquifer appears to occur in drainages (Figure 3-5). Water tends to shed off of the low-permeability limestones that cover much of the land surface along the west flank of the Laramie Range. The water drains off the limestones and collects in drainages. As the surface runoff flows through the drainages, recharge occurs as the water infiltrates into the permeable sandstones and/or fractures. Where rapid recharge occurs, rapid contamination can also occur.

Faults and Fractures

Faults are fractures or fracture zones along which displacement of strata have occurred. If the displacement has resulted in either breaches in confining beds and/or development of large secondary permeability, then the Casper Aquifer may be more vulnerable to contamination than in unfaulted areas (Figure 3-5). Where the faults intercept the ground surface and associated fractures have large apertures there is the potential for rapid infiltration of surface water into the aquifer. This rapid infiltration, in turn, has the potential for rapid contamination of the aquifer.

While faults are typically mapped as a single line, faults frequently do not occur as a discrete feature. Fractures extend variable distances from the fault trace. WWC (1993) reports that at some faults the fracture zone extends less than 10 feet from the fault trace, while other faults have associated fractures extending 50 to 150 feet from the fault trace.

Folds

Folds are bends in the bedding of rocks that result from ductile deformation. Folds found in the Laramie area include anticlines, synclines and monoclines. In many folds, fractures are developed in brittle or competent rocks. These fractures usually occur along the crest of the fold and have the potential for transmitting large quantities of water. Where these fractures extend to the ground surface there is the potential for rapid infiltration of contaminants.

Dissolution Features

Dissolution features are shafts, tunnels, and caves which were created by groundwater dissolving sedimentary rock such as limestone. Dissolution features contribute to the rapid transmission of groundwater.

Exposed Bedrock

Exposed bedrock refers to the surface exposure of the Casper Aquifer (i.e., Casper Formation) which forms an extensive area on the west flank of the Laramie Range. In particular, areas of exposed sandstones are likely to be more vulnerable than exposed limestone because of the sandstones permeability.

Exposed bedrock of an aquifer that supplies a public water system is more vulnerable to contamination than where the aquifer is covered by overlying low

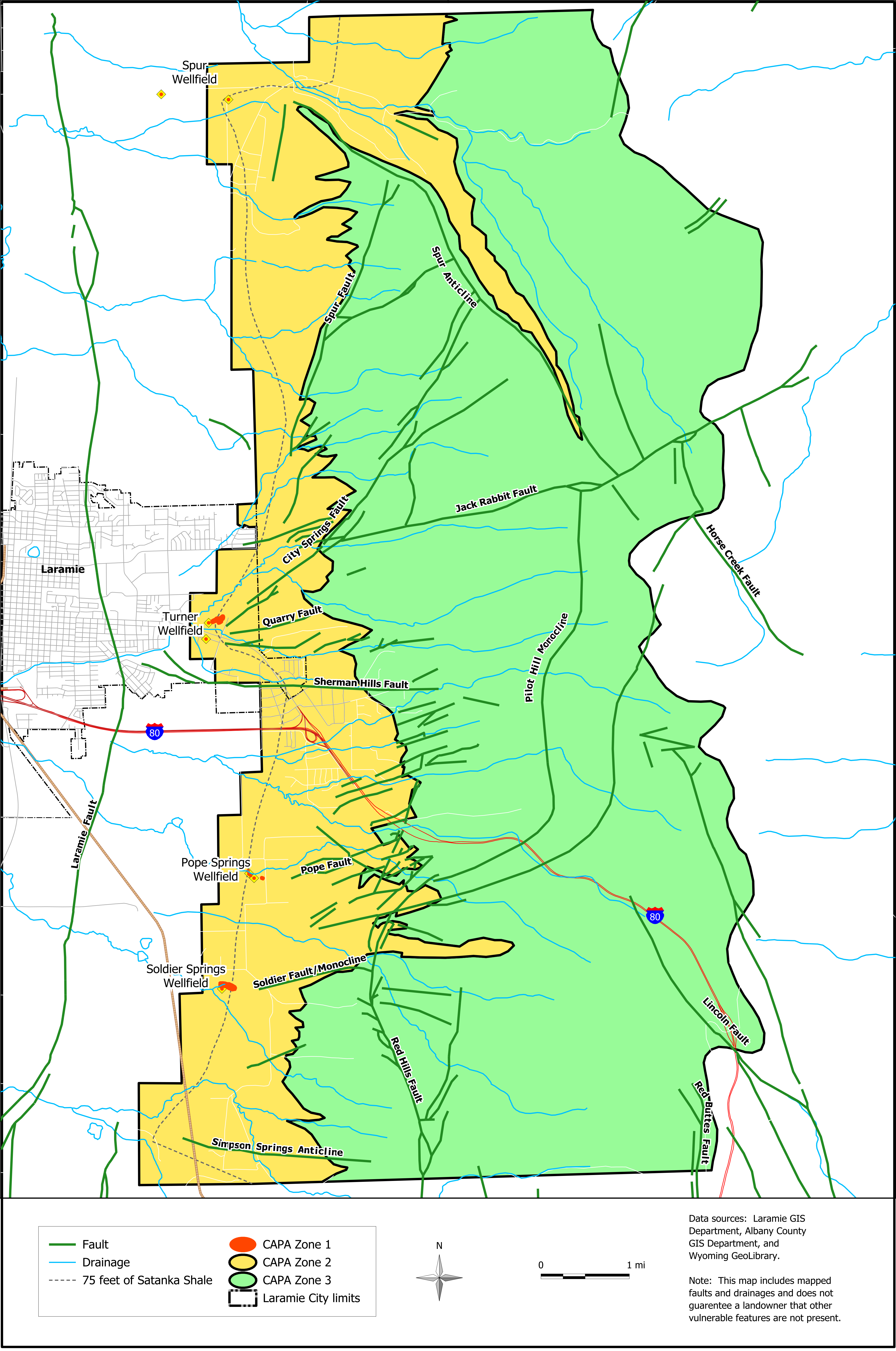


Figure 3-5. Mapped faults and drainages within the Casper Aquifer Protection Area.

permeability formations or unconsolidated material. Where no confining layer is present, rapid infiltration of contaminants from the ground surface to the saturated zone may occur. West of the Casper Aquifer-Satanka Shale contact, the overlying Satanka Shale will provide substantial mitigation of potential contaminants prior entering the aquifer.

Thin Soils

Without the attenuating effect of a biologically and chemically active soil layer between the land surface and the Casper Aquifer, contamination at the surface poses a larger risk to the aquifer than where soils are present.

Shallow Depth to Groundwater

Areas where the depth to groundwater is relatively shallow are also potentially vulnerable to contamination. There is the potential for greater natural remediation as the depth to groundwater increases. Areas where groundwater is close to the ground surface have the potential, where no confining layer is present, for rapid infiltration of contaminants from the ground surface to the saturated zone.

Drainages, faults, and fractures expressed at the surface allow for rapid aquifer recharge. This water can transport contaminants into the Casper Aquifer with little or no attenuation. The other features, dissolution cavities, exposed bedrock, thin soils, and shallow depth to groundwater, increase the vulnerability of the Casper Aquifer but not to the same degree as drainages, faults, and fractures. Dissolution cavities are generally underground and are therefore a less direct pathway than conduit flow features expressed at the surface. Limestones and sandstones make up the exposed bedrock within the CAPA. Limestone increases the vulnerability of the Casper Aquifer primarily through its ability to shed water and contribute to increased overland flow into the drainages, faults, and fractures. Sandstone has greater permeability than limestone and does allow water to infiltrate but at a slower rate than can conduit flow. Thin soils increase the vulnerability of the Casper Aquifer because there is less biological and physical attenuation of a contaminant. Shallow depth to groundwater also increases the vulnerability because there is less distance between the surface and groundwater and therefore less attenuation distance.

It is recommended that the amended regulations deal with the greatest risks by having setbacks of 100-feet from drainages, faults, fractures, and folds expressed at the surface. Additionally, the drainages, faults, fractures, and folds are the most discreet features and setbacks can reasonably be established.

More detailed information regarding the geology and hydrogeology of the Casper Aquifer may be obtained from Morgan (1947), Huntoon (1976), Lundy

(1978), Huntoon and Lundy (1979), Thompson (1979), WWC (1993, 1994, 1996, 1997a,b and 2006), and Ver Ploeg (1998).

Well Data

Municipal well data, as required by the Wyoming WHP Guidance Document, are provided in Table 3-2. The data are derived from City of Laramie Public Works Department files and from the well construction reports.

Pump Data

Pump data for the Laramie municipal wells, as required by the Wyoming WHP Guidance Document, are provided in Table 3-3. The data were gathered from City of Laramie Public Works Department Files and from well construction reports.

Delineation Methods

The Wyoming WHP guidance document, which was used as a guide to determine appropriate delineation methods for the CAPA, requires that three different protection areas be established. The protection areas are designated Zones 1, 2, and 3 as shown on Figure 1-3.

Zone 1 protection areas are to be established around each of the municipal wells. The purpose of the Zone 1, or Accident Prevention Zone, is to prevent the accidental introduction of contaminants into the aquifer in the immediate vicinity of the well. The Wyoming WHP Guidance Document indicates that the Zone 1 protection area is to be a fixed radius of 50 or 100 feet, depending upon well completion and vulnerability to contamination. However, these radii are minimum distances and can be increased to provide additional protection if necessary.

Zones 2 and 3 are designated the Attenuation and Remedial Action Zones, respectively. The purpose of Zone 2 is to protect the well from contact with pathogenic microorganisms and to allow for remediation or clean-up of a spill that may occur in the vicinity of the well. Zone 2 is typically based on a 2-year groundwater time-of-travel. The purpose of Zone 3 is to protect the aquifer from contaminants that may migrate to the well and to allow time for remediation of the contaminant or replacement of the water resource. Zone 3 is typically based on a 5-year groundwater time-of-travel.

For the Casper Aquifer near Laramie, time-of-travel methods were not used to delineate the protection areas for Zone 2 or Zone 3. The Casper Aquifer in the Laramie area is a dual porosity, anisotropic, fractured sandstone and limestone aquifer with no apparent hydrogeologic or flow boundaries between the wellfields. The Casper Aquifer has the potential for rapid recharge and rapid transport of groundwater over large distances. These factors, combined with a lack of detailed hydrogeologic data over large parts of the aquifer and the

Table 3-2. City of Laramie municipal well data.

Well Name	UW Permit No.	Location	Year Drilled	Elevation (ft)	Lithologic Log Location	Well Radius (in)	Total Depth (ft)	Screen Depth (in)	Screened Intervals	Screen Type	Pumping Rates (gpm)	SEO Adjudicated Pump Rate (gpm)
Soldier Wellfield												
Soldier #1	105576	T15N R73W Sec 23, SE, SW	1997	7332.9	WSEO	24	289	20.3	44.1-64.4	Slot	1450	1800
Turner Wellfield												
Turner #1	55507	T15N R73W Sec 14 NE, SE	1982	7273	WSEO	16	240	NA	NA	NA	1750	1400[1]
1st ENL Turner #1	61724	T15N R73W Sec 14 NE, SE	1982	7273	WSEO	16	240	NA	NA	NA	1750	800[1]
2nd ENL Turner #1	72689	T15N R73W Sec 14 NE, SE	1982	7273	WSEO	16	240	NA	NA	NA	1750	300[1]
Turner #2	55508	T15N R73W Sec 35 SE, SW	1982	7266	WSEO	16	350	NA	NA	NA	1250	1400[2]
1st ENL Turner #2	59131	T15N R73W Sec 35 SE, SW	1982	7266	WSEO	16	350	NA	NA	NA	1250	200[2]
Pope Springs Wellfield												
Pope #1	153	T15N R73W Sec 14 NE, SE	1937	7335.5	WSEO	8	156	NA	NA	NA	220	600
Pope #2	154	T15N R73W Sec 14 NE, SE	1938	7338.8	WSEO	8	162	NA	NA	NA	520	600[3]
1st ENL Pope #2	72690	T15N R73W Sec 14 NE, SE	1938	7338.8	WSEO	8	162	NA	NA	NA	675	753
Pope #3	155	T15N R73W Sec 14 NE, SE	1939	7338.8	WSEO	15	158	NA	NA	NA	600	600[4]
1st ENL Pope #3	55505	T15N R73W Sec 14 NE, SE	1939	7338.8	WSEO	15	158	NA	NA	NA	600	250[4]
2nd ENL Pope #3	72691	T15N R73W Sec 14 NE, SE	1939	7338.8	WSEO	15	158	NA	NA	NA	600	50[4]
Pope #4	55506	T15N R73W Sec 14 NE, SE	1982	7351	WSEO	16	350	NA	NA	NA	1500	1750[5]
1st ENL Pope #4	72692	T15N R73W Sec 14 NE, SE	1982	7351	WSEO	16	350	NA	NA	NA	1500	50[5]
Spur Wellfield												
Spur #1	106547	T16N R73W Sec 2 NE, NE	1997	7290.65	WSEO	16	305	NA	NA	NA	1400	1400
Spur #2	107279	T16N R73W Sec 2 NW, NW	1997	7270	WSEO	16	323	NA	NA	NA	1400	1400

[1]Under UW permit numbers 55507, 61724, and 72689, the City of Laramie is adjudicated a total of 2500 gpm from Turner #1.
[2]Under UW permit numbers 55508 and 59131, the City of Laramie is adjudicated a total of 1600 gpm from Turner #2.
[3]Under UW permit numbers 154 and 72690, the City of Laramie is adjudicated a total of 675 gpm from Pope #2.
[4]Under UW permit numbers 155, 55505, and 72691, the City of Laramie is adjudicated a total of 900 gpm from Pope #3.
[5]Under UW permit numbers 55506 and 72692, the City of Laramie is adjudicated a total of1800 gpm from Pope #4.
Note: UW = underground well and SEO = State Engineers Office

Table 3-3. City of Laramie pump data.

Well Name	Pump Type	Pump Make	Pump Model	Pump Setting (ft)	Pump Capacity (GPM)	Motor Make	Motor Model	Motor Rating (HP)	Year Installed
Soldier #1	Line-Shaft Turbine	Floway	14DKH	43	1970	U.S.	VHS	75	1998
Turner #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70503	80	2100	G.E.	JTJ930342	40	1981
Turner #2	Line-Shaft Turbine	Flowserve	14EMM	93	1600	G.E.	JTJ930341	40	2004
Pope #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70504	55	450	G.E.	BV83131	7.5	1982
Pope #2	Line-Shaft Turbine	Gould	8DHHC	60	1100-1480	Emerson	BF28F	200	2007
Pope #3	Line-Shaft Turbine	Aurora Verti-Line	V82-70500	62	1150	G.E.	AVJ120301	40	1982
Pope #4	Line-Shaft Turbine	Aurora Verti-Line	V82-70501	80	2000	G.E.	GTJ729339	75	1982
Spur #1	Line-Shaft Turbine	Floway	12JKh	76	1700	G.E.	VHS	100	2000
Spur #2	Line-Shaft Turbine	Floway	12JKh	86	1700	G.E.	VHS	100	2000

extreme expense of obtaining appropriate data, prevents the use of numerical or semi-analytical delineation methods for defining protection areas based on time-of-travel (EPA, 1990). Consequently, hydrogeologic and vulnerability mapping was used to delineate the CAPA.

Where the aquifer yielding water to wells and springs is characterized by fracture or conduit flow, Zone 3 is delineated first and is defined by flow system boundaries. Zone 3 is delineated using hydrogeologic mapping techniques that identify those parts of the aquifer that might reasonably be expected to yield water to the municipal wells. After creating Zone 3, vulnerability was used to delineate Zone 2. The Zone 2 delineation identifies those areas that are particularly vulnerable to contamination within the larger area Zone 3 delineated by hydrogeologic mapping.

The CAPA was based on the review of existing data which allowed for the determination of the geologic boundaries of the Casper Aquifer and the areas within those boundaries that require different levels of protection. The CAPA delineation is dependent on three primary factors:

- The amount of available information regarding aquifer characteristics; and
- The accuracy of the existing information; and
- The delineation methodology selected and applied in the process.

Published information concerning the Casper Aquifer in the Laramie area was reviewed, often by the authors of the original documents, and updated with the most recent published and unpublished information available from mapping, drilling and aquifer testing.

Delineation Process

The purpose of aquifer protection is to protect public water supplies for present and future uses. The purpose of the delineation process is to define and map the aquifer protection areas. An aquifer protection area considers the entire groundwater resource, including both existing and potential groundwater supply development areas.

Fundamental Findings

Based on the information presented above, the following characteristics were viewed as the fundamental conclusions regarding the Casper Aquifer. The Technical Review Subcommittee reached agreement on these characteristics during the original delineation process:

- Groundwater flow within the Casper Aquifer includes both porous flow (intergranular) and conduit flow (faults, fractures, joints and dissolution features);
- The epsilon and delta members of the Casper Aquifer have higher primary permeability than the underlying gamma, beta and alpha members;
- Fractures associated with faults, folds and bedding planes dramatically enhance the permeability of the sandstones and limestones of the Casper Aquifer;
- The Casper Aquifer is underlain by the Sherman Granite which generally acts as an aquitard or aquiclude;
- The Casper Aquifer is unconfined or semi-confined over most of the outcrop area of the Casper Aquifer;
- The recharge area for the Casper Aquifer is the entire exposed outcrop area of the Casper Aquifer on the west flank of the Laramie Range. Recharge mechanisms for the Casper Aquifer include direct infiltration from precipitation and snow melt and infiltration of surface water runoff, particularly in natural drainage channels;
- The Casper Aquifer is, in general, confined when covered by the Satanka Shale; and
- The lower 50 feet of the Satanka Shale is fractured and in hydraulic connection with the Casper Aquifer.

The delineation of the CAPA discussed below is based on present understanding of the hydrogeology and extent of the Casper Aquifer, its recharge mechanics, and the dynamics of groundwater movement within the Casper Aquifer and between the Casper Aquifer and underlying and overlying geologic strata. The current state of hydrogeologic knowledge of the Casper Aquifer is limited to available data and is subject to refinement as new data become available. Recent investigations, such as the Turner No. 2 downhole camera survey (Wyoming Groundwater, 2004) and ongoing research by University of Wyoming PhD candidate Karl Taboga (Taboga in WWC 2006; Taboga, personal communication), have revealed structural conditions (i.e., large horizontal openings and fractures in the sandstones immediately above or below a limestone layer, and vertical fractures in limestone) and recharge characteristics (i.e., rapid infiltration of overland flow from snow melt into sandstones exposed in upland drainages and recharge through fractures, joints, and bedding planes exposed at the surface, particularly in drainage channels), respectively, that may increase the level of vulnerability in the CAPA.

Zone 1 Protection Area

Many of the municipal wells serving the City of Laramie are drilled in the immediate vicinity of springs. The springs are located at topographic lows where the potentiometric surface of the Casper Aquifer intersects topography or where weaknesses in the confining layer are breached and groundwater from the Casper Aquifer can flow through the overlying Satanka Shale to the ground surface. At many locations the springs are not distinct, but are visible as large, wet grassy areas. When the City wells are not pumped for extended periods of time the springs flow; however, when the municipal wells are pumped and the cone of depression associated with pumping propagates to the springs a reversal of gradient occurs and the springs cease to flow. When the reversal of gradient occurs groundwater moves from the spring site to the well. Additionally, any contaminants introduced in the immediate vicinity of the springs can follow the same pathway as the groundwater and be pumped by the well into the municipal water system. To adequately protect the wells that provide drinking water to the City of Laramie, as shown in Figure 3-6, the Zone 1 protection areas were delineated by establishing a 100-foot radius around the wells and historic spring areas. The delineation procedures followed for each of the water supply sources are described below.

Spur Wellfield

The Zone 1 protection areas for the Spur No. 1 and No. 2 wells have each been established as 100-foot radii around each well. The radii have been assigned to conservatively protect the aquifer in the vicinity of the wells, where the Casper Aquifer occurs at a shallow depth.

Turner Wellfield

The Zone 1 protection area for the Turner wellfield was defined by field mapping. A Global Positioning Satellite (GPS) receiver was used to map the depression associated with the location of the historic City Springs location, spring boxes and the Turner No. 1 and No. 2 wells. A 100-foot buffer was then drawn around each of the mapped features and the resulting polygons were then combined where overlap occurred.

Pope Wellfield

The Zone 1 protection areas for the Pope Wellfield were defined by field mapping with a GPS unit. The now-abandoned cistern, which was constructed over the historic location of Pope Springs, was mapped and a 100-foot buffer

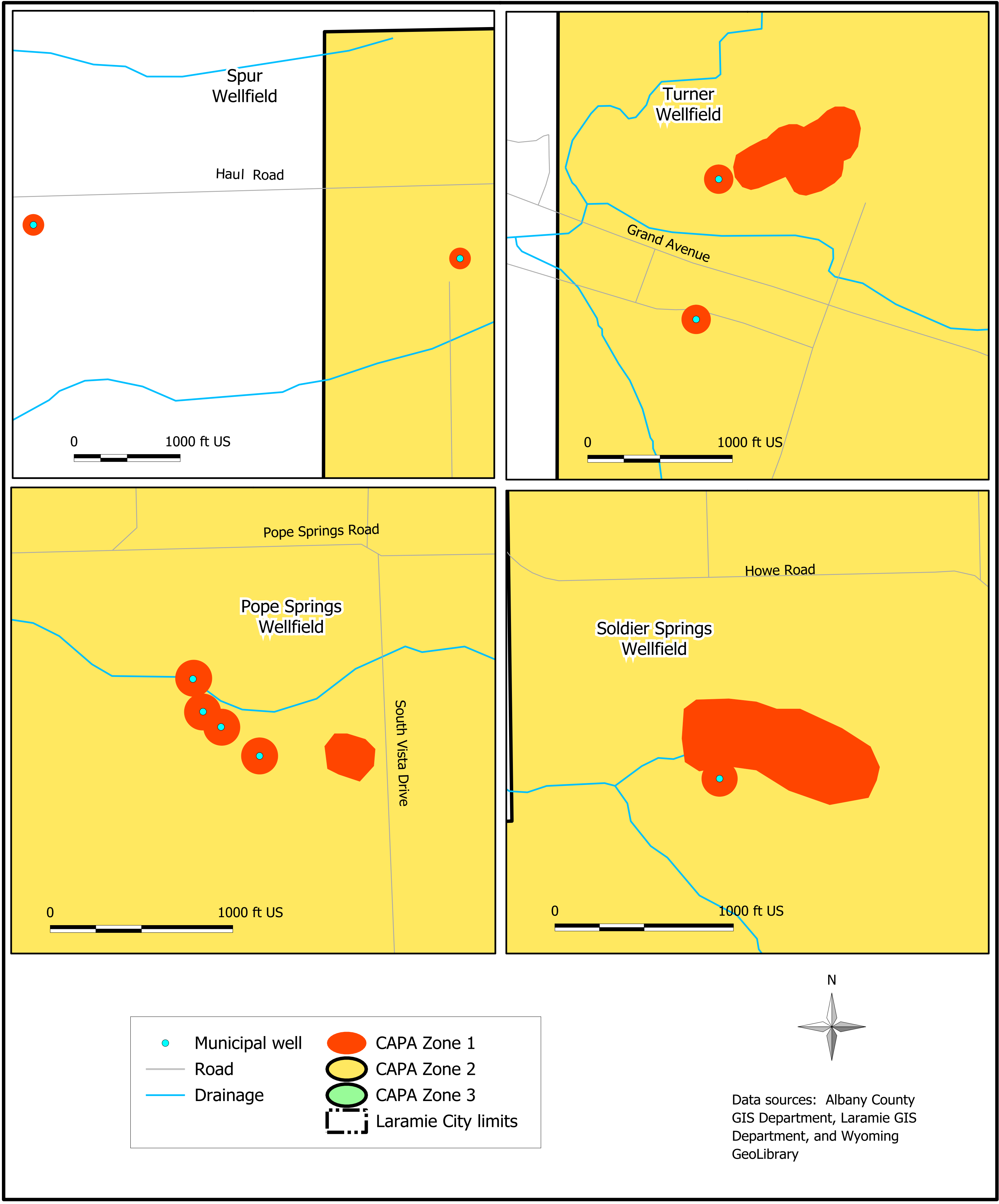


Figure 3-6. Casper Aquifer Protection Area Zone 1 delineations.

created around that feature. Each of the four Pope wells was assigned a 100-foot radius for the Zone 1 protection area. The protection areas for the wells and cistern do not overlap; however, the five zones comprise the Zone 1 protection area for the Pope Wellfield.

Soldier Wellfield

The Zone 1 protection area for the Soldier Wellfield was defined through field mapping. A GPS receiver was used to map the depression associated with the historic location of Soldier Springs, present day Soldier Springs, and the Soldier No. 1 Well. A 100-foot buffer was then drawn around the edge of the depression and the water supply well.

Zone 3 Protection Area

As mentioned earlier, in an aquifer with conduit flow characteristics, Zone 3 is delineated using hydrogeologic mapping techniques that identify those parts of the Casper Aquifer that are expected to yield water to the municipal wells. In essence, Zone 3 encompasses the entire CAPA and this section describes the delineation of the east, west, south, and north boundaries of the Zone 3 CAPA. Figure 1-3 shows the location of the CAPA boundaries.

Zone 3 - Delineation of the East Boundary

The east boundary of the CAPA is located at the topographic divide along the crest of the Laramie Range. This determination is based on the following rationale:

- The Sherman Granite generally serves as a confining layer under the Casper Aquifer;
- The topographic divide is generally very close to the easternmost outcrop of the Casper Aquifer, which is the contact between the Casper Aquifer and the underlying Sherman Granite; and
- The topographic divide of the Laramie Range is generally coincident with the groundwater divide based on the presence of springs that discharge along the contact between the Casper Aquifer and the Sherman Granite. Consequently, groundwater stored in the Casper Aquifer east of the topographic divide probably flows eastward.

Zone 3 - Delineation of the West Boundary

The west boundary of the CAPA was selected after careful consideration of the effectiveness of the Satanka Shale as a hydrogeologic confining layer over the Casper Aquifer.

Existing hydrogeologic data were evaluated and a determination was made that the Satanka Shale generally acts as a confining layer for the Casper Aquifer in the Laramie area. While the data distribution is limited, the following observations of spring and well data indicate that the lower 50 feet of the Satanka Shale can be permeable and in hydraulic connection with the Casper Aquifer.

- The base of the Satanka Shale is composed of interbedded fractured shale and sandstone.
- The water at City Spring, Soldier Springs, and Simpson Springs flows from the Casper Aquifer through approximately 50 feet of basal Satanka Shale, presumably via vertical fractures.
- Water levels measured in Section 1, Township 15 North, Range 73 West reveal only a small difference in hydraulic head between the basal Satanka Shale and the Casper Aquifer.

Based on the above data, the Technical Review Subcommittee believed that the Casper Aquifer may be vulnerable to contamination if 50 feet or less of undisturbed Satanka Shale lies between the Casper Aquifer and the ground surface. The Technical Review Subcommittee agreed that at least 75 vertical feet of undisturbed Satanka Shale (50 percent more than the thickness of the zone of apparent connectivity) was needed to effectively protect the Casper Aquifer from contaminants that may be spilled or introduced at or near the ground surface.

The actual location of the original west boundary for the CAPA was the distance from the Casper-Satanka contact that provided 75 feet of undisturbed Satanka Shale cover when the dip of the formation and slope of the ground surface were considered. Figure 3-7 illustrates the procedure to used predict the offset of 75 feet of Satanka Shale from the contact. As the dip in the Satanka Shale increases, the offset distance decreases. The stratigraphic remainder of the Satanka Shale was considered to be an effective confining layer above the Casper Aquifer.

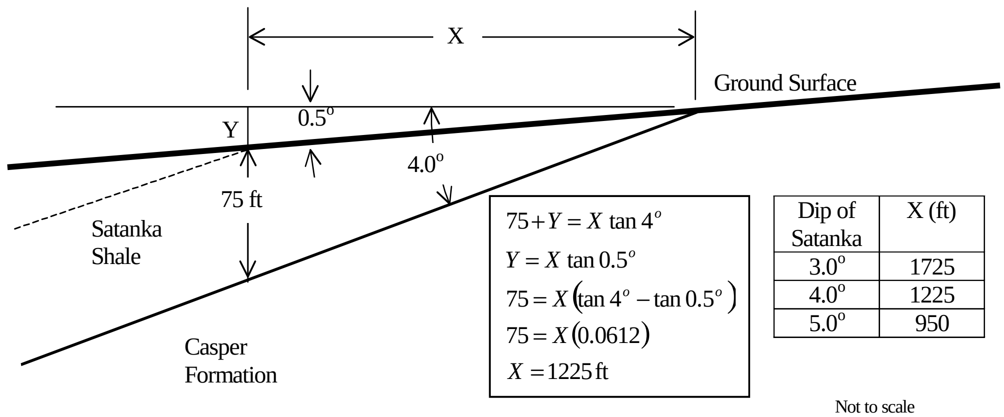


FIGURE 3-7. DETERMINATION OF THE OFFSET DISTANCES AS A FUNCTION OF DIP OF THE SATANKA SHALE.

The original west boundary of Zone 3 was delineated based on drilling data and a set of assumptions about the geology and hydraulics of the Casper Aquifer and Satanka Shale. This original boundary is now designated as the 75 feet line (Figure 1-3). The 75 feet line represents a boundary calculated from a dip formula (Figure 3-7) where there is an estimated 75 feet of Satanka Shale overlying the Casper Aquifer. However, it is known that in several instances the calculated line of 75 feet of Satanka Shale is inaccurate. At Soldier No. 1 well there is 41 feet of Satanka Shale but the calculated 75 feet line is to the east of Soldier No. 1. At Turner No. 2 well, there is 74 feet of Satanka Shale so the calculated 75 feet line should coincide with Turner No. 2 yet the calculated line is east of Turner No. 2. At Spur No. 1 well there is 54 feet of Satanka Shale and yet the calculated 75 feet line is very near that well when the actual line should be further west of the Spur No. 1. Since there are known areas where the calculated line is inaccurate, it was decided that the western boundary should be moved to ensure that at least 75 feet of Satanka Shale was overlying the Casper Aquifer.

In order to account for the uncertainty in local geology and to allow for effective implementation of the CAPP, the west boundary of CAPA Zone 3 has been straightened and moved to the west of the calculated 75 feet line. The west boundary of Zone 3 now provides an additional buffer to the calculated line of 75 feet of Satanka Shale to ensure greater protection of the Casper Aquifer. Additionally, the western boundary was moved to ensure continuous protection between Zones 1 and 2. In previous delineations there was a gap of protection between Zones 1 and 2. Finally, the line was straightened and moved primarily to section, quarter section, and quarter-quarter section lines to provide for easier implementation of the CAPP. Around the Indian Hills subdivision the CAPA west boundary coincides with south, west, and north boundary of the subdivision. The Indian Hills subdivision boundaries were used because City of Laramie sewer and water serve the subdivision, the subdivision is completely built out, and the existing development is single-family residential.

Zone 3 - Delineation of the South Boundary

The reasoning for the placement of the south boundary is as follows:

The springs along the base of the west flank of the Laramie Range, including City Springs, Pope Springs, Soldier Springs, Simpson Springs and others further south, are the surface manifestations of the intersections of east-west trending structural features and a confining bed. The geologic structures contain fractures that allow for the rapid transmission of water downgradient to the point where the water level in the Casper Aquifer intersects a confining layer and the aquifer acquires its maximum saturated thickness (i.e. the potentiometric surface intersects the ground surface). The elevations of the springs increase to the south, with the City Springs being lowest in elevation. This means that the entire Casper Aquifer south of the City Springs has the potential to contribute water to City Springs. However, the southern springs, which are higher in elevation, do not cease flowing during the year and we do not observe hydraulic gradients indicating groundwater flow in the Casper Aquifer from south to north. While there is not a flow system boundary in the Casper Aquifer between any of the springs, there is a significant difference in permeability in the rocks that contribute water to the springs, such that the non-fractured rocks have permeabilities that are orders of magnitude less than the fractured rocks. It has long been asserted that the faults and folds in the Casper Aquifer act as “collectors” of groundwater. Groundwater flowing downgradient through the low-permeability rocks that encounters the fractured rocks preferentially moves downgradient in the fracture system and is discharged at the springs. A small quantity of water may cross the fractured zones, but the vast majority of the water is discharged at the springs. As such, the east-west trending structures, such as Simpson Springs Anticline, that feed water into springs act as localized hydrogeologic boundaries.

The City of Laramie owns Monolith Ranch, Simpson Springs, and the associated water rights. Simpson Springs will likely be the next source of groundwater supply development by the City of Laramie (WWC, 2006). In order to protect future water sources, the south boundary was delineated to include Simpson Springs.

Zone 3 - Delineation of the North Boundary

The reasoning for the placement of the north boundary is as follows:

Pump testing of the Spur wells indicates that the majority of the water is derived from the Casper Aquifer from fractures along the crest of the Spur Anticline (WWC, 1997). Aquifer parameters determined from observation wells indicates that the transmissivity of the aquifer between the Spur wells and observation well C-105 is approximately 432,000 gpd/ft, which is extremely high. The data also indicates that the aquifer between the two wells is confined to leaky. Geologic mapping of the area north of the Spur wells indicates the presence of small faults that trend east-west, but there are no surface discharges to indicate the aquifer is highly transmissive along the faults. Therefore, it appears that the Casper Aquifer may be relatively isotropic north of the Spur wells.

Using the wellhead protection area model (Blandford, Huyakorn, and Wu, 1991), with inputs of: the above transmissivity, confined conditions, aquifer thickness of 700 feet, porosity of 15%, hydraulic gradient of 0.001, long-term pumping rate of 975 gpm, model run time of 5 years, and direction of flow from the north, the result is a capture zone that extends approximately 3,200 feet north of the Spur wells. This capture zone represents a worst-case scenario because it assumes that all of the water is being derived from the north and ignores the contribution of water from the Spur Anticline. Extending the boundary to a point 4,800 feet north of Spur Well No. 2 provides for a 50 percent factor of safety.

Zone 2 Protection Area

As described in the WHP Guidance document, vulnerability mapping is used to subdivide Zone 3 into Zone 2 areas that may require a greater degree of protection. The Zone 2 delineation identifies those areas that are particularly vulnerable to contamination within the larger area delineated by hydrogeologic mapping. As discussed previously, there are numerous features such as faults, folds, exposed bedrock, drainages, and shallow depth to groundwater that make the Casper Aquifer vulnerable to contamination. For example, the WDEQ identified four faults – City Springs, Jackrabbit, Quarry, and Sherman Hills – that appeared to have a reasonably high potential to allow adverse impact to municipal springs and wells. WDEQ suggested that unless there is geologic and/or hydrogeologic evidence to convincingly demonstrate that there is no increased vulnerability (e.g., due to cementation, etc.) related to these faults, then these faults must be included in Zone 2. However, these vulnerable features are distributed throughout the CAPA in a complex geometry, such that Zone 2 boundaries defined by these features would be highly irregular and extremely difficult to manage effectively.

A modified and more practical approach was used by the Technical Review Subcommittee to delineate Zone 2. The outcrop area of the delta and epsilon members of the Casper Aquifer was designated as Zone 2 based on the following considerations:

- The intergranular permeability of the sandstones in the delta and epsilon members is greater than the intergranular permeability of the underlying alpha, beta and gamma members;
- The shallower depth to groundwater near the west edge of the Casper Aquifer outcrop;
- Outcrops of the delta and epsilon members are in proximity to the municipal groundwater supply wells for the City of Laramie; and
- The municipal groundwater supply wells and springs for the City of Laramie are completed primarily in the epsilon and delta members of the Casper Aquifer.

Because the delta member is one of the most permeable of the five members, the Technical Review Subcommittee agreed to extend the east boundary of Zone 2 200 feet east of the base of the delta sandstone outcrop. This provides a buffer to prevent contaminants from directly entering the exposed edge of the delta member of the Casper Aquifer. In those situations in which the 200-foot buffer creates an enclosed or nearly enclosed area of Zone 3, the entire area was designated as Zone 2. The westernmost edge of the line will mark the boundary.

The Technical Review Subcommittee agreed that the CAPA should be divided into two sub-areas designated as the Primary Protection Area (Zone 2) and the Secondary Protection Area (Zone 3) with Zone 2 to receive a higher level of protection than Zone 3.

Current research (Taboga in WWC, 2006 and Taboga, personal communication), suggests a potentially greater aquifer interconnectivity in both Zones 2 and 3, not just the four faults identified by WDEQ, and the vital role that upland drainages play in aquifer recharge. Subsequently, enhanced water transport within the Casper Aquifer is likely, which translates to a higher risk or vulnerability in Zone 3 than may have been previously acknowledged.

In recognition of the impractically to strictly define Zone 2 using vulnerable features such as faults, drainages, and exposed bedrock, and the potential for rapid groundwater flow in the fractured Casper Aquifer, Zone 3 will be managed the same as Zone 2 (see Chapter 5) until research or data shows otherwise. In addition, site-specific investigations designed to identify vulnerable features are recommended for any proposed development in Zone 2 or Zone 3. In essence, the level of protection in Zone 3 will be enhanced to equal the level of protection established in Zone 2.

With Zone 2 defined as the outcrop area of the delta and epsilon members, including the calculated 75 feet of overlying Satanka Shale and the extension of the western boundary west of the calculated 75 feet line (west boundary of the CAPA), the remainder of the CAPA, east of the delta member to the topographic divide of the Laramie Range, is designated as Zone 3.

Aquifer Protection Area Maps

The Aquifer Protection Map, developed using the procedures outlined in the Delineation Process section, is presented as Figure 1-3.

Written Description of Aquifer Protection Areas

Zone 1 Protection Areas

Spur Wellfield

The Zone 1 protection areas for the Spur No. 1 and Spur No. 2 wells consist of a 100-foot fixed radius around each well.

Turner Wellfield

The Zone 1 protection area for Turner No. 1 Well consists of a 100-foot fixed radius. The Zone 1 protection area for Turner No. 2 Well is an irregularly shaped polygon that includes the well, spring boxes, and the topographic low associated with the historic natural discharge points for the City Springs. The protection area has a maximum length of 320 feet in the north-south direction and a maximum length of 680 feet in the east-west direction.

Pope Wellfield

The Zone 1 protection areas for the Pope Wellfield consist of 100-foot fixed radii around the Pope Nos. 1, 2, 3, and 4 wells. The protection areas for Pope Nos. 2 and 3 wells have been merged because of overlap. The Zone 1 protection area for the wellfield also includes a 100-foot setback from the edges of the cistern that is located over the historic Pope Springs.

Soldier Wellfield

The Zone 1 protection areas for the Soldier Wellfield are comprised of a 100-foot fixed radius around the Soldier No. 1 well and a 100-foot setback from the topographic depression associated with the historic Soldier Springs. The maximum length of the protection area is 200 feet in the north-south direction and 600 feet in the east-west direction.

Zone 2 Protection Area

The Zone 2 protection area is an irregularly shaped area that has a maximum east-west width of approximately 19,000 feet and a maximum north-south length of 71,000 feet. The western boundary of Zone 2 primarily follows quarter-quarter, quarter, half-section, and section lines and can be described in the following manner:

> *Beginning in the Southeast corner of the Northwest quarter of the Northeast quarter of Section 36, Township 17 North, Range 73 West; the boundary line extends due south to the Southeast corner of the Northwest quarter of the Southeast quarter of Section 36, Township 17, Range 73; at which point the line extends due west to the Southwest corner of the Northwest quarter of the Southeast quarter of Section 35, Township 17, Range 73; and proceeds due south to the Southwest corner of the Northwest quarter of the Southeast quarter of Section 2, Township 16, Range 73; continues due east to the Southeast corner of the Northwest quarter of the Southeast quarter of*

Section 2, Township 16, Range 73; then proceeds due south to the Southeast corner of the Southwest quarter of the Southeast quarter of Section 14, Township 16, Range 73; where the line continues due east to the Southeast corner of the Southeast quarter of the Southeast quarter of Section 14, Township 16, Range 73; then extends due south to the Southeast corner of the Southeast quarter of the Northeast quarter of Section 26, Township 16, Range 73; where it proceeds due west to the Southwest corner of the Southeast quarter of the Northeast quarter of Section 26, Township 16, Range 73; before extending due south to the Northern boundary of the Indian Hills Subdivision 3rd Addition; and continuing along the northern boundary of Indian Hills Subdivision 3rd addition and Indian Hills 7th addition eastwardly along the northern boundary of the two subdivisions; at the intersection of 45th street and the Northern boundary of Indian Hills Subdivision 7th addition the boundary line continues south along the Eastern edge of the right-of-way for 45th Street adjacent to the Indiana Hills subdivision 7th, 6th, and 4th additions; and continues West along the Southern right-of-way for Crow Drive adjacent to the Indian Hills Subdivision 4th and 3rd additions; and continues West along the Southern most property line of the Indian Hills Subdivision 1st addition to the Southwest corner of the Southeast quarter of Section 26, Township 16, Range 73; and continuing due west to the Southwest corner of the Southwest quarter of the Southeast quarter of Section 26, Township 16, Range 73; where the boundary line extends due south to the Southeast corner of the Southeast quarter of the Northwest quarter of Section 35, Township 16, Range 73; then proceeds due west to the Southwest corner of the Southeast quarter of the Northwest quarter of Section 35, Township 16, Range 73; then continues due south to the Southwest corner of the Northeast quarter of the Northwest quarter of Section 2, Township 15, Range 73; and extends due east to the Southeast corner of the Northeast quarter of the Northwest quarter of Section 2, Township 15, Range 73; and continues due south to the Southeast corner of the Southeast quarter of the Northwest quarter of Section 2, Township 15, Range 73; where the line proceeds due east to the Southeast corner of the Southeast quarter of the Northeast quarter of Section 2, Township 15, Range73; and continues due south to the Southeast corner of the Southeast quarter of the Northeast quarter of Section 11, Township 15, Range 73; before proceeding due west to the Southwest corner of the Southeast *quarter of the Northeast quarter of Section 11, Township 15, Range 73; and extending due south to the Southwest corner of the Southeast quarter of the Southeast quarter of Section 11, Township 15, Range 73; where it proceeds west to the Southwest corner of the Southwest quarter of the Southeast quarter of Section 11, Township 15, Range 73; where the line extends due south to the Southwest corner of the Southwest quarter of the Southeast quarter of Section 14, Township 15, Range 73; then extends due west to the Southwest corner of the Southeast quarter of the Southwest quarter of Section 14, Township 15, Range 73; where the line proceeds due south to the Southwest corner of the Southeast quarter of the Southwest quarter of Section 23, Township 15, Range 73; and continues due west to the Southwest corner of the Southwest quarter of the Southwest quarter of Section 23, Township 15, Range 73; before continuing due south to the Southwest corner of the Southwest quarter of the Southwest quarter of Section 26, Township 15, Range 73; and proceeding due west to the Southwest corner of the Southwest quarter of the Southeast quarter of Section 27, Township 15, Range 73; before continuing south to the end of the boundary line at the Southwest corner of the Northwest quarter of the Northeast quarter of Section 3, Township 14 North, Range 73 West.*

Zone 3 Protection Area

The Zone 3 protection area is an irregularly shaped area that has a maximum east-west width of approximately 26,500 feet and a maximum north-south length of 71,000 feet.

Site-Specific Investigations

Within the large geographic areas defined as Zones 2 and 3, features have been identified that may render the Casper Aquifer vulnerable to contamination. It is recommended that site-specific investigations be conducted when development is proposed within Zones 2 and 3. Development is defined generally as any modification to the natural land surface that may result in the introduction of contaminants and/or an increase in the vulnerability of the Casper Aquifer to contamination (see the respective City Ordinance and County Resolution – Appendix I for exact definitions). These site-specific investigations will be conducted by a professional engineer or professional geologist who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport during the permitting phase. The purpose of the site-specific investigation is to identify, as a minimum, the impacts, if any, of the proposed development(s) on the Casper Aquifer. The site-specific investigation shall describe, to the extent possible given the existing data and site-plan information, the existing conditions, all proposed activities, and all proposed management techniques, including any measures necessary to mitigate risks.

It is recommended that the site-specific investigation include the following 13 items.

1. A literature search to determine the presence of mapped faults, folds, fractures, and other evidence of conduit flow on the subject property.
2. A site narrative that includes historical information on previous land use, contaminant releases, abandoned wells, underground storage tanks, and septic systems as well as any other information relevant to the site.
3. A site plan showing the proposed use and zoning of the property including existing and proposed ground contours accurate to a two-foot interval as referenced to the USGS contour map for the area or other specified elevation standard as required by the City, and for a distance of at least five hundred feet beyond any proposed development activity, existing and proposed structures, parking areas, driveways, landscaping areas, setbacks, surface and subsurface drainage facilities, potential contaminant storage locations and methods of storage, above ground storage tanks, best management practices, utilities, roads stormwater management, and a vicinity map. Where necessary, specific construction details shall be provided to assure adequacy to accepted design standards.
4. Identification of potential contaminants and amounts stored, generated or handled on the subject property.
5. A field inspection shall be conducted to verify the presence or absence of vulnerable features as defined in Section 17.82.070.A. A summary of the field inspection shall include a written report, maps identifying the vulnerable features, and the distance and direction of the nearest well and vulnerable feature. Where subsurface wastewater disposal is proposed, the investigator shall conduct deep pit soil analysis to a depth at least five feet below the proposed bottom of the leaching system to establish that there are no obstructions such as bedrock, water table or other forms of refusal that could interfere with the proper functioning of the wastewater disposal system.
6. A map showing the area and types of exposed bedrock, marshes, perennial drainages, intermittent drainages,

ephemeral drainages, creeks, and other bodies of water on the subject property.

7. Where the 100-year flood plain mapping is unavailable, the professional geologist and/or engineer will calculate the 100-year flood plain for the drainage. The flood plain mapping will be provided on a site map with a scale not to exceed 1 inch equals 200 feet.
8. An evaluation of the water supply and sewage system that includes the potential effects or risks of the systems to the Casper Aquifer and its recharge area and the adequacy and safety of the systems. Items such as floor drains and plumbing schematics and the locations of potential contaminants, waste storage, and liquid transfer area locations shall be provided.
9. A map(s) depicting the potentiometric surface of the Casper Aquifer at the subject property using data from historical water level measurements and published potentiometric surface maps. No new wells shall be drilled for the purpose of determining the potentiometric surface.
10. A surface water risk assessment and mitigation plan for any impacts caused by storm water runoff, retention and/or detention basins on the City water supply and the Casper Aquifer.
11. A maintenance plan and agreement for any retention and/or detention basins and associated improvements will be required. Such plan and agreements shall be recorded in the Albany County Clerk's Office.
12. A groundwater risk assessment and mitigation plan to respond to any evidence of contamination or vulnerability which is the result of the development. Such plan shall not limit the liability of any Person for impacts to the Casper Aquifer.
13. Demonstration of compliance with all applicable City of Laramie and/or Albany County Standards.

After conducting the site-specific investigation, a report of the findings, including maps, should be submitted to the Albany County Planning Department and/or the City of Laramie Community Development Department for review.

It is recommended that the City and County retain a consultant or qualified staff to review the site-specific investigation report. The qualified staff or consultant will provide the City and County with a technical review and rational for either allowing or not allowing the proposed development based upon the site-specific investigation, applicable regulations, and the CAPP. In review of the site-specific investigation, the qualified professional will assess and determine whether the site and development plans meet the overall objectives of the Casper Aquifer Protection Plan and the City Aquifer Protection Ordinance or County Aquifer Protection Resolution, whichever is applicable.

The City or County may attach conditions of approval to ensure the protection of the groundwater quality, including, but not limited to, further evaluation, reasonable technical improvements, monitoring or other mitigation measures. All conditions of approval should be reviewed and evaluated by the professional engineer, geologist, hydrologist, or other qualified designee who reviews the site-specific investigation to ensure that the condition(s) of approval are of sound scientific and technical reasoning.

Modifications to the Casper Aquifer Protection Area Boundaries

The location of zone boundaries may be altered in the future as more information becomes available. Changes to the boundaries of the CAPA should only be allowed:

- When a site-specific investigation indicates significant variation from the assumptions presented herein; and
- Based on the recommendations of three qualified water resource professional licensed by the State of Wyoming to practice engineering and/or geology.

The Laramie Community Development Department and Albany County Planning Department should review the boundary changes and make a recommendation to the Albany County Commissioners and Laramie City Council. In any determination, the criteria established in this chapter should be consistently applied to any proposed modification to the CAPA.

Recommendations

Recommended Investigations

To aid in refining the CAPA delineation process and to increase the understanding of the Casper Aquifer, the following investigations should be undertaken.

1. Establish routine measurement of water levels and water quality in wells completed in the Casper Aquifer in the Laramie area and update potentiometric maps. Currently, the City of Laramie monitors the production wells for water-quality parameters on an annual basis. Water levels are recorded continuously at all production wells and at the Spur monitoring wells.
2. Research recharge mechanisms and vulnerability of the Casper Aquifer to contamination from the ground surface.
3. Conduct tracer test of major faults associated with the City Springs and wells.

4. Investigate the degree of hydraulic interaction between the Casper Aquifer and the overlying Satanka Shale.
5. Delineate the 100-year flood plains within the CAPA.
6. Investigate the degree of hydraulic interaction between the Casper Aquifer and the underlying Sherman Granite.

Of the recommendations listed above, WHPA suggests that establishing a routine groundwater monitoring program be one of the City of Laramie's highest priorities for implementation. A groundwater monitoring program is essential to track changing conditions in the Casper Aquifer. The other recommendations should be completed prior to, or at a minimum, be well underway by the 2010 CAPP update. Recent and ongoing research can be applied or enhanced to fulfill the recommendations. Appendix F contains further guidance on recommended studies found throughout the CAPP.

Site-Specific Investigations

It is recommended that the site-specific investigations be implemented immediately. The site-specific investigations will ensure that all development is reviewed in light of management strategies and will increase protection of the Casper Aquifer.

CHAPTER 4

CONTAMINANT SOURCE INVENTORY

This chapter presents the Contaminant Source Inventory as specified in Section III of Wyoming's WHP Program Guidance Document (1998) and is Step 3 of the five-step process.

INTRODUCTION

The objective of completing a source inventory is to identify all potential and existing sources of contamination that may threaten public drinking water supply wells. Existing sources are those that are known to have caused groundwater contamination. Potential sources are those that may cause groundwater contamination but, to date, have not.

Groundwater contamination can occur many different ways, but often involves the misuse and improper disposal of liquid and solid wastes; the illegal dumping of household, commercial, or industrial chemicals; the accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; the improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial land uses; and liquid and solid waste disposal facilities. Contaminants also can be derived from atmospheric pollutants, such as airborne sulfur and nitrogen compounds, which are created by smoke, flue dust, aerosols, and automobile emissions, fall as acid rain, and infiltrate through the soil.

The inventory process includes the following steps.

1. Obtain a base map to locate existing and potential sources.
2. Obtain available information on existing and potential sources:

   - Determine and record existing data;
   - Identify likely sources for further study;
   - Investigate unknown sources; and

- Verify accuracy and reliability of the information gathered.

3. Describe contaminant sources within the wellhead protection area and complete source identification forms for each existing and potential source of contamination identified.
4. Develop the Source Inventory list from completed Source Identification forms.
5. Prioritize sources within the wellhead protection area for management purposes.
6. Transfer source location and information to wellhead protection area delineation maps.
7. Update, refine and expand Source Inventory information.

APPROACH

The Environmental Advisory Committee Contaminant Source Identification Subcommittee (CSIS) began its inventory in 1998. The mission of this subcommittee was to identify existing and potential sources of contamination to the groundwater supply of the City of Laramie. The CSIS was also charged with prioritizing the inventory list to aid in the development of necessary aquifer area management strategies.

The CSIS used the geologic map adapted from Don A. Lundy (1978) for the base map of this inventory. It is a topographic base map with detailed geologic mapping. Zones 2 and 3 of the Casper Aquifer Protection Area (CAPA) were overlaid onto this map.

The original source inventory was completed using several methods of study. In 1998, databases and published information were used by the University of Wyoming Geography and Recreation Department's Planning Program (UW Planning Program) to survey subdivisions in 16 sections due east of the City of Laramie. Two graduate students within the UW Planning Program completed a contaminant inventory of over 50 sections within the protection area for a master thesis (Hallgarth, 2001) and an EAC intern project (Powell, 2000). The graduate students collected and verified their inventories by field searches, windshield surveys, and door-to-door surveys with the use of a global position system (GPS) and geographic information systems (GIS) computer applications. The UW Planning Program submitted two class reports to the EAC in 2000; Build-out Scenarios-Casper Aquifer Recharge Area 1999-2010 and Terrain Analysis of the Casper Aquifer Protection Area, Laramie, WY (August 2000 and September 2000). The Albany County Assessor's office also contributed source inventory information based on land-ownership files, one and five-meter resolution satellite imagery, and GIS applications.

An independent inventory of contaminant sources in the CAPA was performed in June, 2004 as part of a state funded Source Water Assessment for Laramie. The Source Water Assessment is part of Wyoming's Source Water Assessment and Protection Program (SWAP).

In November 2007, Wittman Hydro Planning Associates, Inc. (WHPA) and the City of Laramie Community Development Department updated the list of potential contaminant sources. This update was conducted in conjunction with the revision of the Casper Aquifer Protection Plan (CAPP). WHPA utilized existing databases from Wyoming Department of Environmental Quality (WDEQ) and the City of Laramie Community Development Department conducted a windshield survey of the area.

The CSIS, WHPA, and City of Laramie Community Development Department researched existing data sources and identified potential contaminant sources located within the protection area. Existing sources were verified by a windshield survey. Research included looking at regulatory reporting requirements such as the following:

- Resource Conservation and Recovery Act (RCRA) Subtitle C
- RCRA Subtitle I
- Superfund Amendments and Reauthorization Act (SARA) Title III
- Underground Injection Control (UIC)
- National Pollution Discharge Elimination System (NPDES)
- Spill Prevention Control and Countermeasure (SPCC)

The following regulatory databases were also reviewed:

- Toxic Chemical Release Inventory (TRI)
- CERCLA Information System (CERCLIS)
- Hazardous Waste Data Management System (HWDMS)
- RCRA Information System (RCRIS)
- Waste Management Permit Compliance System
- Hazardous Material Incident Reporting System
- Underground Storage Tanks Case History File
- The Pollution Prevention Information Clearinghouse (PPIC)
- Federal Reporting Data System (FRDS)
- Leaking Underground Storage Tank database (LUST)
- Groundwater Pollution Control Program database

The UW Planning Program class project (University of Wyoming, Department of Geography and Recreation, 1999a) examined land use activities in an area east of the City of Laramie by a windshield survey. The land-uses included residential areas, commercial sites, industrial facilities, transportation networks, forestry activities, mining operations, and agricultural practices. This information is reported in an unpublished document (University of Wyoming, Department of Geography and Recreation, 1999b). Figure 4-1, updated in 2007, provides County and City land use and zoning designations in the CAPA.

Potential Sources of Contamination

The potential contaminant source inventory was updated in 2007. All of the inventoried contaminant sources are designated potential because the sources have not been documented to have caused, to date, groundwater contamination. Source Identification Forms and Form IV for potential contaminant sources can be found in Appendix G. Due to the complexity of the CAPA and the fact that Zone 2 and Zone 3 are managed as one unit, the potential contaminant sources for all CAPA Zones have been listed together on the Source ID and Inventory List.

Zone 1 Potential Sources of Contamination

The only potential contaminant sources within Zone 1 are the naturally occurring springs at Pope, Soldier, and Turner wellfields.

Zones 2 and 3 Potential Sources of Contamination

Potential sources of contamination are listed in the contaminant source inventory (Table 4-1) and shown in Figure 4-2a. Figures 4-2b, 4-2c, and 4-2d provide a closer look at the potential contaminant sources around Spur, Turner, and Pope and Soldier wellfields, respectively. Figure 4-3 shows the County subdivisions that use septic systems.

General categories of contaminant sources are described below. Management strategies for each of the potential sources of contamination are discussed in Chapter 5.

- **Transportation corridors.** Hazardous materials are transported along these routes and if spills were to occur it could contaminate the Casper Aquifer in a single event. Automobile wastes and petroleum products associated with transportation routes can accumulate over time and be introduced into the aquifer through storm runoff.
- **Residential land use.** Septic systems in the Casper Aquifer are of particular concern because vulnerable features may provide a direct route for sewage effluent to enter the aquifer. Nitrates, bacteria, and other household wastes are all potential contaminants associated with septic systems. Additionally, every house over the Casper Aquifer generates household hazardous wastes and if improperly disposed these hazardous wastes may also enter the aquifer. Fertilizers and pesticides

may enter the aquifer either through runoff into drainages or through leaching into groundwater if improperly applied. Residential areas that are attached to a centralized wastewater system will have much less of an impact on the aquifer than those using septic systems.

- **Abandoned wells.** Improperly abandoned wells completed in the Casper Aquifer, provide a direct pathway for contaminants to enter the Casper Aquifer.
- **Underground and aboveground storage tanks (UST and AST).** USTs and ASTs often store petroleum products or other hazardous materials and leaks may go undetected for some time. Due the materials stored in these tanks, they are considered a potential contaminant source.
- **Stormwater and urban runoff.** Heavy metals, automobile fluids, pesticides, and fertilizers are all contaminants found in stormwater and urban runoff. Stormwater and urban runoff are typically associated with parking lots, building, and roadways. As the stormwater and urban runoff reach drainages and infiltrate the aquifer, associated contaminants are introduced into groundwater.
- **Commercial land use.** Some commercial land uses store, use, and/or generate hazardous materials that if improperly handled may contaminate the aquifer. Storm runoff is generated from impervious areas, and pesticides and fertilizers used by these businesses may be introduced to the Casper Aquifer.
- **Limestone quarries.** Limestone quarries use fuel and blasting materials that if improperly handled may contaminate the aquifer. The blasting materials are consumed during the detonation but could contaminate the aquifer if improperly handled or stored.
- **Agricultural land use.** Waste from commercial concentrated livestock facilities and applications of fertilizers and pesticides pose a risk from agricultural land use to the Casper Aquifer. General livestock grazing poses much less of a threat to groundwater than commercial concentrated feeding operations.
- **Miscellaneous uses.** There are other uses within the CAPA which have the potential to contaminate the Casper Aquifer. These uses produce the following contaminants: stormwater, animal wastes, medical wastes, pesticides, fertilizers, lead, and hazardous materials.

Updating the Contaminant Source Inventory

To ensure that the contaminant source inventory continues to be updated on a regular basis, the assigned City/County staff will incorporate new developments into the inventory as the developments occur. The Albany County Planning Department and the Laramie Community Development Department will provide the development information to the assigned City/County staff. Federal and state databases regarding potential contaminant sources will be accessed once each year to include the latest information in the inventory. Every two years, when the CAPP is updated, a windshield survey will also be conducted to verify contaminant sources

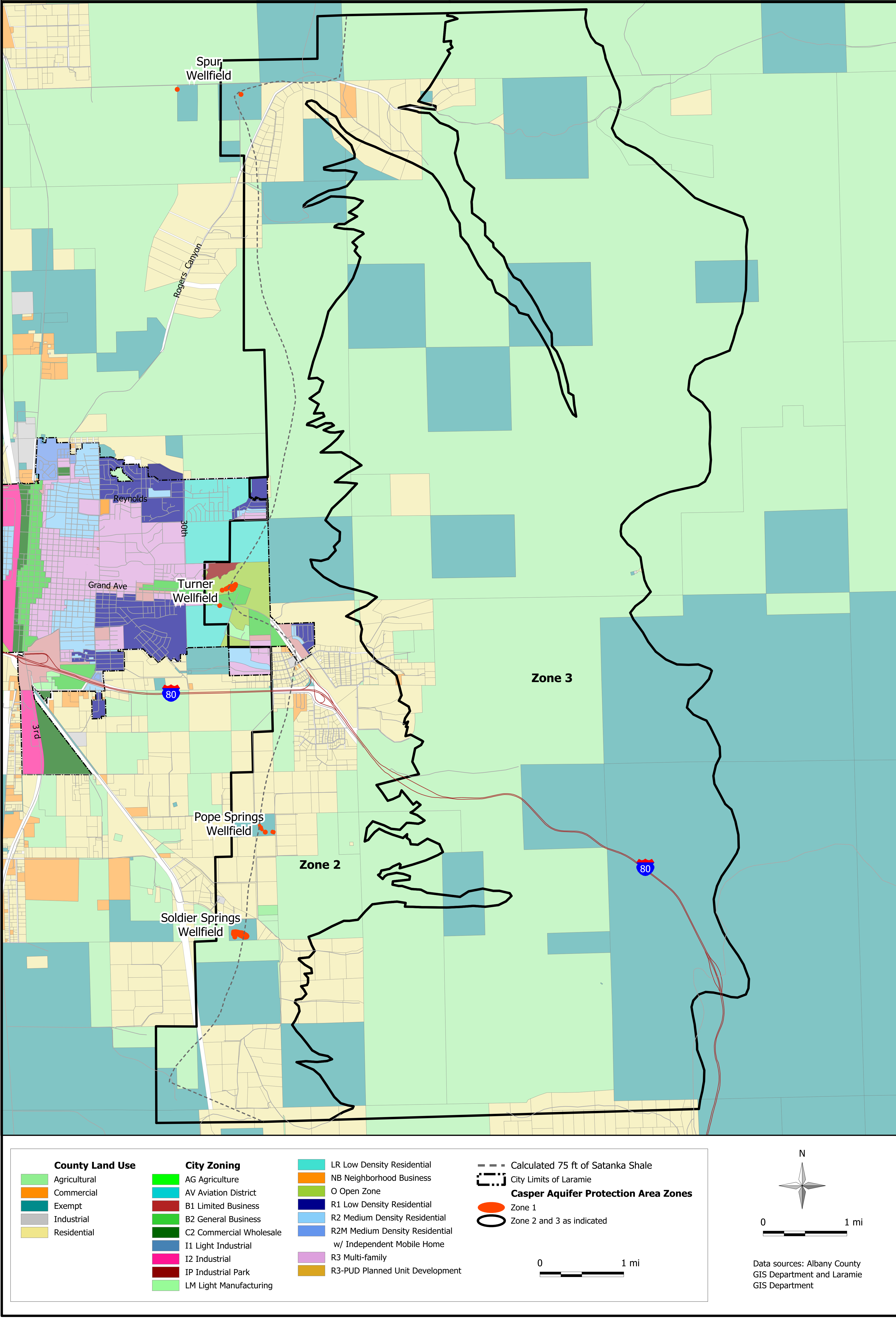


Figure 4-1. Albany County land use and City of Laramie zoning.

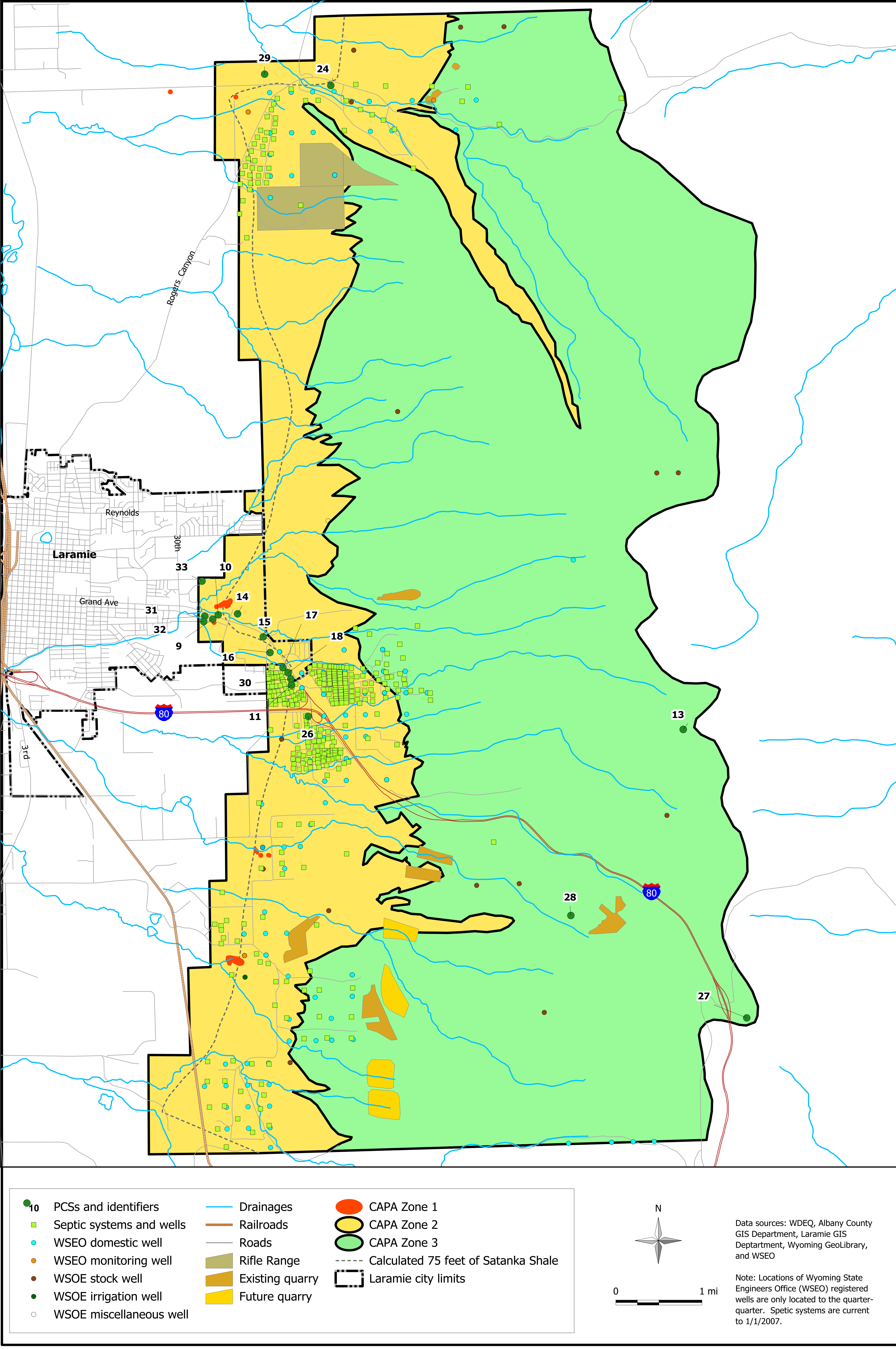


Figure 4-2a. Potential contaminant sources, septic systems, and wells in the CAPA.

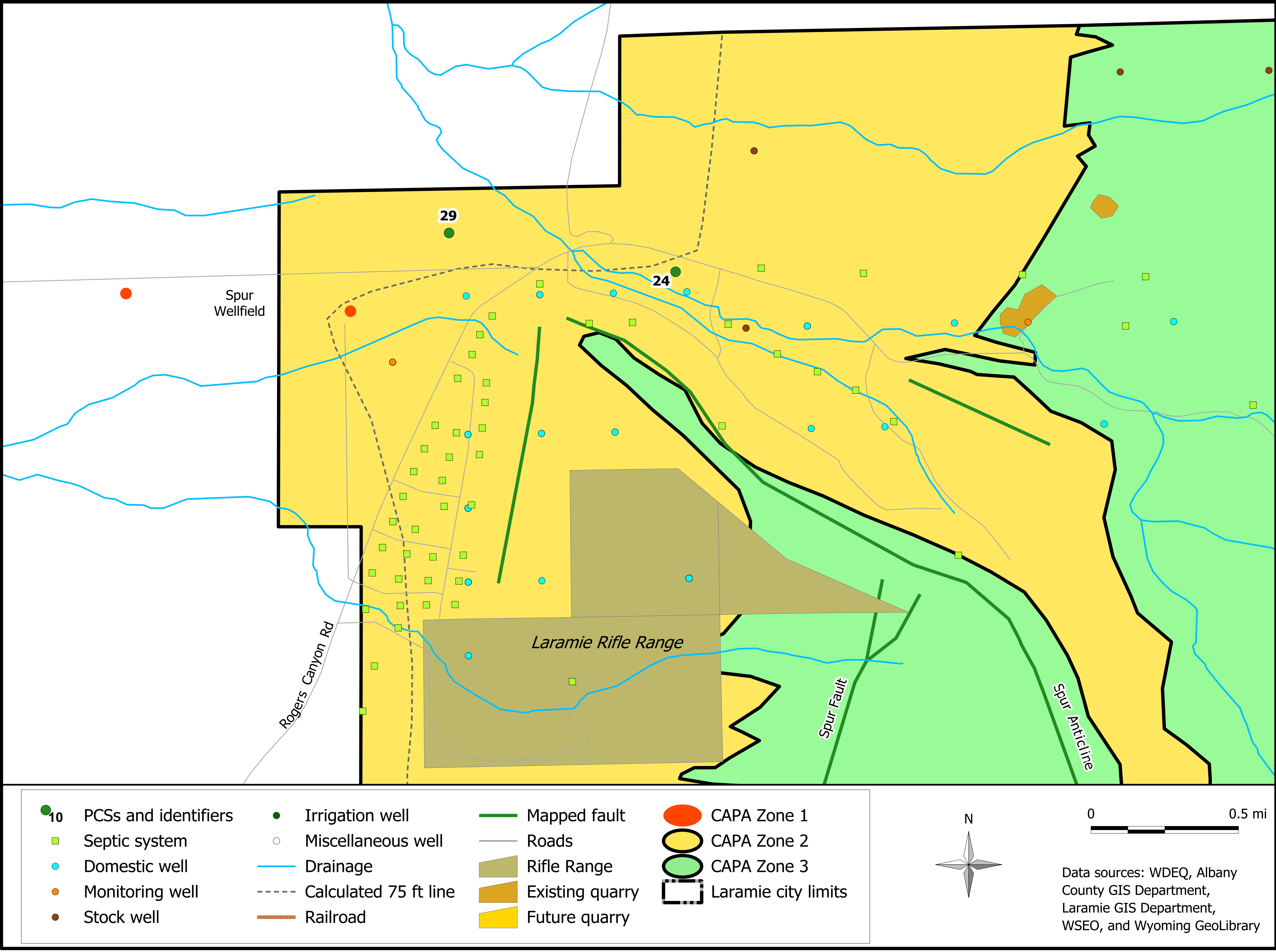


Figure 4-2b. Potential contaminant sources, wells, ans septic systems near Spur Wellfield.

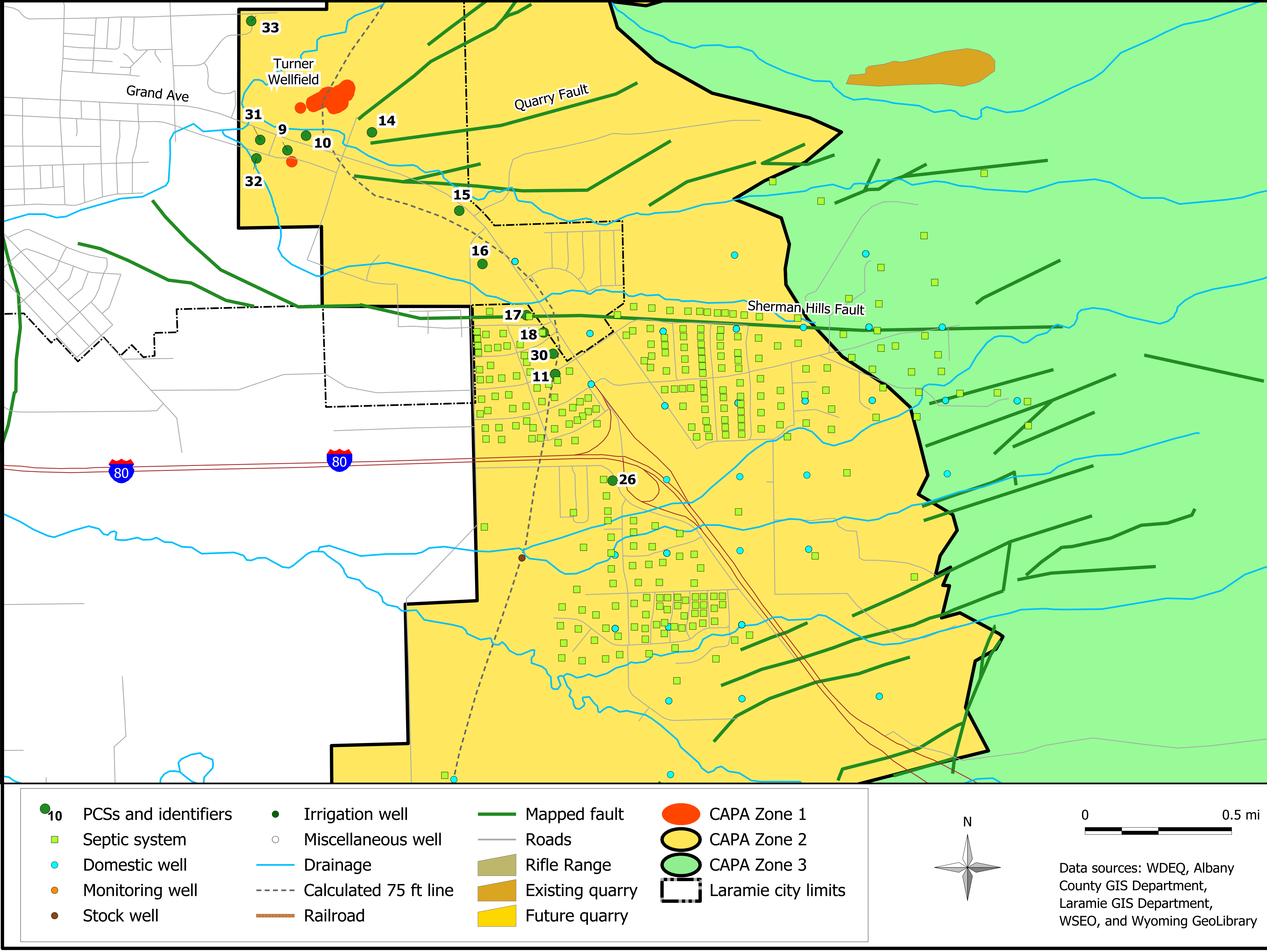


Figure 4-2c. Potential contaminant sources, wells, ans septic systems near Turner Wellfield.

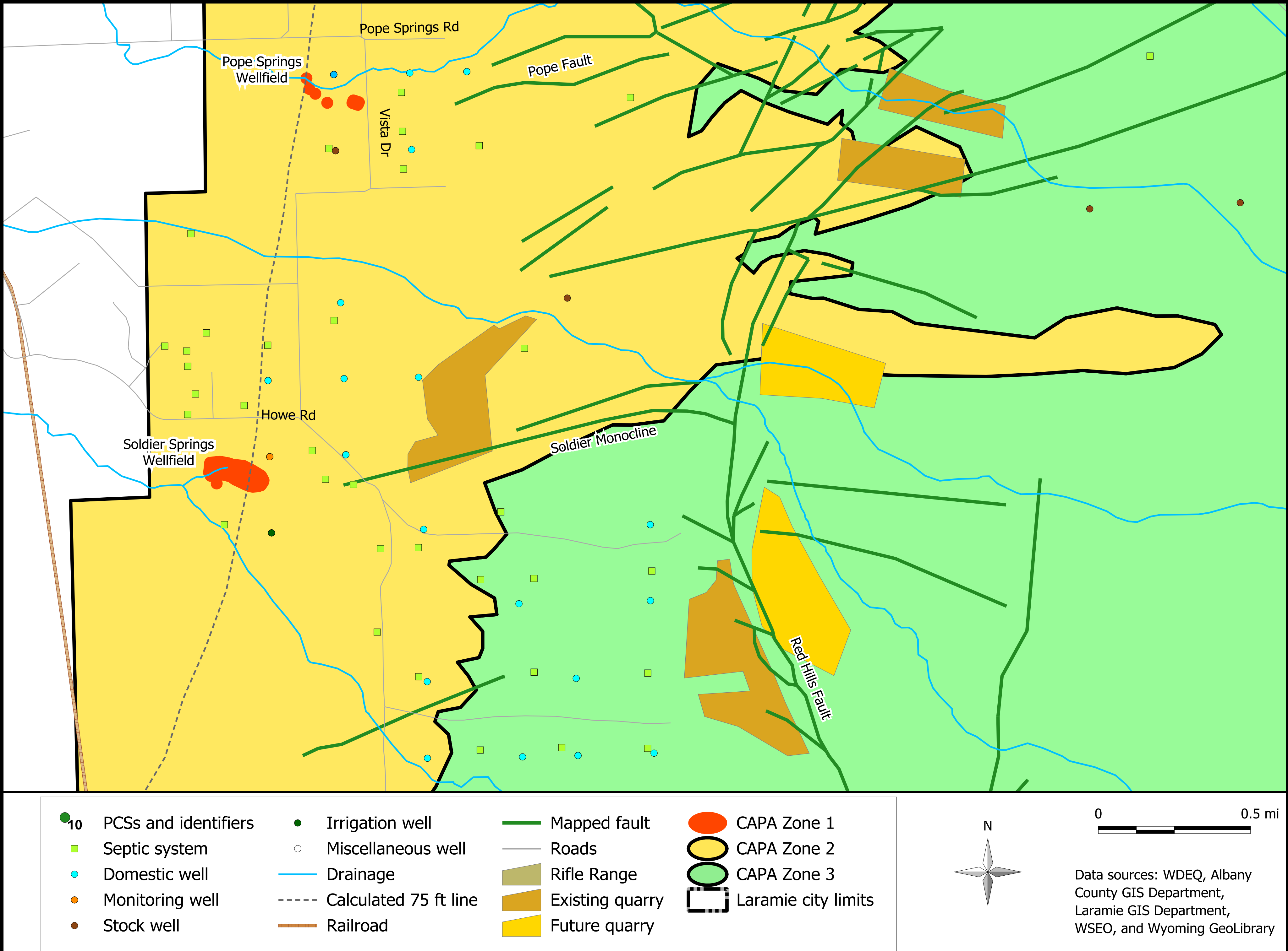


Figure 4-2d. Potential contaminant sources, wells, and septic systems near Pope Springs and Soldier Springs wellfields.

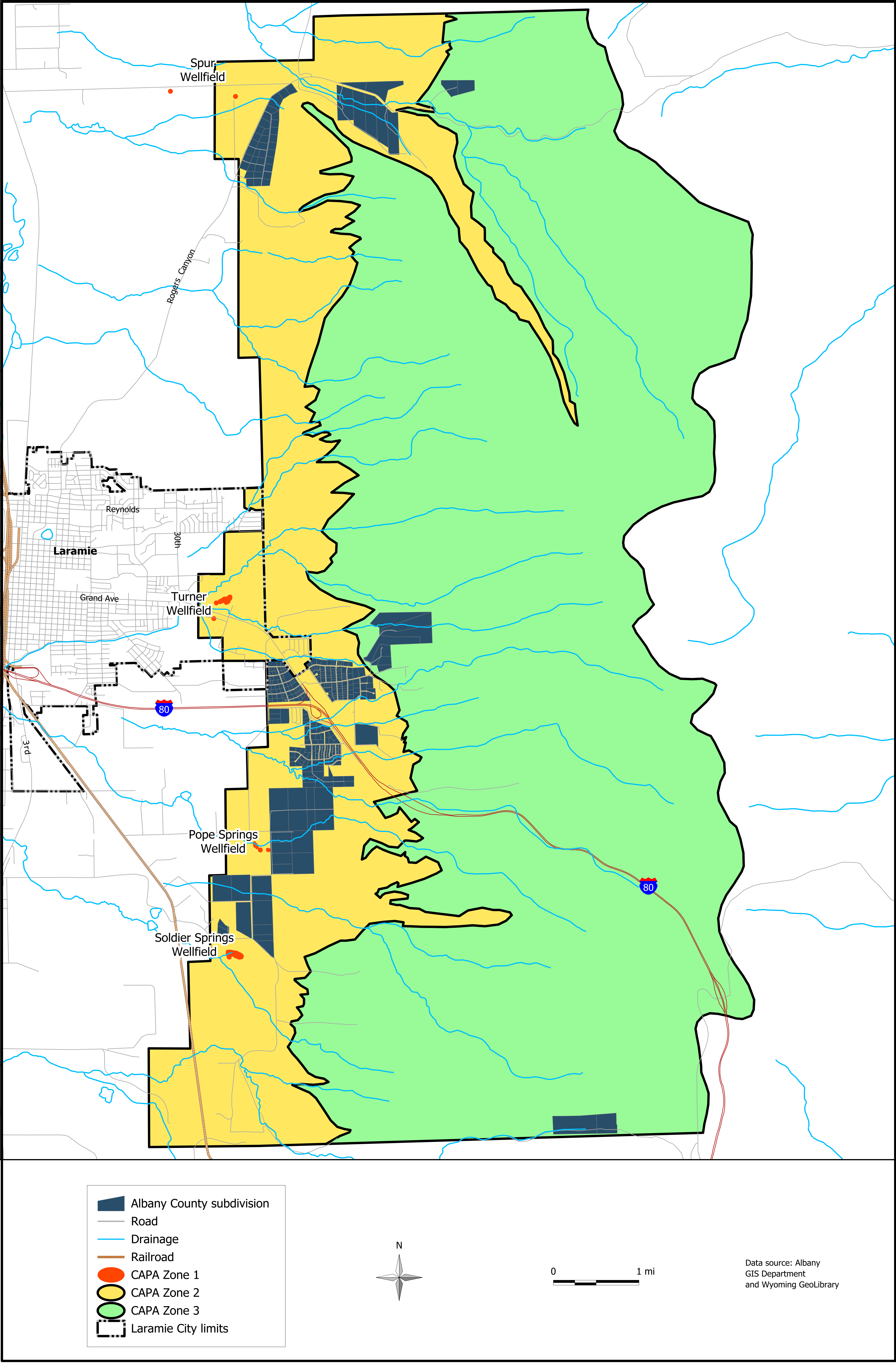


Figure 4-3. Albany County subdivisions within the Casper Aquifer Protection Area.

Table 4-1. Potential contaminant source inventory – updated November 2007.

Map Number*	Nature of Site and Site Name	Site Address/Location	Potential Source	Delineation Zone	Priority**
	Residential Areas	T15N, R73W: Sec 1, S2 &Sec 1 S2 NW4 (Sherman Hills, Imperial Heights, Laramie Plains); Sec 12 (Country Meadows, Sundial Acres, Valley View). T15N, R73W: Sec 14 SE4; Sec 13; Sec 23 E; Sec 24. T15N, R73W: Sec 23 E2; Sec 26 E2; Sec 25; Sec 24, Sec 35; Sec 36.	Septic systems (except for Imperial Heights), household hazardous wastes, pesticides, and fertilizers	Zones 2, 3	High
	Interstate 80	T15N, R73W: Sec 1 W2; Sec 12 NE4; T15N, R72W: Sec 7 NW4; Sec 18 N2; Sec 17 N2; Sec 16 S2; Sec 21 NE4; Sec 22; Sec 27 E2; Sec 26 NW4	Hazardous waste spill, road salts	Zones 2, 3	High
	Springs	T16N, R73W: Sec 35 S2. T15N, R73W: Sec 14 E2; maybe Sec 13. T15N, R73W: Sec 23 S2; Sec 26 N2; Sec 24 W2.	Conduit for contaminants	Zone 1	High
	Wells (municipal, monitoring, abandoned, test, domestic)	Refer to Figure 4-2a, 4-2b, 4-2c, 4-2d	Conduit to groundwater	Zones 1, 2, 3	High
9	Automobile Dealership Laramie GM Auto Center	T16N, R73W: Sec 35 S2 3600 E. Grand Ave.	UST (removed), Automotive waste, hazardous waste generator	Zone 2	High
10	Automobile Dealership Laramie Ford	T16N, R73W: Sec 35 S2 3609 E. Grand Ave.	Detail Shop, Automotive wastes, UST (removed 1991)	Zone 2	High
11	Gas Station Tumbleweed Express	T15N, R73W: Sec 1 SW4, NE4 4700 Bluebird Lane	UST-potentially less than 30 ft of Satanka Shale overlying the Casper Formation at this location	Zone 2	High
	Union Pacific Railroad	T15N, R73W: Sec 26 SW4, SW4; Sec 35 W2; T14N, R73W: Sec 2 W2; Sec 11 W2	Derailment and hazardous waste spill	Zones 2, 3	Medium
13	UST Pilot Hill Radio Repeater	T15N, R 72W, Sec 10	Two 560 gallon diesel tanks (1 removed)	Zone 3	Medium
14	Urban run-off Dollar Tree, Staples, Snowy Range Academy, and Express Pharmacy	4005 and 4027 E. Grand St.	Urban run-off	Zone 2	Medium
15	Urban run-off & auto services Super Wal-mart	T16N, R73W: Sec 35 SW4, SE4 4308 Grand Ave.	Oils, antifreeze, fertilizers, urban run-off	Zone 2	Medium
16	Medical Facility Gem City Bone & Joint	1909 Vista Drive	Medical wastes	Zone 2	Medium
17	Animal Hospital	4619 Bobolink Ln	Medical wastes	Zone 2	Medium
18	Green house	4633 Mockingbird Ln	Fertilizers	Zone 2	Medium
	Quarries (ABA and Active)	Throughout CAPA	Quarry activities (refueling spills, residue from blasting compounds-diesel fuel and ammonium nitrate)	Zones 2, 3	Low

Map Number*	Nature of Site and Site Name	Site Address/Location	Potential Source	Delineation Zone	Priority**
	Rifle Range Laramie Rifle Range Corporation	T16N, R73W: Sec 12 N2	Lead bullets	Zone 2, 3	Low
	Municipal Sewer Lines	T15N, R73W: Sec 1	Nitrates, fecal coliform	Zone 2	Low
	Mosquito Spraying	Throughout CAPA	Bti and Malathion @ 3 ounces/acre	Zone 2, 3	Low
24	Equine Riding Facility	25 Domino	Animal wastes	Zone 2	Low
	Transportation routes	Grand Avenue, I-80, and all other roads located in the CAPA.	Increase salinity	Zone 2, 3	Low
26	UST (Underground Storage Tank) J. T. Peele	2038 Skyline Drive	3,000 gallon diesel tank (removed 1989)	Zone 2	Low
27	UST Sherman Hill Microwave Site	13 Miles W on Happy Jack Road and Exit 323 on I-80	350 gallon gasoline tank (removed 1994)	Zone 3	Low
28	Wastewater Discharge Etchepare Quarry	T15N, R72W, Sec 21	NPDES Mineral Mining Discharge, Construction Sand and Gravel	Zone 3	Low
29	Wastewater Discharge Ninth Street Pit #2	T17N, R73W, Sec 36	NPDES Mineral Mining Discharge, Construction sand and gravel	Zone 2	Low
30	Wood/logging site	Grand Avenue	Fuel from operating equipment	Zone 2	Low
31	Dental office	3421 E. Garfield St.	Dental wastes	Zone 2	Low
32	Detailing shop	3424 E. Garfield St.	Auto wastes, solvents	Zone 2	Medium
33	Golf course Jacoby Golf Course	3501 Willet Drive	Pesticides, fertilizers	Zone 2	Medium
	Agricultural land use	Throughout the CAPA	Animal wastes, pesticides, fertilizers	Zones 2, 3	Low

* Sources without a map number are depicted on the maps (Figure 4-2a, 4-2b, 4-2c, and 4-2d) in other manners. For example, septic systems are represented by green squares.
** Priority qualitatively determined based on distance from wellheads, groundwater flow direction considerations, and types of contaminants present.

CHAPTER 5

CONTAMINANT MANAGEMENT PLAN

This chapter describes Step 4 of the five-step process: the Contaminant Management Plan as required by the Wellhead Protection (WHP) Guidance Document (1998).

INTRODUCTION

The purpose of the Casper Aquifer Protection Plan (CAPP) is to identify and minimize the existing and potential contaminant threats to the groundwater drinking supply. To meet this goal, effective management of identified sources of potential contamination must be implemented. A wide variety of management strategies can be employed depending on the potential threat to the water supply and public reception of the proposed strategies.

This Contaminant Management Plan (CMP) presents recommendations for managing potential contaminant sources identified within the Casper Aquifer Protection Area (CAPA). The CMP is organized into sections, as follows:

- An overview of potential management strategies and approaches considered;
- Detailed discussion of suggested management strategies for each type of contaminant source; and
- Prioritized management strategies with an implementation schedule.

OVERVIEW OF POTENTIAL MANAGEMENT STRATEGIES AND APPROACHES

There are a number of alternative management strategies that may be considered for the protection of the Casper Aquifer. These strategies include both regulatory and non-regulatory approaches. Management strategies should be compatible and consistent with other existing management approaches and should not conflict with existing local, state, or federal laws or regulations. Other factors to be considered when selecting management strategies are the cost and benefits of implementation, availability of staff and expertise, and legal considerations such as, property rights. Most importantly, there must be community support for the management strategies and the adopted approach must effectively provide the degree of control or risk reduction desired for the CAPA. Potential concerns relating to the protection of the Casper Aquifer should be thoroughly considered relative to each prospective management strategy prior to selection to ensure that only the most suitable management controls are implemented. If regulations are adopted, they should directly address the management of existing and future contaminant sources. Regulations should also include enforcement procedures and penalties, and should contain a severability clause to allow a court of law to strike down part of an ordinance without invalidating the whole ordinance. Most successful plans, according to the U.S. Environmental Protection Agency (EPA), include both regulatory and non-regulatory strategies (EPA, 1995).

The following is an overview of the non-regulatory and regulatory management strategies that the Environmental Advisory Committee (EAC), Technical Advisory Committee (TAC), City of Laramie Community Development Department, Albany County Planning Department, and Wittman Hydro Planning Associates, Inc. (WHPA) discussed in developing the recommendations presented in the CMP.

Non-Regulatory Management Strategies

Public Education and Involvement

Public education and involvement builds support for regulatory and voluntary protection efforts such as water conservation, waste oil collection, and water-quality monitoring. Education can include press releases; press conferences; newsletters, meeting and workshops; voluntary committee work; class field trips to the municipal water and waste treatment facilities; and brochures on water protection and the hazards of abandoned and uncapped wells. Education may be the most effective and economic means of altering activities that pose a threat to the Casper Aquifer. When people are aware that their activities can pollute groundwater they may be more careful.

Groundwater Monitoring

Sampling public and private wells throughout the CAPA for selected contaminants through a long-term monitoring effort can aid in assessing water quality in the Casper Aquifer. Monitoring can be used to measure the effectiveness of the CAPP and serve as an early warning system for threats to the aquifer.

Best Management Practices (BMPs)

Best management practices are methods to conduct everyday activities in the CAPA in a manner that will minimize the threat of contaminating the groundwater. A list of BMPs for single-family residences is included in Appendix H.

Household Hazardous Waste Collection Programs

Most of us generate household hazardous waste every day. Items as common as cleaning solvents, paint, batteries, automotive oil and antifreeze can become hazardous waste. Because these items are potentially hazardous, they cannot be placed in a garbage can or waste container. If not properly disposed, these products may contaminate the soil, surface water, and groundwater. Therefore, household hazardous waste collection programs should continue to be made available to the community in order to reduce the quantity of household hazardous waste being disposed improperly. Laramie and Albany County residents must be provided the opportunity to protect their water supply from household wastes and other potential household contaminants.

Land Acquisition Programs

The local government can acquire land that is within the CAPA as protection from land uses that may adversely affect the groundwater. Five ways to acquire property within the CAPA are:

Purchase

Purchase of land is perhaps the most effective means of managing potential contaminant sources; however, it can also be the most expensive.

Donation

Landowners may donate property to eliminate estate or capital gains taxes and have the ability to deduct, over time, the entire value of the donation from federal and other tax obligations.

Conservation Easements

Landowners can grant an easement that protects land from development by dedicating all or a portion of the property to open space or limiting development uses. Landowners retain ownership of the land, voluntarily giving up development rights of their property.

Land Exchanges

A land exchange is a transaction other than sale that transfers land from one owner to another. In terms of the CAPA, land owned by the City of Laramie would be traded for private land, for which the public's control is deemed important to protecting the Casper Aquifer. The exchange may involve surface or subsurface mineral rights or both. The exchange may include a financial payment to equalize the value of the trade.

Transfer of Development Rights

Allows landowners to separate their rights to develop the land, as permitted by zoning, from other rights associated with the land and sell those development rights. A landowner would gain cash value for development rights, yet keep the land in a less-intensive use and continue to enjoy lower property taxes. Transfer of development rights could also include allowing higher density development on one portion of the land while keeping the rest of the land undeveloped.

Memorandum of Agreement or Understanding (MOA/MOU)

A legal agreement between two or more parties that guarantee specific action will be taken or certain activities will be prohibited. A MOA/MOU may be expensive to enforce, but offers the advantage of being capable of dealing with site-specific sources of contamination in a timely manner.

Regulatory Management Strategies

Ordinances/resolutions are the primary form of regulatory management strategies. Ordinances/resolutions are designed to protect the public health and welfare of the community, manage development and land use practices that could contaminate or reduce aquifer recharge, and assure the availability of water supplies for the area. Ordinances/resolutions usually have the same goals as a MOA/MOU and are open to public input and comment. The process of passing an ordinance/resolution, and addressing the diversity of public concerns, may result in considerable time and effort to pass the ordinance. Additionally, once an ordinance/resolution is passed, resources must be devoted to monitoring and enforcement.

Because most of the CAPA is located outside Laramie city limits, the City and County will need to act cooperatively to regulate activities of concern. Potential regulatory management strategies include: zoning regulations, subdivision regulations and codes, and licensing.

Zoning Regulations

Zoning regulations segregate different and possible conflicting activities into different areas of a community and are an effective mechanism for controlling future development. One limitation is that state statutes may provide broad "grandfather" protection for some uses. The current (2007) City and County Comprehensive Plans designate the CAPA as rural growth and agricultural land use, which are the least intensive uses allowed.

Overlay Zoning

A flexible and precise zoning ordinance is a mapped district that sets additional requirements over and above those in the underlying zoning district. For example, an Aquifer Protection Overlay (APO) zone may be applied to the basic zoning within the City and County that requires site-specific investigations for all proposed developments.

Prohibition of Various Land Uses

The City and County have identified prohibited land uses in the APO such as gas stations, landfills, and facilities that store or dispose of hazardous materials. A list of prohibited activities can be found in Table 5-1.

Special Permitting

Special permitting may be used within the CAPA to regulate uses and structures which may negatively impact water and land quality, such as underground storage tanks.

Large Lot Zoning

Large lot zoning would limit the potential for degrading groundwater quality by reducing the density of buildings and on-site wastewater treatment systems, within the CAPA. Thirty-five acre lots or larger, as dictated by Wyoming State statues, should be designated as large lot zoning.

Cluster/Planned Unit Development (PUD) Design

Cluster/PUD design allows for an area of small lot development in association with a conservation easement as a way that limits the overall development density to a level consistent with the goal of protecting the Casper Aquifer. Additional benefits of allowing Cluster/PUD designs are reduced costs to the developer, greater flexibility for the developer, and potential to avoid vulnerable features while still maintaining development potential.

Growth Controls/Timing

Limitations on the number of building permits issued annually or an outright development moratorium based on a community's physical and financial capabilities. Using growth controls and timing would help limit the number of septic systems and would allow time for infrastructure to catch up with development.

Performance Standards

Establishing "critical" threshold limits as a standard for acceptability (e.g., septic system effluent limits).

Subdivision Regulations and Codes

Subdivision regulations fine-tune zoning bylaws, resolutions, and ordinances, and focus primarily on engineering concerns rather than land use. Subdivision regulations may include the following techniques.

Performance Standards

Performance standards may be used to limit the impact of development on water quality. Performance standards could include standards for stormwater runoff, sewage effluent standards, and BMPs that may reduce contaminants that enter stormwater. Performance standards can be enacted during any stage of development including during the site-specific investigations.

Groundwater Impact Assessment (GIA)

Proposed subdivisions would be required to do a GIA. A GIA describes the existing condition of the groundwater resource and identifies potential effects of the proposed development on the CAPA. A GIA would be required with the initial subdivision review to allow the governing bodies to understand the impacts of the development on the CAPA.

Site Design and Operating Standards

To regulate the design, construction, and ongoing operation of various land-use activities by imposing specific physical requirements such as the use of double-walled storage tanks for hazardous materials and to provide standards so that structures will not adversely affect water quality. Groundwater quality can be enhanced through requirements such as vegetated buffer zones, natural landscaping, stringent percent cover standards and alternative roadway designs.

Inspections of Septic Systems

When construction of an individual sewage disposal system has been completed, except for backfilling, an inspection may be performed. The final inspection will verify that the system is installed in accordance with the regulations and the permit. Existing septic systems also may be inspected at regular intervals.

Licensing

Licensing regulations require design and construction activities within an area of special concern be conducted by qualified firms. Qualifications can be established by a state, county or city licensing authority.

Professional Licensing

The State presently regulates the professions of engineering, geology and architecture in Wyoming.

Construction Contractor Licensing

The City of Laramie presently licenses contractors responsible for building construction within the city limits. Similarly, the City and County may license contractors who install and repair on-site wastewater treatment systems and water wells within the CAPA. Design standards and requirements for construction could be communicated to contractors through the licensing process.

Recommended Management Strategies for Potential Contaminant Sources Identified within the Casper Aquifer Protection Area

Potential and existing contaminant sources were identified in Chapter 4 of the CAPP. This section describes recommended management strategies for each CAPA Zone and type of potential contaminant source. Implementation of strategies is the responsibility of the Laramie City Council and Albany County Board of Commissioners.

Zone 1

A Zone 1, or Accident Prevention Zone, is established around each municipal well and spring area as a 100-foot radius as described in Chapter 3. These zones will be managed to prevent the accidental or purposeful introduction of contaminants into the Casper Aquifer in the immediate vicinity of municipal wells. The City must control and maintain the security of these critical areas.

Zone 1 Recommendations

Purchase of Land

It is recommended that the City of Laramie purchase all land within Zone 1. By purchasing the land, the City of Laramie will be able to control the land use and restrict access to Zone 1. Whenever possible and under certain circumstances, the City should also consider purchasing the land immediately adjacent to Zone 1 areas. Once the land has been purchased, the City should annex the purchased property. Annexation gives the City jurisdictional control over the area.

Zoning

The amended ordinance (Appendix I) restricts all development, except open space, within Zone 1. Since this area is in close physical proximity to the municipal drinking water wells, it must be protected with strong measures.

Security

Zone 1 areas should be protected with fencing and padlocked gates with access allowed only for emergency and authorized personnel. Since not all wells are fenced, the highest priority for Zone 1 security should be to fence and secure the Pope Spring wells. Second, the entire Zone 1 area should be fenced for Spur and Turner wellfields rather than the current security which includes fencing of only a small area around the wellheads. Signs should be placed that indicate Zone 1 is a restricted area.

80% of Albany County residents agreed that Albany County should guide development to protect natural resources such as groundwater, floodplains, wetlands, and crucial wildlife habitat – from phone survey conducted by Fairbank, Maslin, Maullin & Associates (2007)

Zones 2 and 3

As required by the Wyoming Department of Environmental Quality (WDEQ), Zone 2 and Zone 3 are designated as the primary and secondary zones of protection, respectively. Conduit flow occurs throughout Zones 2 and 3 as described in Chapter 3 and allows for rapid groundwater flow through interconnected fractures, faults, joints, and dissolution features. Natural drainages in the CAPA also play an important role in groundwater recharge as described in Chapter 3. Due to the conduit flow features and natural drainages throughout Zones 2 and 3, these zones should be managed in the same manner. Currently, these two zones are managed with the same level of protection and this management style should continue. The rest of this section describes management strategies for Zones 2 and 3 and provides a discussion of specific management strategies for specific potential contaminant sources.

Zoning Regulations

Probably the most important step in protecting the Casper Aquifer is controlling future development. An ordinance or resolution, as discussed previously, provides a mechanism to control future land use development. It is important to control land uses within the CAPA because human activities are often the cause of water-quality degradation.

Albany County and the City of Laramie both have an Aquifer Protection Overlay (APO) Zoning Resolution or Ordinance, respectively. However, due to citizen concerns regarding potential developments within the CAPA, Albany County and the City of Laramie requested that the existing ordinances be reviewed. Upon review, WHPA determined that the regulations should include stronger language to protect the Casper Aquifer. The importance of the Casper Aquifer to both Albany County residents and the City of Laramie necessitates that regulation be incorporated into management strategies. The amended County APO Resolution and City APO Ordinance are found in Appendix I.

Zoning Regulations Recommendations

Prohibited Activities

As the annotated bibliography in Appendix J shows, specific activities and land uses have contributed to groundwater contamination throughout the U.S. It is recommended that the activities and land uses listed in Table 5-1 be prohibited in the CAPA. The list of prohibited activities is unlikely to include all future proposed land development that have the potential to adversely impact water quality in the Casper Aquifer. Therefore, the governing bodies should review all developments within the CAPA.

Table 5-1. Recommended prohibited activities.

Prohibited Activity ***The following activities are prohibited in the APO zone:***	**Examples of Prohibited Activities** ***The following are examples of businesses or activities which may conduct the prohibited activity.***
1. Activities involving any equipment for the storage or transmission of any hazardous material to the extent that it is not pre-empted by federal law.	Petroleum pipelines or gasoline stations.
2. The discharge to groundwater of any waste product.	Any business or facility.
3. Commercial car or truck washes, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Car or truck washes, detail shops or car dealership.
4. Commercial and home occupation/home business production or refining of chemicals, including without limitation, hazardous materials or asphalt.	Chemical, petroleum, asphalt or pesticide manufacturer.
5. Commercial and home occupation/home business clothes or cloth cleaning service which involves the use, storage, or disposal of hazardous materials, including without limitation, dry-cleaning solvents.	Dry cleaner.
6. Commercial and home occupation/home business generation of electrical power by means of fossil fuels except generation by means of natural gas or propane.	Fossil-fueled electric power producer.
7. Commercial and home occupation/home business production or fabrication of metal products, electronic boards, electrical components, or other electrical equipment involving the use, storage or disposal of any hazardous material or involving metal plating, metal cleaning or degreasing of parts or equipment with industrial solvents, or etching operations.	Metal foundry, metal finisher, metal machinist metal fabricator, metal plating, electronic circuit board, electrical components or other electrical equipment manufacturer.
8. Commercial and home occupation/home business on-site storage of oil, petroleum or gasoline for the purpose of wholesale or retail sale.	Bulk plant.
9. Commercial and home occupation/home business embalming or crematory services which involve the use, storage or disposal of hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Funeral home or crematory.
10. Commercial and home occupation/home business furniture stripping operations which involve the use, storage or disposal of hazardous materials.	Furniture stripper.

Prohibited Activity ***The following activities are prohibited in the APO zone:***	**Examples of Prohibited Activities** ***The following are examples of businesses or activities which may conduct the prohibited activity.***
11. Commercial and home occupation/home business furniture finishing operations which involve the use, storage or disposal of hazardous materials.	Furniture repair.
12. Storage, treatment, or disposal of hazardous waste permitted under Wyoming law.	Hazardous waste treatment, storage or disposal facility.
13. Commercial and home occupation/home business clothes or cloth cleaning service for any industrial activity that involves the cleaning of clothes or cloth contaminated by hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Industrial laundry.
14. Commercial and home occupation/home business of any biological or chemical testing, analysis or research which involves the use, storage or disposal of hazardous material.	Laboratory: biological, chemical, clinical, educational, product testing or research.
15. Commercial and home occupation/home business pest control businesses which involve storage, mixing or loading of pesticides or other hazardous materials.	Lawn care or pest control service.
16. Commercial and home occupation/home business salvage operations of metal or vehicle parts.	Metal salvage yards, vehicle parts, salvage yards or junk yards.
17. Commercial and home occupation/home business photographic finishing which involves the use, storage, or disposal of hazardous materials.	Photographic finishing laboratory.
18. Commercial and home occupation/home business printing, plate making, lithography, photoengraving or gravure, which involves the use, storage or disposal of hazardous materials.	Printer or publisher.
19. Commercial and home occupation/home business pulp production, which involves the use, storage or disposal of any hazardous materials.	Pulp, paper or cardboard manufacturer.
20. Accumulation or storage of waste oil, anti-freeze or spent lead-acid batteries.	Recycling facility which accepts waste oil, spent anti-freeze or spent lead-acid batteries.
21. Commercial and home occupation/home business production or processing of rubber, resin cements, elastomers or plastic, which involves the use, storage or disposal of hazardous materials.	Rubber, plastic, fabric coating, elastomer or resin cement manufacturer.
22. Storage of pavement de-icing chemicals unless storage takes place within a weather-tight waterproof structure.	Salt or de-icing storage facilities.
23. Commercial and home occupation/home business accumulation, storage, handling, recycling, disposal, reduction, processing, burning, transfer or composting of solid waste.	Solid waste facility or intermediate processing center. Landfill or dumps on residential or commercial property (such as cars, appliances, lawn mowers).
24. Commercial and home occupation/home business finishing or etching of stone, clay, concrete or glass products or painting of clay products which involves the use, storage, or disposal of hazardous materials.	Stone, clay or glass products manufacturer.
25. Commercial and home occupation/home business dying, coating or printing of textiles, or tanning or finishing of leather, which involves the use, storage, or disposal of hazardous materials.	Textile mill, tannery.
26. Commercial and home occupation/home business involving the repair or maintenance of automotive or marine vehicles or internal combustion engines of vehicles, involving the use, storage or disposal of hazardous materials, including solvents, lubricants, paints, brake or transmission fluids or the generation of hazardous wastes.	Vehicle service facilities which may include: new or used car dealership, automobile body repair or paint shop, aircraft repair shop, automobile radiator, or transmission repair; small-engine repair; boat dealer; recreational vehicle dealer; motorcycle dealer; truck dealer; truck stop; diesel service station; automotive service station, municipal garage, employee fleet maintenance garage or construction equipment repair or rental.

Prohibited Activity ***The following activities are prohibited in the APO zone:***	**Examples of Prohibited Activities** ***The following are examples of businesses or activities which may conduct the prohibited activity.***
27. Commercial and home occupation/home business of on-site storage of hazardous materials for the purpose of wholesale or retail sale.	Wholesale trade, storage or warehousing of hazardous substances, hazardous wastes, pesticides, oil or petroleum.
28. Commercial and home occupation/home business production or treatment of wood, veneer, plywood, or reconstituted wood, which involves the use, storage or disposal of any hazardous material.	Manufacturer of wood veneer, plywood or reconstituted wood products.
29. All Underground Injection Control (UIC) wells except Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, 5B7, 5E3, 5E4, and 5E5 and Class V subclasses 5A1 and 5A2 , if 5A1 and 5A2 facilities do not use any additives, as defined in WDEQ Chapter 16.	Underground injection control facilities.
30. Water wells which are not capped. Water wells which are not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface, or in accordance with the state engineer's requirements or recommendations, whichever is stricter.	Residential, commercial, or agricultural uses.
31. Application of pesticides and herbicides which do not become non-hazardous within 48 hours of application or which are not applied according to the manufacturer's instructions.	Residential, commercial or agricultural uses.
32. Application of fertilizer at greater than the agronomic uptake rate of the vegetation fertilized.	Residential, commercial or agricultural uses.
33. Commercial and home occupation/home business quarrying and sand and gravel mining unless the operations are conducted pursuant to valid permits issued by the Wyoming Department of Environmental Quality, Bureau of Land Management or other federal or state regulatory agency.	
34. Above ground storage of any hazardous material, including oil and petroleum, unless enclosed in secondary containment.	Agricultural gasoline storage.
35. Installation and use of on-site wastewater treatment systems or septic-systems within Laramie City limits. Installation and use of on-site wastewater treatment systems or septic-systems in densities higher than 1 system per 10 acres in the unincorporated area of the APO.	Residential lots with septic systems or on-site wastewater treatment systems.
36. Commercial and home occupation/home business animal feeding operations where a) animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and b) crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.	Feedlot, concentrated animal feeding operation, stockyards or boarding stable.
37. Commercial and home occupation/home business golf courses or intensely managed turf.	Golf course or driving range.
38. Commercial and home occupation/home business cemeteries.	Cemeteries of all types.

(text continued on next page)

Setback from Vulnerable Features

As discussed in Chapter 3, Site-Specific Investigations, there are several characteristics of the Casper Aquifer that render it vulnerable to contamination. Some of these characteristics are discrete features that should be protected by requiring setbacks. It is recommended that a 100 feet setback from all development be required for the following features:

- Folds, faults, fractures or other evidence of conduit flow that extend to the ground surface.
- Perennial, intermittent, and ephemeral drainages.

Site-Specific Investigations for All Proposed Development in the APO

Chapter 3 describes the 13 steps that should be completed for a site-specific investigation. It is recommended that a site-specific investigation be completed for all new development within the APO. The site-specific investigation will enable the City/County governing bodies to identify the potential impacts, if any, that the proposed development may have on the Casper Aquifer.

Approval for Development within the APO

It is recommended that the County and City permit development only if the following criteria are met:

1. No vulnerable feature, as described above, exists within 100 feet of the proposed development;
2. The site-specific investigation has been completed and a report of the findings submitted to the appropriate governing body;
3. A professional engineer (the City or County Engineer or other licensed professional engineer), geologist, hydrologist, or other qualified designee who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport, other than the professional that performed the site-specific investigation, must review the site-specific investigation and verify that the proposed development meets the requirements of this ordinance. If review of the site-specific investigation is conducted by anyone other than the City or County Engineer, the City or County may be reimbursed for the cost of the review.

In review of the site-specific investigation, the qualified professional will assess and determine whether the site and development plans meet the overall objectives of the Casper Aquifer Protection Plan and the ordinance or resolution, whichever is applicable.

The City and County should retain a qualified consultant or staff to conduct reviews of development proposals within the CAPA. These reviews will provide the City and County staff, City Planning Commission, Albany County Planning and Zoning Commission, County Commissioners, and City Council with the rational required to either permit or not permit proposed developments. As discussed in Chapter 3, site-specific investigations will ensure that the potential risks to the Casper Aquifer are identified and that the developer is integrating aquifer protection into the proposed development. Upon completion of a site-specific investigation, the City and County will use the retained consultant to assess the potential impact of the proposed development on the Casper Aquifer. These reviews should consider the CAPP and applicable ordinances/resolutions. While the reviews would be conducted using local government funds, the government entities may be able to recover the costs to review development plans through increased application fees or other measures. Development within the CAPA should include BMPs that are proven effective for the local conditions such as conduit flow, thin permeable soils, and an arid climate.

The County and the City may also attach conditions to the approval of a development to ensure protection of groundwater quality. Conditions may include further evaluation, reasonable technical improvements, monitoring or other mitigation measures deemed necessary.

Design Standards for On-site Wastewater Treatment/Septic Systems

It is recommended that the City and County require, by regulation, that installation, design, repair, and removal of septic systems located within the CAPA be in accordance with plans and specifications prepared by and certified by a professional engineer skilled in the science of wastewater disposal and licensed to practice in the State of Wyoming.

Septic systems should be pumped out at least every five years or on a schedule recommended by a City/County licensed wastewater pumper/hauler. Pumping will prevent solids, oils, and grease from building up to a level where these waste materials will be washed out into the leach field and/or clog leach field lines. A database regarding the septic systems and their pumping and inspection schedules should be maintained and updated by the City and County GIS to maintain records and track schedules.

It is recommended that the County and City maintain authority to inspect new and replaced septic systems and leach fields, prior to backfilling, to verify proper installation and confirm design information stated in the permit application. Inspections should also occur at least once every three years to ensure that baffles are operating correctly, that no leaks are occurring, and to check the levels of sludge and scum in the tank.

Connection to Municipal or District Sewage Collection Lines

For those existing areas where septic systems are currently in use, it is recommended that the East Laramie/Albany County Wastewater Feasibility Study be conducted (see section entitled East Laramie/Albany County Wastewater Feasibility Study). Upon completion of the study if municipal or district sewage collection lines are the recommended course of action the following terms should apply.

- No one-site wastewater treatment systems should be used one year after installation of a municipal sewer collection line in a right of way or easement that is contiguous to the property on which the system is location.
- No one-site wastewater treatment systems should be used one year after the inclusion of the property containing the on-site system in a district connected to the City of Laramie's wastewater treatment system or another wastewater treatment facility and if the sewage collection line is in a right of way or easement that is contiguous to the property.

The provisions for connecting to a City of Laramie sewage collection line in Albany County should be consistent with the existing City of Laramie-Albany County 201 Wastewater Agreement.

Pre-existing Nonconforming Uses

A pre-existing nonconforming use is a use prohibited by the regulation but which was in place prior to the property being included in the APO zone. Pre-existing nonconforming uses may continue in the same location but should not be expanded in size or scope. If the pre-existing nonconforming use is damaged, they may be repaired and resume at the same location, size, and scope, provided that after the repairs are complete, the best available control technology is in place to prevent hazardous materials from entering the Casper Aquifer.

A pre-existing nonconforming use may be expanded if the following conditions are met.

- A site-specific investigation is completed.
- The development is approved by the governing body.
- Control technology built into the expansion will prevent an increased risk to the Casper Aquifer.

Once a pre-existing nonconforming use is included in the APO, it is recommended that the following conditions be required.

- Store hazardous material in an enclosed structure or under a roof that eliminates stormwater entry to the containment area.
- Provide floors within a structure where hazardous material is stored, coated to protect the surface of the floor from deterioration due to spillage of any such material. A structure which may be used for storage or transfer of hazardous material should be protected from stormwater run-on and ground water intrusion.
- Store hazardous material within an enclosed impermeable containment area which is capable of containing at least the volume of the largest container of hazardous material present in the area or 110% of the total volume of all such containers in the area, whichever is larger, without overflow of released hazardous material from the containment area.
- Store hazardous material in a manner that will prevent the contact of chemicals with any materials so as to create a hazard of fire, explosion or generation of toxic substances.
- Store hazardous materials only in containers that have been certified by a state or federal agency or the American Society of Testing Materials as suitable for the transport or storage of the material.
- Store all hazardous material in an area secured against entry by the public, except items offered for retail sale in their original unopened containers.
- Not use, maintain or install floor drains, dry wells or other infiltration devices or appurtenances which allow the release of wastewater to the ground water.
- Not discharge any substance or material to the ground in the APO zone unless the discharge is permitted by law.

Proper Plugging and Abandonment of Unused Wells

Improperly abandoned wells provide a direct conduit to the Casper Aquifer. If a contaminant were introduced into the well, it would immediately enter the groundwater system.

It is recommended that all wells, including but not limited to groundwater pumping wells and monitoring wells, that are no longer in use by the owner be properly plugged and abandoned in accordance with Chapter 11, Section 70, Part G of the Wyoming Department of Environmental Quality Rules and Regulations.

Exception from 100-feet Setback from Vulnerable Features for Infrastructure

It is recommended that the construction of sewer and water lines that are connected to either a centralized wastewater or water system or the City of Laramie's Wastewater or Water system, be allowed within the APO in order to protect water quality. Sewer lines should be engineered in such a way as to limit the possibility of an undetected leak; this may include double walled pipes and regular pressure testing or other engineering techniques and leak detection systems that reduce the possibility of undetected leaks. Exceptions may also include other general utilities used specifically to serve local developments such as electric lines, gas lines for heating, cable television, and telephone lines. Roads may also be excepted if appropriate stormwater drainage and management is included.

City of Laramie Unified Development Code

It is recommended that the amended Aquifer Protection Overlay Zoning Ordinance and CAPP be incorporated into the City of Laramie's Unified Development Code. Incorporating the CAPP and amended ordinance into the Unified Development Code will result in consistency within the City and a single source of information for developers within the City.

Groundwater Monitoring

Currently, the City of Laramie monitors all municipal production wells on an annual basis for major microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic chemicals, and radionuclides as required by EPA. Water-quality results are compared to historical levels. If the results show that concentrations have increased over historical levels, the water is immediately re-sampled. If the second sample again shows higher concentrations, more detailed sampling is undertaken and a study is initiated to identify the source of contamination. Water levels are measured continuously at all of the municipal production wells and at Spur monitoring wells #7, #8, #10, #11, and #12.

To date, there has not been a systematic, aquifer-wide, long-term groundwater monitoring program to assess water quality in the Casper Aquifer. All of the potential contaminant sources outlined in Chapter 4 may have measurable impacts on water quality but there is not enough data available to assess water quality trends. Groundwater monitoring should be used to establish baseline water quality and to understand the impacts from existing and future development on the Casper Aquifer.

One major concern is the septic systems associated with several subdivisions in Albany County. Wastewater effluent, specifically nitrates and bacteria, from these subdivisions may have measurable impacts to the community's groundwater supply.

While septic systems are a concern, all potential contaminant sources should be monitored through the systematic and long-term study of water quality in the Casper Aquifer. The groundwater monitoring network can assess the water quality and quantity near potential contaminant sources. For example, long-term monitoring wells should be established near mining operations so that the impacts of mining are fully understood.

Groundwater Monitoring Recommendations

Groundwater Monitoring Program

It is recommended that the City and County develop a program to routinely collect groundwater samples and water levels throughout the CAPA to establish baseline water quality data and to evaluate changes in groundwater quality over time. The baseline data collected from this program should be used to set standards for quantifying contamination in the Casper Aquifer. A systematic monitoring program has a secondary benefit of increasing understanding of the Casper Aquifer. The City of Laramie should continue to evaluate water-quality at the City wells in the current manner of comparing current results to historical concentrations and initiating additional sampling when results show increased concentrations.

A good monitoring program can provide an 'early warning' to the arrival of contaminated groundwater at a municipal supply well. The monitoring wells should be located throughout Zones 2 and 3 such that detection would provide enough lead time to either mitigate the in-coming contamination before it can reach a municipal well or to arrange for an alternate drinking water supply or treatment.

The groundwater-monitoring program should include periodic monitoring of groundwater for suspected or known contaminants (e.g., nitrates from septic systems or petroleum products from vehicles on I-80). Monitoring should include a program for voluntary testing of residential wells and creation of permanent monitoring wells within Zones 2 and 3. Incentive plans for residents who allow testing of their well might evoke more interest in such a program.

Design a Plan for Groundwater Monitoring Program

It is recommended the City design a plan for a long-term groundwater monitoring network and sampling program. Initiating a long-term, aquifer-wide groundwater monitoring program is the highest priority. It is recommended that funding be acquired or set aside as quickly as possible to establish a monitoring program immediately. Appendix F includes a description of the recommended groundwater monitoring program.

General Education and Plan Implementation

One of the most effective ways to manage the CAPA is through education of the public, both private citizens and businesses. The CAPP is a first step in protecting the Casper Aquifer but in order to be effective, the CAPP MUST be implemented. A City/County staff person is needed whose primary responsibility is to implement the CAPP.

General Education Recommendations

It is recommended that a joint City/County staff be assigned to implement the CAPP. This person should be responsible for implementing the CAPP and serve as a liaison between the City and County. The assigned City/County staff should report their activities annually to the Laramie Community Development Department and Albany County Planning Department. In addition, EAC (Environmental Advisory Committee) should continue to provide guidance, advice, and support to assigned City/County staff as well as receive an annual progress report.

The assigned City/County staff would be the public contact for information regarding the CAPP and CAPA. The staff would be responsible for providing public education to both adults and children including such topics as water conservation and protection, disposal of hazardous wastes, BMPs, and general groundwater education. The groundwater monitoring program should be used to educate the public about water quality and water levels in the Casper Aquifer.

Particularly, the residents living in the CAPA may benefit from sampling residential wells and understanding their ability to protect their own drinking water. The City/County staff would ensure that recommendations in the CAPP are implemented.

Best Management Practices (BMPs)

BMPs are designed to minimize groundwater contamination by reducing the possibility of introducing contaminants into the Casper Aquifer. Appendix H includes BMPs for residential land use.

BMPs Recommendations

The BMP list should be continuously updated and provided to residents and developers in the CAPA. It is recommended that the County Planning Department and Laramie Community Development Department have additional and more detailed BMP guidelines available for the public to review and for developers to incorporate into their design.

Household Hazardous Wastes

Currently the City of Laramie and Albany County work together to provide recycling and disposal services for household hazardous wastes. In the past, volunteer organizations have hosted bi-annual collections but found it difficult to consistently operate. Therefore, the Solid Waste Division (SWD) is taking over this task and will host collection days in the spring and fall. The SWD maintains information on disposal and recycling on their website and through their office.

Household Hazardous Waste Recommendations

The City and County should continue to work together and provide recycling and disposal of household hazardous wastes through the SWD. These collection days should be advertised in the Laramie Boomerang, on the City and County websites, and through general education opportunities. The SWD should pursue funding to allow them to recycle pesticides and herbicides in addition to paints and batteries.

Specific Contaminant Source Management

On-site Wastewater Treatment Systems/Septic Systems

According to the EPA Decentralized Systems Technology Fact Sheets (EPA 932-F-99-075, September 1999 and EPA 832-F-00-044, September 2000) a typical septic tank system consists of a septic tank and a below-ground absorption field (also called a drainfield or leachfield). The septic tank is an underground, watertight vessel installed to receive wastewater from the home. It is designed to allow the solids to settle out and separate from the liquid, to allow for limited digestion of organic matter, and to store the solids while the clarified liquid is passed on for further treatment and disposal. Effluent flows out of the septic tank and is distributed into the soil through the leachfield. The soil below the leachfield provides final treatment and disposal of the septic tank

effluent. After the effluent has passed into the soil, most of it percolates downward and outward, eventually entering the shallow groundwater. A small portion of the effluent is used by plants or evaporates from the soil. Although the septic tank removes some pollutants from wastewater, further treatment is required after the effluent leaves the tank. Nitrogen compounds, suspended solids, organic and inorganic materials, and bacteria and viruses must be reduced before the effluent is considered purified. These pollutants are reduced or completely removed from the wastewater by the soil into which the wastewater drains if the system is designed and installed correctly, and maintained by the homeowner. Failure of systems to adequately treat wastewater may be related to inadequate siting, inappropriate installation, or poor operation and maintenance.

The majority of the CAPA is outside of Laramie City limits, so currently all rural homeowners within the CAPA use an on-site small wastewater system. Management of septic systems is a high priority because 1) subdivisions within Zones 2 and 3 have systems that are over 30 years old which is the average lifespan of a septic system, 2) new subdivisions are located up gradient from Laramie's wellfields, and 3) residential wells are susceptible to contamination from septic systems due to proximity. Elevated nitrate values (4 - 10.6 mg/l) from drinking water samples within Zone 2 were detected during a Septic System and Water Quality Workshop offered to rural homeowners in January 2001. The U.S. EPA maximum contaminant level is 10 mg/l. In the spring of 2000 the EAC completed a nitrate loading analysis for a high-density subdivision, located within Zone 2 just east of the City limits. This analysis, which followed a methodology promulgated by WDEQ, predicted elevated nitrate levels down gradient from the subdivision (Appendix K).

Albany County is working under a delegation agreement with the WDEQ to regulate small wastewater systems within the County (Appendix L). The County established a permitting process for septic systems and issued the specifications, Albany County Design and Construction Standards for Small Wastewater Facilities. As part of the permitting process, the septic system design and site plan are submitted for review by the County Planning office or designee. Permitted septic systems in Albany County are then added to a GIS database denoting their location and associated permits. The GIS database will be used as a comprehensive planning tool.

On-site Wastewater Treatment Systems/Septic System Recommendations

East Laramie/Albany County Wastewater Feasibility Study and Plan

The City of Laramie and Albany County will work cooperatively to develop an East Laramie/Albany Wastewater Feasibility Study in an effort to assess groundwater quality impacts from residential septic systems. This study will:

1. evaluate the Casper Aquifer water quality within and downgradient of subdivisions within the CAPA (at a minimum this will include a survey of nitrate concentrations);
2. evaluate the costs and risks associated with residential septic systems and alternative wastewater disposal systems;
3. determine if and where alternatives to on-site wastewater disposal is needed;
4. examine alternatives (such as advanced septic systems, centralized septic systems, and sewer) to on-site wastewater disposal systems and feasibility for the CAPA; and
5. evaluate both fiscal and engineering aspects of the alternatives for areas within the CAPA that need waste disposal systems other than septic systems.

The feasibility study will be the first step in determining the impacts of residential septic systems and therefore should begin immediately (2008). Due to the intense interest this recommendation has garnered and statements by several homeowners, it is expected that homeowners in the CAPA will be willing to participate in the sampling that will be required for this study.

Sewer

Due to a high level of concern regarding water-quality impacts from septic systems, the City and County should immediately begin the East Laramie/Albany County Wastewater Feasibility Study (see East Laramie/Albany County Wastewater Feasibility Study and Plan section for further details).

All future subdivisions within the County that have housing densities greater than 10 acres should be required to connect to the City's sewer system or provide a centralized wastewater disposal treatment facility. The cost for increases in sewer capacity due to future development may be assessed to the developer. The City should update its Sewer Master Plan to address increasing sewer capacity east of Laramie as needed. The City and County should work together to determine incentives, grants, and other financial opportunities for areas where on-site septic systems are either prohibited in the future or areas where the Feasibility Study finds that existing systems need to be replaced with alternative systems.

Underground Injection Control (UIC) Class V subclasses 5E3, 5E4, and 5E5 are permitted in the CAPA to allow areas that cannot be served by City sewer an alternative. UICs are permitted by WDEQ and the City of Laramie and Albany County should request WDEQ to notify them through the public notice process of all proposed UICs. Through the public notice, the City of Laramie and Albany County should request that the Casper Aquifer be considered when permitting and establishing requirements for the UIC facility. WDEQ can attach monitoring and operational requirements when permitting UIC facilities.

Inspections

It is recommended that the County Planning Office maintain authority to inspect new and replaced septic systems and leach fields, prior to backfilling, to verify proper installation and confirm design information stated in the permit application and at least once every three years.

Pumping

The septic systems should be pumped out at least every five years or on a schedule that is recommended by a licensed wastewater hauler/pumper.

Education

Approximately 400 conventional septic systems exist within the CAPA (Figure 4-2a). Education is recommended to promote proper maintenance of septic systems in the CAPA. A homeowner's guide to septic systems is available at the Albany County Planning Office and contains the following information:

- Description of a typical septic system;
- How to care for a septic system; and
- Tips to avoid trouble.

Design and Location Standards

The following design and location standards are recommended for septic systems within the CAPA.

Certification for Systems

It is recommended that the City and County require, by regulation, installation, design, repair, and removal of septic systems located within the APO zone be in accordance with plans and specifications prepared by and certified by a professional engineer skilled in the science of wastewater disposal and licensed to practice in the State of Wyoming.

Setback from Vulnerable Features

Features observed in the CAPA have been identified as having the potential to provide routes of contamination to the Casper Aquifer from the ground surface. These vulnerable features are discussed in detail in Chapter 3 and no septic systems should be installed within 100 feet of these vulnerable features.

Evaluate Septic System Risks

It is recommended that a site-specific investigation be conducted as part of designing on-site wastewater treatment systems proposed within Zones 2 and 3, or whenever any septic system is being repaired, replaced, or installed within Zone 2 or 3. The site-specific investigation should be performed by a Wyoming registered engineer and/or Wyoming licensed geologist qualified to perform the investigation and should address the requirements identified in Chapter 3.

If the site-specific investigation determines that leachate from the on-site wastewater treatment system may infiltrate through faults, fractures, or dissolution features and into the Casper Aquifer, it is recommended that the septic system be deemed inappropriate for the subject site and either the development must connect to a centralized system or be moved to an appropriate site.

Study of Residential Impacts on Water Quality

In conjunction with the long-term groundwater monitoring program, a study should be conducted regarding the impacts of residential development on the Casper Aquifer (see Appendix F for additional details). Land use surrounding the monitoring wells should be analyzed and contaminant levels within these wells should be viewed in light of existing land use. Landowners should be contacted to determine landscaping practices, chemical use, water use, and septic system maintenance in the vicinity of the monitoring well. The land use impact study should also determine the density of residential development that the CAPA can sustain without negatively impacting the Casper Aquifer.

Interstate 80 (I-80)

Transport of hazardous materials along I-80 has been categorized as a threat with a high likelihood and greatest potential severity of damage to the Casper Aquifer (see Table 6-1). I-80, from milepost 323 to 317, cuts through the Casper Aquifer exposing the aquifer to contamination from spills. Figure 5-1 shows the number of crashes on I-80 that involved a semi-tractor and trailer from 1998 to 2006 according to Wyoming Department of Transportation (WYDOT). WYDOT personnel estimated that 25% of the semi-tractor and trailers haul hazardous wastes (Mulcare, personal communication).

In addition to hazardous materials, stormwater run-off from I-80 carries oil, grease, metal particles from tires and brake pads, and other automotive fluids and particles from the road over the recharge area. The stormwater may then infiltrate into the Casper Aquifer along with any associated contaminants.

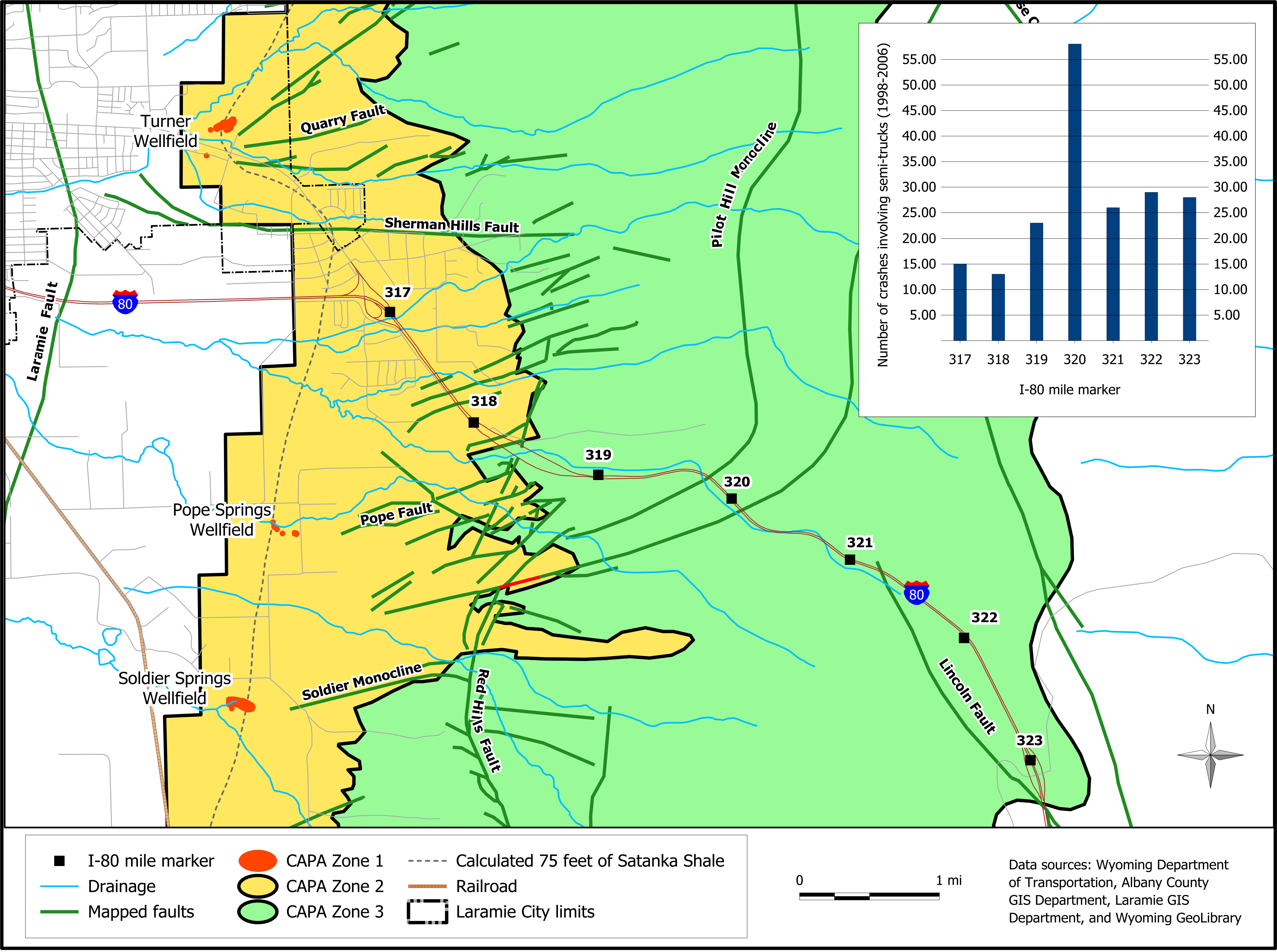


Figure 5-1. Crashes involving semi-trucks and tractors per highway mile from 1998-2006.

Interstate 80 Recommendations

Pre-Incident Emergency Response Strategies

Since I-80 is a high likelihood and severe risk to the aquifer, the City/County should take immediate steps to reduce the likelihood and risk of this threat. One effective first step is to prepare for a hazardous material spill. In order to prepare for such an incident, training of emergency response personnel and a test of the emergency response system should be conducted immediately. After the initial training, emergency response training should occur annually. It is recommended that the Emergency Response Coordinator be involved in the CAPP process.

The EPA provides some tabletop training modules via their website and these could be used by local personnel. Additionally, the emergency response personnel may find it helpful to contact WDEQ or EPA Region 8 to assist in training exercises.

Post-Incident Emergency Response Strategies

- The Wyoming Highway Patrol should notify the Laramie Albany County Records and Communications (LARC), which would in turn notify the Laramie Fire Department, Albany County Sheriff's Office, and Public Works Department that a spill has occurred.
- Responding agencies appraise extent and severity of spill and begin initial mitigation efforts.
- Responding agencies notify Albany County Emergency Coordinator who may initiate use of the CAPP Contingency Plan.
- Public Works Department will begin testing the monitoring wells along the I-80 corridor.
- WDEQ will be notified and requested to provide additional spill mitigation assistance, as needed.

Mitigation Measures Study

To protect the Casper Aquifer from contamination, it is recommended that an investigation be funded to consider mitigation alternatives (Appendix F). Conceptual designs and cost estimates for alternative mitigation designs would be generated during the study.

Because of the risks posed by I-80 as a potential contaminant source, and the complex design considerations, it is further recommended that the City and County acquire the professional services necessary to complete this task. The selected consultant must have demonstrated experience in the design and construction of environmental mitigation projects, expertise in the hydraulics and hydrology of stormwater management, and a familiarity with the local hydrogeology. WYDOT should be involved as a partner throughout the design and construction of the project.

Retention Pond

One potential mitigation alternative is the construction of a lined retention pond. The retention pond may allow spilled liquids to be retained rather than infiltrating into the Casper Aquifer. The pond would be located east of the epsilon and delta members that are the primary production zones for the City's municipal wells.

Re-route I-80

By re-routing I-80, the entire CAPA could be avoided and thus the risk from I-80 eliminated. Working with WYDOT, the City of Laramie should determine if re-routing I-80 is a feasible option.

Signs

It is recommended that road signs designating a Water Supply Protection Area be posted along I-80 between milepost 323 to 317. The road signs should comply with the City Water System Vulnerability Abatement Program. The City and County should work together with the WYDOT to install the signs, which would be designed to alert the public to report spills by calling 911.

Cleaning I-80

The City of Laramie and Albany County should work with WYDOT to ensure regular street sweeping of I-80. WYDOT should properly dispose of all materials in a landfill or other appropriate disposal facility.

MOA/MOU

The City of Laramie and Albany County should enter into an MOA/MOU with WYDOT immediately. The MOA/MOU could be used to provide support from WYDOT for the I-80 mitigation study, help with sign placement, and ensure regular I-80 cleaning.

Road Salt Application

Road salt (NaCl) may enter the groundwater after deicing materials are used on I-80 and other transportation corridors in the CAPA. g However, because numerous hazardous materials are transported along I-80 and these materials pose a greater risk to the Casper Aquifer than high salinity, there must be a balance between safety for drivers and the increased risks of accidents compared to the water-quality risk from road salts.

Road Salt application Recommendations

Monitoring

Sample for chlorides or measure conductivity at monitoring wells along I-80. Due to the high volume of traffic along this corridor it is not feasible to eliminate deicing materials, therefore, monitoring is the best management strategy.

Springs

Springs have been identified throughout the CAPA that provide a direct pathway from the ground surface to the Casper Aquifer. Most prominent are the historic springs located adjacent to the City's water supply wells. The historic springs, made up of City Springs, Pope Springs, and Soldier Springs, do not flow because the municipal wells reverse the groundwater flow direction. This makes the historic springs a direct conduit to groundwater and the City of Laramie's drinking water.

Other ephemeral springs have been identified in upland areas. Ephemeral springs when not flowing, also are a direct conduit to the Casper Aquifer. A spring in Telephone Canyon along I-80 is especially significant because it presents a direct pathway to the Casper Aquifer from hazardous material spills on I-80.

All springs, flowing or not, put the aquifer at some degree of risk because springs, by definition are where the aquifer meets the land surface. Springs are groundwater discharge points; the flow of water is up and out. Because springs discharge water there is hydraulic protection from light non-aqueous phase liquids (LNAPL). LNAPLs are liquids that are sparingly soluble in water and less dense than water. For example, oil is an LNAPL because it "floats" on top of water and does not mix with water. However if a dense non-aqueous phase liquid (DNAPL) were introduced at a spring the DNAPL may contaminate the Casper Aquifer. DNAPLs are liquids that are denser than water and do not dissolve or mix easily in water. Many chlorinated solvents, such as trichloroethylene, are DNAPLs. Because the DNAPL is denser than water, it may enter the aquifer and be transmitted along the same pathways as water.

Springs Recommendations

Education

Public education will increase awareness of how springs may provide a potential pathway for migration of contaminants from a surface source to the Casper Aquifer. Springs located in undeveloped upland areas, away from contaminant sources, present less of a threat. Through education, the City and County should work to ensure that land use practices in the vicinity of springs are protective of the aquifer.

Mitigation Measure

The mitigation measures study recommended for the I-80 corridor should address mitigation strategies for potential contamination of the spring in Telephone Canyon.

Land Purchases and Regulations

The historic springs adjacent to the City's municipal supply wells fall within the Zone 1 delineation. We recommend the City purchase land within Zone 1 and prohibit all uses except open space within Zone 1. Whenever possible, the City should also purchase land adjacent to Zone 1 at the Turner, Pope, and Soldier wellfields.

Wells

A well completed in the Casper Aquifer provides a direct conduit for the introduction of contaminants into the aquifer. Wells, whether for the public water supply, stock watering, irrigation or domestic use, must comply with the well construction standards from the Wyoming State Engineer's Office (SEO) or the WDEQ. The SEO provides well design requirements in their Regulations and Instructions, Part III, Water Well Minimum Construction Standards. The WDEQ does not regulate the construction of domestic wells, but Chapter 11, Part G, and Chapter 12, Section 9 of Wyoming Water Quality Rules and Regulations apply to the construction of monitoring wells and public drinking water supply wells, respectively.

Wells Recommendations

Education

Education will increase awareness of how private wells may be a pathway for contaminants. Of particular importance is that wells should be properly capped (i.e., locked or bolted closed) to prevent unauthorized direct access to the interior of the well. Information in the form of a brochure should be prepared to inform residents of the importance of properly capping, constructing, and abandoning wells. The County and City should use similar techniques to educate the owners of the existing wells in the area about proper well maintenance and require proper well abandonment.

Through education, the City and County should work to ensure that all non-municipal water wells constructed in the CAPA are capped and cased with a surface seal.

Well Design

It is recommended the City and County adopt the amended APO ordinance. The ordinance prohibits wells that are not properly capped and not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface. The cement grout seal prevents the vertical migration of chemical, biological, or radiological contaminants via the well and annulus. Annular seals will also reduce the waste of groundwater by leakage and prevent the mixing of groundwater between aquifers.

Abandoned Wells

Proper abandonment of wells is imperative in protecting the Casper Aquifer. Improperly abandoned wells are particularly hazardous because the well is a direct conduit that leads directly from the ground surface into the groundwater. The locations of improperly abandoned wells are often unknown making accidental introduction of contaminants more likely.

Abandoned Wells Recommendations

Ordinance

The amended County APO Resolution and City APO Ordinance requires landowners to properly plug and abandon wells in accordance with Chapter 11, Section 70, Part G of the Wyoming Department of Environmental Quality Rules and Regulations.

Public Education

The assigned City/County staff should contact owners of improperly abandoned wells. The landowner should first be advised of the hazards posed by an improperly abandoned well and instructed on the proper methods of plugging a well. The WDEQ and the SEO should also be advised of the presence of an abandoned well for the enforcement of existing regulations.

Information in the form of a brochure should explain that abandoned and improperly constructed wells may serve as a conduit for surface contamination to reach groundwater. The brochure should provide information on how to properly plug and abandon a well.

Underground Injection Control (UIC) Wells

Classes I, II, III, and IV UIC wells as defined in WDEQ Chapter 13, and most Class V UIC wells as defined in WDEQ Chapter 16 would cause groundwater or aquifer degradation due to their inherent use. However, some types of UIC wells are beneficial. WDEQ Chapter 16 lists beneficial uses as Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, and 5B7. Beneficial uses include but are not limited to remediating groundwater, replenishing groundwater in an aquifer, or confining contaminants inside the aquifer. Class V 5E3, 5E4, and 5E5 UICs are types of wastewater disposal systems which are permitted by WDEQ, are appropriate alternatives to septic systems, and may help protect groundwater quality. Class V 5A1 (e.g., direct heat reinjection facilities) and 5A2 (e.g., heat pump/air conditioner return flow facilities) are also wells that may harmless as long as no additives are used when injecting water into the aquifer. Currently there are no UIC wells in the CAPA but because their inherent use could cause groundwater degradation, it is important to prohibit them.

UIC Wells Recommendation

Ordinance

All UIC wells, except Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, 5B7, 5E3, 5E4, and 5E5 and Class V subclasses 5A1 and 5A2, if 5A1 and 5A2 facilities do not use any additives, as defined in WDEQ Chapter 16, should be prohibited in the CAPA.

Hazardous Materials Spills along Union Pacific Railroad (UPRR)

The UPRR Hermosa spur line crosses a portion of Zone 2 south of Laramie. Thousands of rail and tanker cars carrying hazardous material use this line annually.

Hazardous Materials Spills along UPRR Recommendations

Memorandum of Agreement or Understanding (MOA/MOU)

The City and County need to establish a notification protocol with the UPRR Risk Management Communication Center in case of a spill along the Hermosa Line within Zone 2. It is important that UPRR understand that if a spill occurs in this area, groundwater contamination prevention measures should be taken immediately.

Emergency Response Training

Communication between UPRR, the City and the County is the most effective means of managing the threat of contamination from derailment. Establishing clear lines of communication prior to an accident will decrease the response time of the City and County. Emergency response drills should be conducted that include a hazardous material spill along the UPRR so that the lines of communication are in place prior to an emergency.

Signs

Signs indicating the CAPA and emergency phone numbers should be posted along railroad rights-of-way in the CAPA.

Limestone Quarries

Permitted active limestone quarries exist east of the Turner, Soldier, and Pope wellfields. Most of the quarries are operated by Mountain Cement Company for the production of Portland cement and are regulated by WDEQ.

The quarries remove the overburden (material not suitable for cement) and expose the underlying limestone in areas (<100 acres) within the CAPA. Explosive storage, blasting, large truck traffic, and bulk fuel storage occurs within the CAPA. Some of the quarries are located near faults and the blasting process has the potential to generate contaminants and induce additional fracturing. One of the more substantial threats posed by limestone quarrying occurs in the bulk storage of fuel. However, the refueling areas are lined by an impermeable layer that can contain the entire volume of the largest possible release, include a spill kit, and are "dish shaped" to fully contain a spill. Additionally, the quarry operations are permitted and regulated by the State. The active quarry areas are secured by fencing and gates that restrict access and reduce the potential for intentional contamination. Upon completion, the mined areas are reclaimed using the overburden removed at the beginning of the process and long-term impacts of quarry should be minimal.

Limestone Quarries Recommendations

Existing Regulations

Limestone quarries are regulated by Wyoming state law and regulations and the existing regulations should be used to protect the Casper Aquifer. Currently, the regulations include the Wyoming Environmental Quality Act, Title 35, Chapter 11 and WDEQ water quality rules and regulations.

Monitoring

The quarry operators should incorporate two of their monitoring wells into the City's long-term monitoring network described at the beginning of this chapter. Monitoring limestone quarries will ensure that the impacts, if any, from quarrying are identified.

MOA/MOU

As part of the MOA/MOU, quarry owners in the CAPA should be informed of the sensitivity of the Casper Aquifer to contamination and the importance of BMPs, spill prevention, and rapid clean-up of spills of hazardous materials. The MOA/MOU should establish that the permitted is responsible for mitigating any contamination of the aquifer that results from quarry operations. Quarry operators should provide to the City a spill or accident contingency plan, a notification protocol, and with water-quality data that are collected annually from monitoring wells at the quarries.

Permitting

The City/County should request that the WDEQ-Land Quality Division review and approve all applications for permits to mine or quarry within the CAPA in light of the CAPP.

Landfills and Dumps

Landfills and dumps may have materials that could contaminate the aquifer. Landfills are permitted waste disposal sites where the wasted material is placed in trenches, compacted, and covered with compacted soil to reduce the ability of water to infiltrate into the buried waste. A properly operated landfill covers the waste every day with compacted soil. The Laramie Landfill is located approximately 2 miles west of the CAPA which is considered to be a safe distance. The general groundwater flow direction is westward and any groundwater beneath the Laramie Landfill will flow away from the CAPA.

Dumps are a broad category of unpermitted waste disposal that may include innocuous items such as broken rock or glass to contaminants such as used oil.

Currently, there are no known dumps in the CAPA. The annual clean-up day appears to be accomplishing the desired effect of eliminating illegal dumping.

Landfills and Dumps Recommendations

Clean-Up Days

The County hosts annual clean-up days which allows residents to bring items to the Laramie Landfill or local collection sites for free. It is recommended that these annual clean-up days continue and that large-scale advertisement of this collection event occur to encourage all City and County residents to participate.

Ordinance

The amended County APO Resolution and City APO Ordinance prohibit landfills and dumps within the APO. Upon identification of illegal dump sites, WDEQ should be contacted and asked to investigate the scene. The owners of the dumps should be contacted and informed of their responsibility to rid the community of said nuisance. Landowners should be made responsible to pay for cleanup

Laramie Rifle Range

The Laramie Rifle Range Corporation (LRRC) operates a shooting sports facility within the CAPA on approximately 320 acres located in Sections 1 and 12, Township 16 North, Range 73 West. The establishment of the facility predates adoption of the CAPP by the City and County.

The operation of the LRRC facility is important to the residents of Laramie and Albany County. This facility serves the residents in the County who are interested in shooting sports and serves to protect the welfare and safety of the general public by providing a safe location for the discharge of firearms. In 1998, the City developed the Spur Wellfield which is located approximately 1 mile northwest of the LRRC facility. The area surrounding the facility is also experiencing increased rural residential development that obtains drinking water from the Casper Aquifer.

The primary concern regarding the LRRC is the use of lead bullets and the possible leaching of lead from the bullets into groundwater. Lead adheres to iron minerals, organic matter, and clay materials. Generally, lead does not leach into groundwater due to its tendency to adsorb onto solid materials, and consequently, lead contamination is contained to the top six inches of soil (Lin et al, 1995; Voigt, 2007).

Laramie Rifle Range Recommendations

Monitoring and Investigation

The risk of contamination to Albany County residents and Laramie's water supply as a result of activities at the LRRC is unknown but based upon mobility studies the risk should be low. However, the area should be included in the groundwater monitoring program to determine if any lead is leaching into the groundwater. The soils around the shooting areas should also be tested to determine the depth of lead contamination, if any.

If the monitoring indicates that lead has leached into the groundwater and/or is present in large quantities in the soil, further investigations should be initiated. The study should include more detailed sampling of the soils and groundwater. The investigation should further provide recommendations for monitoring, mitigation strategies (e.g., BMPs, design and operation standards, etc.) and ultimately, remediation of the site, if it is determined that operation of the facility poses a significant threat to the Casper Aquifer.

Communication

The City and/or County officials should initiate a meeting with the LRCC. The purpose of the meeting is to:

- Inform the LRCC of the CAPP.
- Discuss the need for groundwater monitoring.
- Discuss funding for an initial independent investigation of the facility for both groundwater and soil contamination. If this study finds contamination, further investigations would be warranted
- Discuss a timeline for completion of the initial investigation.
- Establish the LRRC's ultimate responsibility for monitoring, mitigating, and if need be, remediation of the site.

MOA/MOU

Based on discussions with the LRRC described above, a formal agreement should be drafted specifying the responsibilities of the LRRC for protecting the aquifer. If agreement with the LRRC cannot be reached, the measures described herein and above should be accomplished by regulation.

Sewer Lines

While sewer lines are preferable to septic systems in the CAPA, sewer lines may leak or break. However, through design and inspections, the likelihood of groundwater contamination can be reduced.

Sewer Lines Recommendations

Design

As sewer lines are extended out to other areas of the CAPA or as existing lines are replaced, the sewer lines should be engineered in such a way as to limit the possibility of an undetected leak. Engineering techniques may include double walled pipes and regular pressure testing or other engineering techniques and leak detection systems that reduce the possibility of undetected leaks. The best technologies and engineering should be used to provide the highest level of protection.

Inspections

The City should ensure that the sewer lines that serve all subdivisions, starting with the Imperial Heights Subdivision, do not leak especially where the sewer line is buried beneath Grand Avenue and crosses the Quarry Fault (e.g., by using a pipeline video camera). A break in the sewer line near the Quarry Fault could have serious impacts on water quality at the Turner Wellfield. As other subdivisions in the APO are placed on centralized wastewater systems, inspections should occur in these subdivisions as well. If portions of the APO are served by utilities other than the City, part of the utility's responsibility should include inspections.

Urban Runoff

Paved parking lots in the CAPA may contribute contaminated runoff that infiltrates into the Casper Aquifer. Rainwater collects oil and grease from paved surfaces, motor vehicles, metal particles from tires and brake pads, and may carry these pollutants across the recharge area or into storm drains, that eventually flow to the Laramie River. If allowed to infiltrate, stormwater also provides a source of recharge to the Casper Aquifer.

Urban Runoff Recommendations

Design Standards

Even though the City of Laramie currently does not come under any federal stormwater management requirements, it is recommended that stormwater management and engineering become a part of development standards in the CAPA. The County and City Engineering departments should provide design standards and recommendations for use within the CAPA that reduces the pollution load and, if possible, provide recharge benefits.

Interjurisdictional Communication

The City and County Planning commissions should be made aware of the importance of permitting future parking lots and streets located in the CAPA. Additionally, the Engineering departments should base their design standards and recommendations on the latest research in regards to stormwater management in arid aquifer protection zones.

Underground Storage Tanks (UST)

USTs pose a high risk to groundwater due to the nature of materials stored within these vessels and the inability to readily see leaks except through secondary detection methods. Due to the high risk posed, USTs should remain prohibited in the CAPA.

UST Recommendations

Existing Regulations

The existing County APO Resolution and City APO Ordinance prohibit installation of all new underground storage tanks within the CAPA. This prohibition should not apply to the repair, maintenance, or replacement of existing USTs if secondary containment is added. The prohibition of UTSs is carried over to the amended County APO Resolution and City APO Ordinance.

Aboveground Storage Tanks (AST)

ASTs are generally used to store fuel and leaks from tanks storing hazardous materials may pose a threat to drinking water.

AST Recommendations

Design and Location Standards

ASTs should be designed and operated according to the State of Wyoming's standards (Chapter 17, Water Quality Rules and Regulations).

Education

Owners of ASTs should be given information on best management practices of ASTs to ensure proper installation and monitoring procedures.

Ordinance

It is recommended that the amended ordinance prohibit ASTs unless the following conditions are met.

1. Store hazardous material in an enclosed structure or under a roof which eliminates stormwater entry to the containment area.
2. Provide floors within a structure where hazardous material is stored, coated to protect the surface of the floor from deterioration due to spillage of any such material. A structure which may be used for storage or transfer of hazardous material shall be protected from stormwater run-on and ground water intrusion.
3. Store hazardous material within an enclosed impermeable containment area which is capable of containing at least the volume of the largest container of such hazardous material present in the area or 110% of the total volume of all such containers in the area, whichever is larger, without overflow of released hazardous material from the containment area.
4. Store hazardous material in a manner that will prevent the contact of chemicals with any materials so as to create a hazard of fire, explosion or generation of toxic substances.
5. Store hazardous materials only in containers that have been certified by a state or federal agency or the American Society of Testing Materials as suitable for the transport or storage of the material.
6. Store all hazardous material in an area secured against entry by the public, except items offered for retail sale in their original unopened containers.
7. Not use, maintain or install floor drains, dry wells or other infiltration devices or appurtenances which allow the release of wastewater to the ground water.
8. Not discharge any substance or material to the ground in the APO zone unless the discharge is permitted by law.

Pesticide and Fertilizer Application

Businesses and residents within the CAPA apply pesticides and fertilizers to landscaped areas. These chemicals have the potential to leach into the groundwater, especially if applied improperly.

The City Parks and Recreation Division, Mosquito Control Program conducts aerial applications of bacillus thuringiensis israelensis (Bti) each May. Bti is a bacterial-based mosquito control product that is harmless to humans, other mammals, birds, and fish. The City's larval control program applies Bti to wet areas and wetlands that are known to be mosquito breeding habitats. The City's mosquito control program also includes aerial application of ultra low concentrations of malathion in June. The aerial applications of Bti and malathion occasionally occur within the CAPA.

Pesticide and Fertilizer Application Recommendations

Landscaping Requirements

New developments within the CAPA are recommended to landscape using native plants, BMPs, low maintenance and low water vegetation, and xeriscape concepts. Native vegetation will reduce the amount of pesticides, herbicides, and fertilizers that need to be applied. The City and County Planning commissions should be aware of the benefits and encourage the use of native and xeriscape landscaping.

Education

Residents and businesses within the CAPA should be educated regarding the use of native plants to reduce the need for watering and chemical use. Additionally, landscaping businesses should be educated and encouraged to provide native landscaping services. The local government entities should lead by example and initiate native landscaping throughout their facilities and open space.

All individuals, organizations, and government departments using fertilizers, herbicides, pesticides, or insecticides are required by federal law to apply it according to the manufacturers' specifications. Brochures should be developed to promote the reduced applications, organic alternatives, and, if used, proper application of pesticides, insecticides, herbicides and fertilizers.

Agriculture

Agriculture, particularly livestock grazing, is the dominant land use within the CAPA. Agriculture zoning is the least intensive land use within Albany County. Livestock grazing is a source of potential contamination because the waste produced by the animals may enter the groundwater. Where there are uncapped wells or thin soils, there is a greater potential for wastes to enter the Casper Aquifer. High concentrations of animals also increase the risk of contamination. Particularly, commercial feedlots and confined animal feeding operations may have large amounts of waste which can enter the groundwater system and contribute to nitrate and bacterial contamination.

Agriculture Recommendations

Ordinance

It is recommended that the amended County APO Resolution and City APO Ordinance include the following provisions.

1. Prohibit commercial animal feeding operations where
    a. animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and
    b. crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.
2. Prohibit all livestock and irrigation wells that are not capped.
3. Prohibit all livestock and irrigation wells that are not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface.

Medical Wastes

There are several businesses in Zone 2 which produce medical wastes. The contamination from medical wastes was deemed a low threat in the potential contaminant inventory.

Medical Waste Recommendations

Existing Regulations

Existing regulations should be used to manage medical waste sources. The disposal and handling of medical wastes in

Wyoming is regulated by the Occupational Health and Safety Administration of the Department of Employment.

Existing Nonconforming Use

Nonconforming uses are uses which are prohibited by current regulations but were in place before the regulation took effect. There are some businesses along the east end of Grand Avenue that may be nonconforming.

Existing Nonconforming Use Recommendations

Existing Regulations

The City and County should use existing regulations, such as State UST regulations and the amended ordinance, to manage nonconforming uses within the CAPA.

Education

The City and County should continue to educate all business owners about the importance of pollution prevention practices, BMPs, and to inform them about the CAPA and CAPP.

Land Acquisition

Land acquisition may be used as a management strategy to protect the most sensitive areas of the CAPA. Land acquisition, as stated previously, includes: purchasing, donations, conservation easements, land exchanges, transfer of development rights, and MOA/MOU.

Land Acquisition Recommendations

Purchasing

It is recommended that the City of Laramie, purchase all land within Zone 1 of the CAPA. The City should also consider purchasing land in Zone 2 that is adjacent to Zone 1 at the Turner, Pope, and Soldier wellfields. Purchasing land in these areas will ensure protection of the most critical areas within the CAPA. Once purchase is accomplished, annexation of these areas should be a high priority.

Conservation Easements and Other Land Acquisition Mechanisms

It is recommended that the City and County work towards a conservation easement program that will allow landowners to set aside a portion of their land that protects the land from development. Donation of land is another mechanism for the City and County to protect sensitive areas from development. Transferring development rights and land exchanges would also allow the City and County developmental control over specific land areas and should also be pursued as the City and County continue to protect the Casper Aquifer.

Work with Landowners

The City government should work with CAPA landowners to shift development rights, change density requirements in specific areas, purchase land, and/or obtain conservation easements. While it is highly unlikely that all of the CAPA will come under public ownership, the landowners within the CAPA have natural incentives to protect the groundwater in order to protect their investment. These landowners should be viewed as valuable resources in protecting groundwater.

Recommended Management Strategies and Implementation Schedule

Implementation of management strategies is the responsibility of the Laramie City Council and Albany County Board of Commissioners. This section prioritizes recommendations for managing potential contaminant sources with an implementation schedule.

As of January 2008, the Laramie City Council and Albany County Board of Commissioners have implemented the following items:

1. Established an overlay zoning district.
2. Established a systematic groundwater monitoring program for the Casper Aquifer at the City of Laramie production wells.
3. Created a permanent staff position to develop and oversee an on-site wastewater management program within the CAPA, including:
    a. Consistently and thoroughly inspect new on-site wastewater treatment facilities, and
    b. Inspections of on-site wastewater treatment facilities upon property transfers.
4. Established requirements for two compartment septic tanks for new or replacement construction of on-site wastewater treatment systems.
5. Collected household hazardous wastes on a semi-annual basis.

YEAR 2008 MANAGEMENT GOALS (IMMEDIATE IMPLEMENTATION)

The following management programs and policies should be implemented immediately:

1. The City and County should pass the amended ordinance and resolution, respectively, as provided in Appendix I.
2. Begin East Laramie/Albany County Wastewater Feasibility Study.
3. Design and implement an expanded groundwater monitoring program.
4. Purse WYDOT MOA/MOU, obtain funding, and begin I-80 mitigation study.
5. Assign a joint City/County staff person to implement the CAPP by June 2008.
6. Retain a consultant or qualified staff to review site-specific investigations and development plans within the CAPA.

YEAR 2009 MANAGEMENT GOALS (WITHIN 1 YEARS)

1. Begin inspecting existing septic systems through the Water and Wastewater Engineer staff position and repeat inspections every three years.
2. Conduct a table-top emergency response drill using a hazardous material spill on I-80 as the scenario. In 2009, a full-scale exercise using a similar scenario should be conducted.
3. Purchase Zone 1 property.

YEAR 2010 MANAGEMENT GOALS (WITHIN 2 YEARS)

The following management programs and policies should be implemented no later than 2010. Note that the time frame for these programs is based not on lesser importance, but by the logistical constraint:

1. Investigate impacts of residential development on water quality.
2. Pursue funding and initiate a study of I-80 mitigation measures.
3. Implement all educational goals described in this chapter.
    a. General education program for aquifer protection.
    b. Septic system maintenance.
    c. The potential for wells and springs to provide a direct route for the introduction of contaminants into the aquifer.
    d. Proper well construction, capping, plugging, and abandonment.
    e. Best Management Practices for potential contaminant sources.

f. Proper pesticide and fertilizer application and ways to decrease the need for these chemicals to residents, businesses, and local governments.

4. Post signs along I-80 and UPRR to indicate CAPA and provide phone numbers for emergencies.
5. Establish Memoranda of Understanding or other agreements with the UPRR and quarry owners.
6. Conduct annual emergency response training for other contamination scenarios such as railroad derailment.
7. Contact owners of improperly capped, unused or abandoned wells and require that owner properly cap or abandon the well.
8. Inspect sewer lines in the CAPA.
9. Establish design standards for stormwater management.
10. Adopt landscaping BMPs within the CAPA.
11. Consider purchasing Zone 2 land immediately adjacent to Zone 1 at the Turner, Pope, and Soldier wellfields.
12. Work with WYDOT to establish a regular cleaning schedule for I-80.
13. Become a member of the National Groundwater Foundation.

Year 2012 Management Goals (within 4 years)

1. Work with landowners to determine the potential for establishing public land within the CAPA.
2. Pursue funding for recycling pesticides and herbicides through the Solid Waste Management District.
3. Begin talking with LRRC to implement initial investigation of lead levels in soils. through the Solid Waste Management District.

NOTE

When evaluating future environmental concerns in Albany County and the City of Laramie, the data used by the EAC, the Albany County Planning and Zoning Commission, Laramie Planning Commission, other government officials, and any hired consultants will not be limited to the contaminant sources, land uses and other information used in the CAPP. Any contaminant sources, future growth, future land use and any other information affecting the CAPP will be considered as changes occur and the CAPP is updated.

CHAPTER 6

CONTINGENCY PLAN

This chapter describes Step 5 of the five-step process for aquifer protection: development of a Contingency Plan in the event of a serious shortage or contamination of groundwater supplies.

INTRODUCTION

The Safe Drinking Water Act (SDWA) requires that Wellhead Protection (WHP) Programs include contingency plans. The Contingency Plan described in this chapter, addresses problems that need to be overcome in the event of a water supply shortage or a contamination incident that impacts the system's ability to supply an adequate quantity of safe drinking water to the public. A contingency plan to help provide potable water to the public during water supply emergencies is critical to any drinking water protection program. The contingency plan defines a chain of command and creates descriptions of individual roles and responsibilities during an emergency. Evaluating potential emergency situations and developing appropriate responses prior to an event can reduce reaction times and reduce the risk of making inappropriate decisions that result in further harm or extend the emergency.

CONTINGENCY PLAN ORGANIZATION

The Contingency Plan is comprised of the following elements: (1) present water source capacity and water demand; (2) chain of command and areas of responsibilities during an emergency; (3) short-term emergency responses, including water conservation and decontamination; and (4) the development of new groundwater sources in response to long-term shortages or the loss of an existing source.

CONTINGENCY PLAN DEVELOPMENT

The Contingency Plan was originally developed by the Contingency Planning Subcommittee of the Environmental Advisory Committee (EAC) using the following guidance documents:

- Guide to Ground-Water Supply Contingency Planning for Local and State Governments, Technical Assistance Document, EPA 440/6-90-003, May 1990.

- Wyoming Wellhead Protection Program Guidance Document, Version 3.1, June 1998.

The Contingency Plan was updated in 2007 by WHPA.

Contingency Plan Distribution

It is recommended that the Contingency Plan be incorporated into the Albany County Municipal Emergency Operations Plan as part of the Hazardous Materials Incident Response Annex managed by the County Emergency Management Coordinator. A copy of the Contingency Plan will be available at the Laramie Community Development Department and the Albany County Planning Office.

Contingency Plan Review and Update Procedures

The water demand and source inventory tables and emergency response team roster must be reviewed and updated every two years. The Contingency Plan should also be modified as changes occur in the water system infrastructure.

Water demand and source inventory data should be reviewed and updated with the same methodology used in previous water supply master plan studies (WWC, 1995; WWC, 2006) or using the best data available at the time of review. Data should be confirmed with the City Utility Manager. An updated Contingency Plan will be reviewed and signed by the City Utility Manager, the County Emergency Management Coordinator, and the Public Works Director to ensure that the most current information has been incorporate into the Contingency Plan.

The Albany County Exercise Design Team tested the Contingency Plan in 2000 with a table-top exercise and in 2001 with a full-scale exercise. The full-scale exercise was held on the summit of Interstate 80 (I-80) near the east boundary of Zone 3 and simulated a diesel spill within the CAPA. The exercise was attended by all emergency response agencies and City/County officials.

Full-scale emergency response exercises should be conducted every two years with alternate years used for table-top exercises. This will allow for several different scenarios to be tested. After each full-scale exercise, the Contingency Plan should be updated with the information learned from the exercise to ensure that the most effective and efficient Contingency Plan is in place. Updating the Contingency Plan should be conducted by the assigned City/County staff in cooperation with the Emergency Management Coordinator and City Utility Manager.

Emergency Likelihood and Severity Chart

Table 6-1 evaluates potential threats by assigning estimates for both likelihood and severity. Events are ranked according to their likelihood to occur and the impact on the water system, (i.e., severity). The estimations were made by James Case, Hazards Staff Geologist at the Wyoming State Geological Survey.

Table 6-1. Emergency likelihood and severity chart for Laramie Regional Drinking Water Protection Program.

Type of Emergency	Likelihood (10-High – 1-Low)	Severity (10-High – 1-Low)	Remarks
NATURAL			
Drought	6	6	Long-term effects unknown
Flood	3	4	Does occur – further study warranted
Ice & Snow Storm	8	4	
Wind	7	2	
Earthquake	5	5	Overdue
Fire	3	4	
MAN-MADE			
Spill/Chemical Contamination	6	10	I-80 and UPRR spills addressed
Sabotage	5	8	Heightened security recommended
Power Outage	5	3	
Operator Error	4	3	
Equipment Failure	5	4	
Explosion	1	5	
Vandalism	7	8	Heightened security recommended

City of Laramie Water Demands and Source Inventory

Table 6-2 shows the historic and projected water demand in million gallons per day (MGD). Table 6-3 shows the existing source capacity of the water system operated by the City of Laramie. This information is from the City of Laramie Public Utilities division (Lytle, personal communication) and the *Laramie Water Management Strategy Level II* (WWC, 2006).

TABLE 6-2. CITY OF LARAMIE WATER DEMAND.

Year	Season[1,2]	Average Day (MGD)	Peak Day (MGD)
2000*	Winter	4.3	8
	Summer	10.7	14.8
2006*	Winter	3.5	6.9
	Summer	9.4	12.5
2011**	Winter	4.9	7.8
	Summer	10.5	15.9

[1]*winter months: November, December, January, February, and March*
[2]*summer months: June, July, and August*
* *2000 and 2006 values from City of Laramie water operations production data (Lytle, personal communication).*
** *2011 values taken from Laramie Water Management Plan Level II (WWC, 2006).*

TABLE 6-3. CITY OF LARAMIE WATER CAPACITY INVENTORY.

Source	Winter Capacity (MGD)		Summer Capacity (MGD)	
	Average	Peak^^	Average	Peak^^
Laramie River	2.5	6.8	6.8	7.5
Turner Wellfield	1.7	4	1.7	4
Pope Wellfield*	1.3	4.2	1.3	4.2
Soldier Wellfield*	1.2	1.2	1.2	1.2
Spur Wellfield**	2	4	2	4
Total (MGD)	8.7	20.2	13	20.9

**These Pope and Soldier Wellfields must be considered together for a contamination event due to connectivity. The peak capacity of both wellfields producing simultaneously is 4.5 mgd (Lytle, personal communication).*
***See the Spur wellfield condition of use agreement at the City of Laramie Public Works Department/Utilities Division.*
^^Peak capacity values were obtained from maximum production levels and direct conversation with City of Laramie Water Utilities Division.

Alternative Potable Short-term Emergency Water Supplies and Coordinating Agencies

Emergency agencies that might assist in the distribution of short-term emergency potable (i.e., drinking) water are listed below (see Emergency Notification Roster for contact information).

- Culligan Water Systems
- Smith Beverage
- American Red Cross
- Salvation Army
- National Guard: To obtain 400 gallon water 'buffaloes' tank trucks from other parts of Wyoming, or to obtain portable water purification units, the governor must request assistance from the Quartermaster Corp in Ft. Carson, Colorado. Contact the Wyoming Emergency Management Agency (WEMA) to initiate this process. WEMA advised that the Wyoming Army National Guard's ability to provide potable water to Laramie is negligible. The Guard has one 5,000 gallon water truck and eight to ten 350 gallon water buffaloes. This may be enough to supply one gallon per person per day for a couple days, depending on the location of the water source. This supply would sustain life only and would not meet any requirements for sanitation or auxiliary needs.
- Local grocery stores such as Safeway, Albertson's, and Wal-Mart.
- Army Corps of Engineers: They would most likely enlist the help of commercial trucking companies to supply potable water.
- Through local coordination there may be additional sources of water from private wells and with water hauling equipment already being used by many residents west of Laramie who haul potable water to their homes.
- An emergency water conservation ordinance would be activated for Laramie residents to conserve water limited to essential uses necessary for survival.

The federal and state governments have no responsibility to provide their towns/cities with potable water. Consequently, it is the responsibility of local government to coordinate and assist in the procurement of emergency potable water.

Water Distribution System and Storage Facilities

Maps of the water distribution system and storage systems are maintained by the City of Laramie Public Works Department. Requests for updates may be directed to the City Engineering Division at (307) 721-5291.

All inspection, decontamination, and reconstruction of the water distribution system are performed in accordance with the American Public Health Association Standard Methods, which is prepared by the American Public Health Association, the American Water Works Association (AWWA) and Water Environment Federation. The Utility Manager maintains a copy and is responsible for the appropriate implementation of the AWWA procedures.

Emergency Response

Albany County and the City of Laramie have an emergency notification protocol in place. In the event of a water supply emergency, a call to 911 or to any City or County official will invoke dispatch of the County Emergency Management Coordinator.

The County Emergency Management Coordinator assumes the following assignments in preparation or during an emergency.

- Coordinate responsible personnel for Contingency Plan development and training (see Emergency Notification Roster at the end of this chapter).
- Maintains channel of communication with Incident Command, which is an on-site Emergency Operation Center vehicle.
- Coordinates channels of command, responsibilities, and designates alternate staff or teams in accordance with the Hazardous Materials Incident Response Annex of the City of Laramie Fire Department.
- Makes contact with the Wyoming Office of Homeland Security, Wyoming Department of Environmental Quality (WDEQ), Wyoming Highway Patrol, a local geologist, and other state and federal agencies that are deemed necessary and responsible for coordinating and providing emergency relief.
- Activates the Emergency Operations Center (EOC), if necessary.
- Coordinates authorization to hire consultants to perform remediation or source development projects.

- Coordinates review and exercising of a water conservation program in conjunction with the Director of Public Works and elected and appointed City and County officials.
- Coordinates all emergency functions with Incident Command, and if necessary, assigns a Public Information Officer (PIO) to work with Incident Command.

WATER SHORTAGE CONTINGENCY PLANS AND SCENARIOS

The Contingency Plan will be implemented, at the discretion of the County Emergency Management Coordinator, when groundwater production wells or surface water systems are rendered inoperable as a consequence of direct contamination or potential contamination or other disaster shortage. The County Emergency Management Coordinator will coordinate this effort with the Public Works Director, the Utility Manager, the City Manager, and elected and appointed City officials.

Contamination of wells or the water treatment plant will result in the isolation or shut down of the affected supply source at the discretion of water utility operators based on their understanding of the contamination event. In the event of a permanent denial of use for a city well(s) or the water treatment plant, new drinking water sources will be developed. The siting, development, and financing of establishing new permanent drinking water sources are described in the Laramie Water Management Plan Level II (WWC, 2006). The water management plan can be reviewed in the Utility Division Manager's office. The following is a brief review of water supply development procedures:

- Development of additional water sources focuses on two different sources: surface water and groundwater. Methods for developing surface water include adding pipelines from the Laramie River to the water treatment plant, pressurizing the pipes into town to handle the increased water supply, lining Pioneer Canal, or developing a non-potable irrigation system for City parks and golf courses.
- The Casper Aquifer is the only groundwater source in the region capable of providing sufficient supplies of water for municipal use. This source can be developed in two ways: drilling new wells or increasing production from existing wells. There are a number of prospects for further development of the Casper Aquifer described in the Water Management Plan (WWC, 2006). An example of a high priority future

groundwater prospect is Simpson Springs, located on the City-owned Monolith Ranch south of Laramie.

The following Contingency Plan elements are listed in the recommended order of implementation. County Emergency Management Coordinator will implement these recommendations with the Public Works Director and the Utility Manager. For example, curtailment of water use should be implemented prior to evaluation and implementation of increased production from the Laramie River, and this prior to distribution of bottled water, etc. With any contamination scenario, all Contingency Plan elements should be chosen in consideration of the duration of the contamination event and loss of the water supply.

- Set priorities for water use (i.e., drinking and food preparation, for facilities such as hospital, medical clinics, and veterinary facilities).
- Water use restrictions that can be voluntary or mandatory depending on the severity of the situation. If public health is an immediate issue, the Emergency Broadcast System should be invoked. For example, in 1997 the 24-inch water transmission line was out of service for one week, and a short-term voluntary request proved it is possible to almost halve water demand with public cooperation (Wes Bressler, personal communication, 1999).
- **Expected shortfalls** of up to **25 percent** of the anticipated water supply or less can be handled by public notification and a request for ***voluntary*** cooperation or compliance.
- **Expected shortfalls greater than 25 percent** of anticipated water supply may require ***mandatory*** controls to ensure minimum delivery to the entire population.
- Increase production from the Laramie River - when conditions permit.
- Increase production from unaffected wells - where and when conditions permit.
- Import and distribute bottled water - Consult emergency notification roster for bottled water suppliers and emergency assistance agencies for possible help with distribution.
- Obtain and operate a temporary water treatment unit - This unit must be requested by the Governor through WEMA.
- Implement the next phase of City's current water source development or treatment options (WWC, 2006) based upon characteristics and projected duration of water supply shortage.

Potential Contaminant Scenarios and Spill Contingency Plan

Potential Scenarios

Three potential scenarios were analyzed to determine the impacts on water availability and are described below:

Scenario 1

The Laramie River is contaminated upstream of the Water Treatment Plant which could potentially create a loss of the Water Treatment Plant.

Scenario 2

A hazardous material is spilled on I-80 close to the Grand Avenue/I-80 interchange. This scenario could lead to a loss of the Turner Wellfield.

Scenario 3

A hazardous material is spilled on I-80 between the rest area and the bottom of Telephone Canyon which could result in the loss of Pope Springs and Soldier Springs wellfields.

Table 6-4 presents these three scenarios which have been identified as the most likely incidents to cause a disruption to the City of Laramie's drinking water supply. These scenarios are considered as priorities for planning purposes. Planners should be aware that different scenarios will require the use of different response equipment, personnel and procedures to allow development of appropriate response approaches.

Supply totals were tabulated by adding the existing water sources average and peak capacity from Table 6-3 and excluding the contaminated water source (Table 6-4). For example, in scenario #3 (loss of Pope Springs and Soldier Springs wellfields) the average winter supply total = 6.2 mgd. This was tabulated by adding 2.5 mgd (Laramie River winter capacity average) + 1.7 mgd (Turner Wellfield winter capacity average) + 2.0 mgd (Spur Wellfield winter capacity average) = 6.2 mgd average winter supply total. The average and peak day supply total numbers from Table 6-4 are then subtracted from Laramie's average and peak day demands from Table 6-2 (the highest demands from 2000-2011 were used so that the worst case scenario was analyzed). Deficiencies were calculated and are shown in Table 6-5.

Table 6-4. Potential shortages associated with possible contamination scenarios.

Scenario #1 – Contamination of the Laramie River upstream of the water treatment plant
Potential Impact: Loss of water treatment plant

WINTER DAILY AVERAGE (MGD)		WINTER PEAK DAY (MGD)	
Supply	6.2	Supply	12.5
Demand	4.9	Demand	8.0
Shortage	none	Shortage	none
SUMMARY DAILY AVERAGE (MGD)		SUMMER PEAK DAY (MGD)	
Supply	6.2	Supply	12.5
Demand	10.7	Demand	15.9
Shortage	4.5	Shortage	3.4

Scenario #2 – Spill occurs on I-80 (proximate to Grand Avenue/I-80 interchange)
Potential Impact: Loss of Turner Wellfield

WINTER DAILY AVERAGE (MGD)		WINTER PEAK DAY (MGD)	
Supply	7.0	Supply	15.3
Demand	4.9	Demand	8.0
Shortage	none	Shortage	none
SUMMARY DAILY AVERAGE (MGD)		SUMMER PEAK DAY (MGD)	
Supply	11.3	Supply	16.0
Demand	10.7	Demand	15.9
Shortage	none	Shortage	none

Scenario #3 – Spill occurs on I-80 (between rest area and bottom of Telephone Canyon)
Potential Impact: Loss of Pope Springs and Soldier Springs wellfields depending on location of spill

WINTER DAILY AVERAGE (MGD)		WINTER PEAK DAY (MGD)	
Supply	6.2	Supply	14.8
Demand	4.9	Demand	8.0
Shortage	none	Shortage	none
SUMMARY DAILY AVERAGE (MGD)		SUMMER PEAK DAY (MGD)	
Supply	10.5	Supply	15.5
Demand	10.7	Demand	15.9
Shortage	0.2	Shortage	0.4

Notes: Mitigation may prohibit migration of contaminants to Soldier Springs Wellfield in Scenario 3. The greatest values of demand and supply for average and peak day for winter and summer between the years 2000-2011 were considered.

Table 6-5. Water deficiency compared to average and peak demands in winter and summer.

Scenario	Deficiency for Average Day Demand (MGD)		Deficiency for Peak Day Demand (MGD)	
	Winter	Summer	Winter	Summer
#1 Loss of water treatment plant	--	4.5	--	3.4
#2 Loss of Turner Wellfield	--	--	--	--
#3 Loss of Pope Springs and Soldier Springs wellfields	--	0.2	--	0.4

Water deficiencies shown in Table 6-5 are based upon average and peak capacities. Pumping at peak capacities is not sustainable over the long-term. If a well(s) were inoperable due to contamination, the remaining wells are unable to pump at peak capacities beyond 40 to 50 days. Therefore, the average capacity should be considered the long-term capacity of the water systems. Over the long-term, average capacities may be unable to deliver during peak times and additional supplies may be required.

Spill Contingency Plan

A spill of potentially hazardous substances along I-80 has the highest likelihood and highest severity of damage to Laramie's groundwater supply, the Casper Aquifer. It is recommended that a mock disaster simulating a spill along I-80 be used to test, evaluate, and refine the following Contingency Plan outline. Table 6-6 provides a checklist of elements from the following Contingency Plan section that would be implemented in each of the different scenarios.

Spill Contingency Plan Elements

1. The County Emergency Management Coordinator will notify the Transportation Department, the Water Department, UPRR, the Fire Department, WEMA, the Albany County Commissioners, the Laramie City Manager, the City Council, the Laramie Mayor and other relevant agencies and officials, as well as submit a preliminary news release.
2. If the spill occurs within the CAPA, mitigation strategies will be rapidly employed.
3. The County Emergency Management Coordinator shall immediately direct the Utility Manager to take all available courses of action to shut off and isolate potentially contaminated wells from the distribution system, and employ a 24-hour alert with testing of proximate sources and distribution systems.

4. Assess the possibility of using absorbent materials, or isolating the contaminant material on the highway and railroad culvert systems. Assistance may be requested from the WYDOT and UPRR to implement with these maneuvers.
5. Once an initial assessment of the emergency is obtained directives to a designated contractor to proceed with further mitigation or decontamination should be ordered by the County Emergency Management Coordinator, if necessary.
6. The County Emergency Management Coordinator, in cooperation with the Public Works Director and elected City Officials, shall implement a water conservation program, and order alternative potable water supplies, if necessary (see section on Water Shortage Contingency Plan and Scenarios).
7. News releases should be submitted on a daily basis by the Public Information Officer, providing all necessary public information regarding the drinking water supply and at minimum, encouraging water conservation (see Press Release Template at end of section).
8. The need for extended periods of increased groundwater production should be assessed in consultation with the Director of Public Works, elected and appointed City and County officials, State and Federal environmental agencies, and implemented, if necessary.

The mitigation measures study outlined in Chapter 5 and Appendix F should be completed as soon as possible to provide a professional assessment of effective and practical approaches that may be implemented before a hazardous material spills occurs on I-80.

Table 6-6. Contingency plan elements for scenarios with inadequate supply.

SCENARIO	CONTINGENCY PLAN ELEMENT							
	1	2	3	4	5	6	7	8
Scenario #1: Summer Daily Average and Peak					x	x	x	x
Scenario #3: Summer Daily Average and Peak	x	x	x	x	x	x	x	x

Sources of Funds and Disaster Relief

Financing for developing or cleaning up water sources due to spills, sabotage, or other man-made activities would most likely entail the City of Laramie hiring a consultant to perform the work, and then seeking compensation from the responsible parties.

Local Emergency Fund Reserves

Since legal compensation, as well as disaster relief funds, can take up to a year (or more) to receive, reserved funds should be an integral part of Laramie's Municipal Water System Emergency Preparedness effort. (Contact Laramie City Manager)

Governor's Contingency Fund

In 1989, the Governor of Wyoming established provisions which allow the Governor's Contingency Fund to be utilized for containment, cleanup, and disposal of substances posing an eminent threat to the health, safety or welfare of humans, wildlife and/or waters of the State (including groundwater). These funds are available only when immediate action is required or the responsible party is unknown. The funding must be requested from the Governor and the WDEQ Director.

Pollution Revolving Fund

Limited federal funding may be available through the Pollution Revolving Fund, administered by the U.S. Coast Guard, for the reimbursement of state and federal costs related to the containment, removal, mitigation, and disposal of oil releases. In addition, EPA may provide limited funds to ensure timely initiation of containment action when use of the Pollution Revolving Fund is not authorized. Requests for EPA funds must come from the Governor. Additional information is available in the Wyoming Oil and Hazardous Substances Pollution Contingency Plan (1989) and Section 311(k) of the Clean Water Act.

Legal Compensation

Generally, the burden of the cost of clean-up following a contamination incident rests with the responsible party. The County/City Attorney should be directed to pursue legal remedies whenever possible.

Federal Emergency Management Agency (FEMA)

In the event of a major disaster, FEMA may provide mobile telecommunications, operational support, life support, and power generation assets for the on-site management of the disaster. Requests would be made through the Wyoming Emergency Management Agency.

Recommendations in the Contingency Plan

1. Full-scale exercises should be conducted every two years with alternate years used for table-top exercises.
2. After each full-scale exercise, the Contingency Plan should be updated with the information learned from the exercise to ensure that the most effective and efficient Contingency Plan is in place. Updating the Contingency Plan should be conducted by the Water Outreach Coordinator in cooperation with the Emergency Management Coordinator.
3. Pursue funding and initiate study of I-80 mitigation measures (see Chapter 5 and Appendix F).

Press Release Template

The following notice regards:

1. Potential contamination of the City of Laramie's water supply
2. Municipal water shortage

It is vital that all residents of Laramie observe the following water use restrictions until further notice:

The characteristics and potential public health hazards associated with this contaminant are as follows:

City personnel are taking the following steps to address this problem:

For further information, please contact ______________________________
at this phone number:______________________________

A press conference is scheduled for ______________________________
to be held at ______________________________

News updates will be provided as additional information becomes available.

Time:________________ **Date:**______________________________
Signed:

Distribution:	**FAX**	**PHONE**
Laramie Daily Boomerang	721-2973	742-2176
Branding Iron	766-4027	766-6190
KOWB	742-4576	745-4888
KUWR (Wyoming Public Radio)	766-6184	766-4240
KRQU	745-7397	745-5208
Bresnan Cable		745-7333
KCGWY		745-9242
KIMX		745-5208
KOCA		745-0937
City TV – Channel 11		721-5226

EMERGENCY NOTIFICATION ROSTER

TABLE 6-7. EMERGENCY NOTIFICATION ROSTER.

POSITION/AGENCY	CONTACT/ NAME	ROLES	WORK PHONE	HOME PHONE
Wyoming Office of Homeland Security	Joe Moore-Director Larry Maierus-Deputy Director	Respond/ Guidance	777-4663	
Federal Bureau of Investigation	Richard Fanelli John Lynch	Respond/ Guidance	307-632-6224	
Wyoming DEQ Herschler Bldg. Cheyenne, WY 82002	Joe Hunter Emergency Coordinator General line	Respond/ Guidance	(307) 777-5885 (307) 777-7781	(page) 432-1108 (cell) 631-2880
National Response Center Washington D.C.	Emergency Line	Respond/ Guidance	(800) 424-8802	
US EPA Region VIII	Emergency Line	Respond/ Guidance	(303) 564-1788	
Emergency Response Branch One Denver Place 999 18th Street, Suite 500 Denver, CO 80202				
County Emergency Management Coordinator Hazard Assessment Coordinator Fire Department	Randy Vickers	Guidance/ Coordination Respond/ Guidance	911 721-5302	760-5946 (cell) 742-3670 (home)
Assistant Emergency Management Coordinator Albany County Sheriff	Jim Pond	Respond/ Guidance	721-2526	742-5982
City Engineer		Guidance	721-5273	
City Public Works Director		Guidance	721-5241 Direct 721-5230 Ad. Assist	
City Utility Manager		Respond/ Guidance	721-5281 Direct 721-5280 Ad. Assist	

POSITION/AGENCY	CONTACT/ NAME	ROLES	WORK PHONE	HOME PHONE
City Water Utility pager person	Non-Emergency Dispatch		721-2526	
Chief of Police		Guidance	721-3552	
Wyoming Highway Patrol	Dispatch Lt. Gunther	Respond/ Guidance	(307) 777-4321 745-2101	721-2046
Wyoming Department of Transportation	Tim McGary	Respond/ Guidance	745-2100	
Union Pacific Railroad Risk Management Communication Center	Frank Lerch	Respond	(888) 877-7267	
County Commission Chairman		Guidance	721-2568	
City Manager		Guidance	721-5226 (Exec. Assist.	
Emergency Contractor (Heavy Equipment)	Bird-O'Donnell Construction	Respond	745-3213	
Bottled Water	Culligan Anheuser-Busch	Respond	745-3893 (314) 577-2000	721-8929 (after hrs)
Water Buffaloes	National Guard	Respond	Contact WEMA	
Emergency Assistance	American Red Cross National Guard Salvation Army	Respond	Contact Albany Co. EMA to coordinate these agencies	
News Media Boomerang KOWB KUWR (Wyoming Public Radio) KRQU Branding Iron Bresnan Cable KIMX KCGWY KOCA Channel 11			 742-2176 745-4888 766-4240 745-5208 766-6190 745-7333 745-5208 745-9242 745-0937 721-5226	
EAC Technical Committee		Guidance	721-5230	

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APPENDIX A

ENVIRONMENTAL ADVISORY COMMITTEE MEMBERS

2001-2002 Environmental Advisory Committee

NAME	REPRESENTATION
Bill Brizuela (chairman)	Local Business Owner
Ben Jordan (vice chairman)	Hydrogeologist
Joel Farber	Engineer/Geologist
Stan Huff	Retired Citizen
Paul Etchepare	Concerned Citizen
Norm Rhodine	Retired UW Faculty
Jerry Schmidt	Retired USFS Employee
Public Information Subcommittee	
Mary Bower	
Carol Frost	
Kathy Rittle	
Bill Brizuela	
Norm Rhodine	
Aquifer Area Management Subcommittee	
Paul Etchepare	
Ron Olsen	
Richard Allen	
Stan Huff	
Kristi Radosevich	
Ben Jordan	

NAME	REPRESENTATION
Charlie DeWolf	
Karl Taboga	
Bill Sansing	
Valentine Sworts	
Joel Farber	
Technical Review Subcommittee	
Alan VerPloeg	
Ben Jordan	
Chris Moody	
Demian Saffer	
Jim Case	
Joel Farber	
Keith Clarey	
Paul Etchepare	
Stan Huff	
Tom Edgar	

APPENDIX B

CAPP LETTER OF APPROVAL FROM WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Dave Freudenthal, Governor

Department of Environmental Quality

To protect, conserve and enhance the quality of Wyoming's environment for the benefit of current and future generations.

John Corra, Director

July 3, 2007

Terry Haugen, Public Works Director
PO Box C
Laramie, WY 82073

RE: Casper Aquifer Protection Plan

Dear Mr. Haugen:

The Department of Environmental Quality (DEQ) has reviewed the Casper Aquifer Protection Plan (CAPP) submitted to this office May 10, 2007. DEQ finds that the CAPP has met all requirements as described in the Wyoming Wellhead Protection Guidance Document and has incorporated the required additional elements identified by DEQ during the review process.

DEQ recognizes that an unprecedented number of people pooled their time and expertise over the period of many years to develop the CAPP. DEQ congratulates the City of Laramie and the Environmental Advisory Committee on the completion of this significant effort. However, DEQ reminds the City of Laramie that the CAPP is a living document and must be updated at least once every two years. Please send two copies of any changes or updates made to DEQ.

DEQ reminds the City of Laramie that the purpose of the CAPP is to prevent the occurrence of or minimize the severity of aquifer contamination. While having a protection plan does not preclude the possibility that contamination could occur, a strong plan that is conscientiously implemented by the community will help protect the City of Laramie's water supply.

If you have any comments or concerns, please contact Kim Parker at 307-777-6128.

Sincerely,

John W. Wagner
Department of Environmental Quality
Water Quality Division Administrator

c: Kim Parker, DEQ/WQD, Cheyenne
Lou Harmon, DEQ/WQD, Cheyenne
Kevin Fredrick, DEQ/WQD, Cheyenne
Tim Chestnut, Albany County Commissioner, Albany County Courthouse, 525 Grand Avenue, Room 210, Laramie, WY 82070

APPENDIX C

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APPENDIX D

RESOLUTION OF SUPPORT

JOINT RESOLUTION NO. 2000-02 OF SUPPORT

RESOLUTION SUPPORTING THE ENVIRONMENTAL ADVISORY COMMITTEE'S (EAC) DEVELOPMENT OF THE LARAMIE REGIONAL DRINKING WATER PROTECTION PROGRAM

WHEREAS, the EAC has prepared a Delineation Report and Delineation Map which identify land areas that contribute water to public drinking water supplies for the Laramie Regional Drinking Water Protection Area; and

WHEREAS, the EAC has prepared a Contingency Plan which addresses problems that the City of Laramie's public water supply system may need to overcome in the event of water supply shortages or a contamination incident that impacts the system's ability to supply an adequate quantity of safe drinking water to the public; and

WHEREAS, the Laramie City Council and the Albany County Board of County Commissioners request the EAC to proceed with developing an Aquifer Area Management Plan that will make recommendations on how to manage the existing potential sources of contamination identified within the aquifer protection area and to ensure that future land-use activities do not pose a threat to the water quality of the most permeable parts of the Casper aquifer in the Laramie Regional Drinking Water Protection area; and

WHEREAS, the Laramie City Council and the Albany County Board of County Commissioners wish to thank the EAC members for all their hard work and effort in developing the comprehensive Delineation Report, Delineation Map, and the Contingency Plan.

NOW THERFORE, BE IT RESOLVED, by the Laramie City Council and the Albany County Board of County Commissioners that the City of Laramie and Albany County accept the Delineation Report, Delineation Map, and the Contingency Plan of the Laramie Regional Drinking Water Protection Program as written.

PASSED AND APPROVED this 4th day of January, 2000.

David F. Williams, Mayor and
President of the Laramie City
Council, Laramie, Wyoming

Pat Gabriel, Chairman
Albany County Board of County
Commissioners

ATTEST:

Sue Morris-Jones, CMC
City Clerk

ATTEST:

Jackie Gonzales
Albany County Clerk

APPENDIX E

DELINEATION REPORTS VERSION 1.0 AND 2.0

DELINEATION REPORT

for the

CASPER AQUIFER PROTECTION AREA

LARAMIE, WYOMING

TECHNICAL REVIEW SUBCOMMITTEE OF THE

ENVIRONMENTAL ADVISORY COMMITTEE

PREPARED FOR:

CITY OF LARAMIE AND ALBANY COUNTY, WYOMING

June, 1999

Respectfully submitted by the Technical Review Subcommittee:

Keith E. Clarey, P.G. (TriHydro Corporation)

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Dr. Thomas Edgar, P.E. (University of Wyoming)

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Paul G. Etchepare, Jr. (Warren Livestock)

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J. Joel Farber, P.G. & P.E. (Consultant)

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Dr. Peter Huntoon, P.G. (University of Nevada at Las Vegas)

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Todd Jarvis is the liaison to The Environmental Advisory Committee.

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1.0 INTRODUCTION

1.1 DRINKING WATER PROTECTION PROGRAMS

1.1.1 A National Perspective

Public drinking water supplies have always influenced the location and development of communities by both defining and directing their growth. Historically, the location of a good source of drinking water was a key factor in determining the location of centers of population. Safe drinking water is essential to the quality of community life because of the link between public health and the quality of the public water supply.

Since the 1986 Amendments to the Safe Drinking Water Act, which established the Wellhead Protection Program (WHP), the United States Environmental Protection Agency (EPA) has supported states and communities in their efforts to protect their sources of drinking water. The EPA Source Water Protection (SWP) goal is that "by the year 2005, 60 percent of the population served by community water systems will receive their water from systems with SWP programs in place under both WHP and watershed protection programs" (EPA, 1997).

Groundwater protection programs in the United States and Canada all follow a similar five-part program guided by public participation; which includes:

1. Forming a local Drinking Water Protection Committee;

2. Identifying land areas that contribute water to public water supplies;

3. Inventorying existing and future potential sources of contamination;

4. Developing a management program to deal with identified existing and future contaminant sources; and

5. Preparing a contingency plan to address contamination incidents and other water supply emergencies.

This report focuses strictly on part two, "identifying land areas that contribute water to public drinking water supplies". This investigation has been conducted using the broader approach of aquifer protection rather than the more restrictive concept of wellhead protection.

1.1.2 A Regional Perspective

Although several other Wyoming communities have initiated groundwater protection programs, those communities have relied on outside expertise to develop and implement these programs. In contrast, the Laramie Regional Drinking Water Protection Program has adopted a "do-it-yourself" approach, as advocated in "Wyoming's Wellhead Protection Program Guidance Document" (Wyoming Department of Environmental Quality, 1997). The Laramie Program utilizes the volunteer efforts of over 25 city and county residents divided into five subcommittees, each assigned a task from the groundwater protection program described above. The subcommittee which delineated the aquifer protection area consists of hydrologists, geoscientists, engineers, and others with technical training and background in groundwater protection. Thus, the Laramie Regional Drinking Water Protection Program is proof that community residents can develop Source Water Protection plan for a minimal investment.

1.1.3 A Local Perspective

Approximately 65 percent of the City of Laramie and the South Laramie Water and Sewer District drinking water supplies are derived from wells and springs tapping the Casper aquifer. Many residents who live outside the Laramie municipal area rely on groundwater for 100 percent of their drinking water supplies.

The Casper Formation is exposed along the west side of the Laramie Range (east of the City of Laramie) and is vulnerable to contamination for the following reasons:

Points of withdrawal (municipal and domestic wells) are in proximity to the recharge area;

The aquifer is fractured and has extensive exposures of porous sandstones. These fractures are commonly found in topographic drainages where surface water is concentrated prior to recharging the aquifer; and

Interstate - 80 (I-80) cuts through the entire thickness of the Casper Formation.

Any Aquifer Protection Program must be responsive to the needs and the development of the local community. As such, the Aquifer Protection Plan will be revisited in the future. As new data on the Casper aquifer become available, future workers may decide to revise the aquifer delineation map presented in this report.

Differences between wellhead and aquifer protection programs are summarized below. Additional information may be obtained from the Laramie Regional Drinking Water Protection Program Web page at <lariat.org/Aquifer/index.html> and from references listed at the end of this report.

1.2 HISTORY OF THE LARAMIE DRINKING WATER PROTECTION PROGRAM

The City of Laramie was successful in obtaining a grant from the EPA to develop a WHP Plan in 1993. Western Water Consultants, Inc. (WWC) developed the initial approach to delineating WHP areas based on hydrogeologic mapping and development of time-of-travel contours near mapped faults (WWC, 1993). The EPA grant required development of a WHP ordinance, and a draft was completed in late 1996 (City of Laramie, 1996). Citizens voiced numerous concerns at this time, based upon (1) the prescriptive nature of the ordinance, (2) the dependence of the 1993 WHPA upon the location of identified faults, and (3) the exclusion of limestone quarries, located within the Casper Formation, from the WHPA (for example, see Huntoon, 1996).

As a result of citizen concerns and challenges to the proposed WHP ordinance, the City Council and County Commissioners instructed the Laramie Environmental Advisory Committee to develop an Aquifer Protection Program. The primary goal of the program was to develop and implement the Laramie Regional Drinking Water Protection Program for the Casper aquifer.

1.3 WELLHEAD VERSUS AQUIFER PROTECTION

1.3.1 Wellhead Protection Areas

The delineation of a Wellhead Protection Area (WHPA) is an important means of directly and immediately safeguarding the public water supply (Witten and Horsley, 1995). As defined in the 1986 federal Safe Drinking Water Act amendments, a WHPA is "the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." Pumping wells within an aquifer will affect the natural movement of groundwater by drawing water to the well. WHPAs are those land areas that contribute groundwater (and potential contaminants) to the pumping wells. In this sense, WHPAs are subsets of the larger, aquifer system (Figure 1-1).

1.3.2 Aquifer Protection Areas

The 1996 Safe Drinking Water Act amendments promote Source Water or "Aquifer" Protection. Aquifer protection will usually encompass a larger area than Wellhead Protection, and thus provides even greater safety for public water supplies over the long term. Wellhead Protection protects the area surrounding a water well or wellfield, while Aquifer Protection protects a larger portion of the whole aquifer, and will likely extend beyond operating wellfields (Figure 1-1). By protecting a larger portion of the aquifer, it is expected that groundwater available to users (from storage and/or recharge in other parts of the aquifer) will be safeguarded from contamination.

The protection of an aquifer requires an understanding of the extent of both the aquifer and its overlying and upgradient lands from which its water is derived (Witten and Horsley, 1995). The delineation of aquifer protection area boundaries is independent of the effects of pumping wells and is more directly related to the natural hydrologic flow patterns. Both surface water and groundwater flow conditions must be factored into the delineation of an aquifer protection area.

2.0 GEOLOGY AND HYDROGEOLOGY OF THE CASPER AQUIFER

The following sections summarize the geology and hydrogeology of the Casper aquifer as it pertains to the delineation of a protection area for the aquifer. The discussion emphasizes the following hydrogeologic elements of the Casper aquifer:

geologic and stratigraphic description of the region; and

hydraulic relationship between overlying and underlying rock units.

2.1 GEOLOGY AND GEOLOGIC HISTORY

The Casper Formation is comprised of sandstone interbedded with limestone and shale (Figure 2-1) exposed on the western slope of the Laramie Range, east of the City of Laramie (Figure 2-2). It is approximately 700 feet thick and is informally subdivided from the bottom to the top into five members, named alpha through epsilon, each of which consists of a sandstone layer bounded at the top by a regionally continuous limestone.

The Casper Formation is located below the Satanka Shale and above the Fountain Formation and the underlying Sherman Granite. The Permian Satanka Shale is predominantly red shale with interbedded siltstone and sandstone layers and is approximately 250 to 320 feet thick in the Laramie area. The lower 20 feet of the Satanka Shale has abundant red and white sandstones similar to the underlying Casper Formation. The Satanka Shale is exposed at the base of the Laramie Range near the eastern corporate limits of the City of Laramie.

The Pennsylvanian Fountain Formation is an irregularly distributed sedimentary unit which is thin (less than 50 feet) to absent in the Laramie area (Lundy, 1978). For this document, it will be considered a part of the alpha unit of the Casper aquifer (Figure 2-1).

The Precambrian Sherman Granite is a crystalline igneous rock generally exposed east of the crest of the Laramie Range (Figure 2-2). It was formed by the slow cooling of magma (liquid rock) and is a large mass of interlocking minerals. This is in contrast to the overlying formations which are layered sedimentary rocks derived from chemical precipitation and deposition of detrital material.

During the period of uplift that created the Laramie Range, these rock formations were tilted approximately 3-5 degrees to the west and locally folded and faulted as indicated on Plate I. Folding occurs mostly as east-west trending anticlines and monoclines that plunge to the west. Faulting consists of numerous normal and reverse faults that trend in many directions (Lundy, 1978 and Ver Ploeg, 1996). Not all faults can be observed at the ground surface due to small displacement or to coverage by overlying deposits, such as windblown sand, alluvium and colluvium. In most cases, the faults and folds observed in the Casper Formation do not propagate vertically through the entire thickness of the overlying Satanka Shale. Exceptions are the Sherman Hill and Laramie faults in which offset lithology indicates shearing through the Satanka Shale.

2. 2 HYDROGEOLOGY

The movement of groundwater in the Laramie area occurs primarily in the lateral direction within the permeable layers and, to a lesser extent, in the vertical direction along fractures. The permeabilities within the Casper sandstones are very large in contrast to the overlying and underlying strata. Consequently, hydraulic communication between the formations is limited, and the formations are generally considered distinct hydrostratigraphic units.

2.2.1Hydrogeology of the Casper Aquifer

The term Casper Formation is used here to describe the geologic material that comprises the unit. The term Casper aquifer is used when describing the water bearing and transmission characteristics of the formation even where the Casper Formation is unsaturated.

As listed in the Glossary, an aquifer is “a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells and springs.” This definition can be interpreted to include only the saturated portion of a formation. For purposes of the Laramie Regional Drinking Water Protection Program, the definition of the Casper aquifer must be expanded to include both the saturated and unsaturated (vadose zone) parts of the Casper Formation. As shown in Figure 2-3, the upper part of the Casper aquifer is unsaturated on the west slope of the Laramie Range. The unsaturated thickness of the Casper aquifer decreases from east to west. During recharge events, the vadose zone transmits water from the surface to the underlying saturated material. In this manner, the entire Casper Formation constitutes the Casper aquifer to account for the recharge, storage, movement and discharge of water.

The saturated portion of the aquifer is relatively thin at the crest of the range and gradually thickens westward toward the Satanka-Casper contact. A short distance west of this contact, the entire thickness of the Casper Formation is saturated and the Casper aquifer attains its maximum thickness as a confined, artesian aquifer due to the confining properties of the overlying Satanka Shale.

East of where the Casper Formation is fully saturated, the exposed sandstone units may be confined or unconfined depending on their location, as shown in Figure 2-3. The limestones that separate the sandstones have negligible permeabilities and serve as local confining layers that define subaquifers within the Casper aquifer. Therefore, the informal members, designated in descending order (epsilon, delta, gamma, beta, and alpha), comprise subaquifers within the Casper aquifer (Figure 2-2).

2.2.2 Hydrogeology of the Sherman Granite

The Sherman Granite, as used here, includes associated granite gneiss and other metamorphic lithologies underlying the Casper Formation. Unaltered Sherman Granite has extremely low intergranular or intercrystalline permeability. Like most granites, permeability within the Sherman Granite is limited to where the granite is extensively weathered and/or fractured by faults and joints. Many domestic wells obtain drinking water from the granite, but well yields are typically small and dependent on fractures.

To date, there has not been a systematic study of the hydrogeology of the Sherman Granite and its hydraulic relationship to the Casper aquifer. Because of the much lower permeability and limited storage capacity of fractures in the Sherman Granite compared to the sandstones of the Casper Formation, the Sherman Granite is treated here as a confining unit below the Casper aquifer.

However, if faults in the Casper Formation are continuous between the two units, there may be some hydraulic connection between them. Preliminary chemical analyses of strontium concentrations and isotopic ratios from waters within the Casper aquifer suggest there may be some mixing between waters of the Sherman Granite and the Casper aquifer (Frost and Toner, 1996). It is believed that any hydraulic connection is minor due to the small permeability of the unfractured crystalline rock and the limited storage capacity of fractures. Therefore, the Sherman Granite will be assumed to be an aquitard or aquiclude (see Glossary).

2.2.3 Hydrogeology of the Satanka Shale

The hydraulic relationship between the Satanka Shale and the Casper aquifer is a critical element in the delineation of a protection area for the Casper aquifer. The hydrogeology of the Satanka Shale has not been studied in detail, but observations made during studies of the Casper aquifer provide some data regarding the hydraulic relationship between the Satanka Shale and the underlying Casper aquifer (Lundy, 1978; Huntoon and Lundy, 1979; WWC, 1993, 1994, 1997a,b and Weston, 1995).

Taken in its entirety, the Satanka Shale is a regional confining layer above the Casper aquifer. However, the permeable sandstones in the Satanka Shale provide water to many domestic and stock wells in the Laramie area. Approximately 300 feet of shale, siltstone, and sandstone isolates the Casper aquifer from overlying aquifers including permeable beds within the Satanka Shale.

The hydraulic head in the Casper aquifer is typically 20 to 40 feet greater than the heads in the permeable layers within the Satanka Shale. The Casper aquifer is confined where overlain by the Satanka Shale (JMM, 1989; WWC 1993, 1994, 1997a,b; and Weston, 1995). Hydraulic separation between the Casper aquifer and permeable layers in the Satanka Shale has been documented during pumping tests conducted at the Spur Wellfield, LaPrele Park Prospect, and the Turner Wellfield where no observable head declines occurred in the monitored intervals in the Satanka Shale as the Casper aquifer was pumped (WWC, 1993, 1996, 1997a,b).

Important for the Laramie Regional Drinking Water Protection Program is the fact that fractures in the lower 50 feet of the Satanka Shale can be permeable. In contrast to the observations above, there are some localities where groundwater from the Casper aquifer has been observed to flow upward into the lower 50 feet of the Satanka Shale at Simpson, Soldier, and Pope Springs (Plate I). Consequently, to be safe, the protection provided for the Casper aquifer is extended to the lower 50 feet of the Satanka Shale.

More detailed information regarding the geology and hydrogeology of the Casper aquifer may be obtained from Morgan (1947), Huntoon (1976), Lundy (1978), Huntoon and Lundy (1979), Thompson (1979), WWC (1993, 1994, 1996) and Ver Ploeg (1996).

3.0 PHYSICAL CHARACTERISTICS OF THE CASPER AQUIFER

This section summarizes the physical characteristics of the Casper aquifer as it pertains to the delineation of a protection area for the Casper aquifer. The discussion emphasizes the following hydrologic elements of the Casper aquifer:

groundwater flow patterns;

permeability characteristics;

recharge area; and

geologic features that enhance the vulnerability of the aquifer to contamination.

3.1 GROUNDWATER FLOW PATTERNS

As shown on published potentiometric surface maps, groundwater in the Casper aquifer in the vicinity of Laramie generally flows from east to west, from areas of high elevation at the crest of the Laramie Range toward lower elevations within the Laramie Basin (Lundy, 1978; Thompson, 1979). This pattern is altered locally to a more radial pattern close to the City's municipal wellfields and the springs, which discharge large quantities of water from the Casper aquifer. Flow patterns are also locally altered to some degree by the permeability imparted by fracturing associated with faults and folds.

3.2 PERMEABILITY CHARACTERISTICS

There are two types of permeability in the Casper aquifer: (1) intergranular permeability; and (2) conduit flow. Intergranular permeability refers to the ability to transmit water through the pore spaces between individual grains in the undeformed aquifer. In the Casper aquifer, the sandstones have large intergranular permeability whereas the limestones have negligible permeability. Ground water flow through the sandstone matrix is slow, with calculated velocities approaching 0.8 feet per day (WWC, 1993). The permeability of the limestones is several orders of magnitude less than the sandstones.

The intergranular permeability of the sandstones that comprise the five members of the Casper Formation is variable, with the greatest permeability occurring in the epsilon and delta members and the lowest permeability in the alpha member. The variation is due to the greater abundance of very fine sand, silt, and calcite cement that fill the pore spaces in the lower sandstones. Intergranular permeability is responsible for providing water to wells on the order of 1 to 100 gallons per minute (gpm).

Conduit flow refers to the flow of water through cavities or fractures associated with dissolution, faults, folds, joints, and partings along bedding planes. Conduit flow is typically orders of magnitude greater than intergranular permeability, and is capable of yielding large quantities of water to wells, as demonstrated by the Laramie municipal wells. Production from the municipal wells that penetrate the fractured aquifer is on the order of 1,500 to 2,500 gpm. These high-yield wells tap fractures associated with faults and folds that have deformed the Casper Formation. At the Spur and Turner wellfields, where the aquifer has been fractured, the upper and lower members of the Casper Formation are hydraulically connected with each other through the fractures.

Specific permeability enhancements associated with the faults and folds in the Casper aquifer shown on Plate I cannot be determined with certainty; some structures may enhance aquifer permeability while others may reduce permeability. Although the effects that each structure has on aquifer permeability are not known, it is important to recognize the hydraulic complexity imparted to the Casper aquifer by geologic structures such as faults and folds.

3.3 RECHARGE AREA

Recharge refers to the replenishment of the Casper aquifer by the infiltration of water derived from rainfall and snowmelt through the unsaturated zone. This process occurs to some degree wherever the Casper Formation is exposed at the surface. Consequently, the entire surface exposure of the Casper Formation is assumed to be the recharge area for the Casper aquifer.

Lundy (1978) observed surface water infiltrating directly into the exposed gamma sandstone which has relatively large intergranular permeability; whereas, surface water tends to shed off exposed limestones, which have low permeability. In addition to infiltration into the porous sandstones, infiltration into the subsurface is enhanced by fractures, joints, and faults exposed at the surface, particularly in drainage channels eroded along fracture zones.

Careful examination of water level data by WWC (1997b) during a storm event showed increases in water levels in most of the monitoring wells observed during the pumping test of the Spur production wells located in Township 16N, Range 73W. The change in water levels appeared to be in response to a change in head in the recharge area.

3.3.1 Tritium Data

Tritium is used to age-date groundwater. Tritium dating is based on detecting the existence of tritium produced in atmospheric hydrogen bomb tests in the 1950's and 1960's in a water sample. Dr. Carol Frost and Rachel Toner of the University of Wyoming measured tritium concentrations in Casper aquifer water collected from a variety of domestic and municipal wells in the Laramie area. The presence of tritium indicates that the groundwater was exposed at the surface during the 1950's. These analyses indicate that Casper water withdrawn from the Turner Wellfield and Soldier Springs is young, with most of the water having been recharged within the last 43 years. Water less than 43 years of age was also detected at a domestic well in Sherman Hills Estates (Frost and Toner, 1996).

This research indicates that the well and spring water in the Laramie municipal supply is young, inasmuch as the water being produced from the aquifer was recharged within approximately the last 40 years. This suggests that water travels quickly through the aquifer, making it vulnerable to contamination. It is likely that a contamination event would affect the municipal well supply within a few decades, at most.

4.0 DELINEATION METHODS

Hydrogeologic mapping was used to delineate the protection area for the Casper aquifer. This procedure is often the most appropriate method for aquifer protection, whereas mathematical/analytical procedures are often more appropriate for wellhead protection. The protection area for the Casper aquifer in the Laramie area was based on the review of existing data which allowed the determination of the geologic boundaries of the aquifer and the areas within those boundaries that require different levels of protection.

This section presents a flowchart (Figure 4-1) that describes the decision-making process used to define the aquifer protection area. An aquifer protection area delineation is dependent on three primary factors:

The amount of available information regarding aquifer characteristics;

The accuracy of the existing information; and

The delineation methodology selected and applied in the process.

Known information concerning the Casper aquifer in the Laramie area was reviewed, often by the authors of the original documents, and updated with the most recent information available from mapping, drilling and aquifer testing, both published and unpublished. The aquifer protection area delineation that follows represents the consensus view of the Technical Review Subcommittee as the best representation of the aquifer protection area required for the Casper aquifer. The decision-making process described in Figure 4-1 was used to reach this consensus of opinion.

5.0 DELINEATION PROCESS

The purpose of aquifer protection is to safeguard the public water supplies for both present and future uses. The purpose of the delineation process is to define and map the aquifer protection areas. An aquifer protection area considers the entire groundwater resource including both existing and potential groundwater supply development areas. Within this framework, this section describes the decisions made by the Technical Review Committee to define and map the aquifer protection areas for the Casper aquifer in the Laramie area.

5.1 Fundamental Assumptions

Based on the information presented in Sections 2 and 3, the following were viewed as the fundamental assumptions about the Casper aquifer. The Technical Review Subcommittee reached a unanimous consensus on these issues during the delineation process:

Groundwater flow within the Casper aquifer includes both porous flow (intergranular) and conduit flow (faults, fractures, joints, and dissolution cavities);

The epsilon and delta members of the Casper Formation have higher permeability than the underlying gamma, beta and alpha members;

The Casper aquifer is underlain by the Sherman Granite which acts as an aquitard or aquiclude;

The Casper aquifer is unconfined or semi-confined in most of the outcrop area of the Casper Formation;

The recharge area for the Casper aquifer is the entire exposed outcrop area of the Casper Formation along the western slope of the Laramie Range. Recharge mechanisms for the Casper aquifer include direct infiltration from precipitation and snow melt and infiltration of surface water run-off, particularly in natural drainage channels;

The aquifer generally is confined when covered by the Satanka Shale; and

The lower 50 feet of the Satanka Shale is fractured and in hydraulic connection with the Casper Formation.

Based on these assumptions, the Technical Review Committee agreed on the locations of the current boundaries of the aquifer protection areas and recommended a procedure to be followed when modifying the boundaries in the future.

The aquifer protection delineation discussed below is based on the Technical Review Committees' present understanding of the hydrogeology and extent of the Casper aquifer, its recharge mechanics and the dynamics of groundwater movement between the aquifer and underlying and overlying geologic strata. The current state of hydrogeologic knowledge of the Casper aquifer is limited to available data, and is subject to refinement as new data are collected and become available.

5.2 DELINEATION OF THE EASTERN BOUNDARY

5.2.1 Geologic Considerations

The Sherman Granite crops out high on the east side of the Laramie Mountains. The Casper Formation is exposed on both the eastern and western sides of the summit. Eastward draining springs are located above the exposed granite in the Casper Formation. For these springs to exist, there must be flow in the easterly direction on the east flank of the range.

5.2.2 Hydrologic Considerations

The eastern boundary of the Casper aquifer protection area is located at the topographic divide along the crest of the Laramie Range. This determination is based on the following rationale:

The Sherman Granite serves as a confining layer under the Casper aquifer;

The topographic divide is generally very close to the easternmost outcrop of the Casper Formation, which is the contact between the Casper Formation and the underlying Sherman Granite; and

The topographic divide of the Laramie Range is generally coincident with the groundwater divide based on the presence of springs that discharge along the contact between the Casper Formation and the Sherman Granite. Consequently, groundwater stored in the Casper Formation east of the topographic divide probably flows eastward.

The eastern boundary shown on Plate I is the topographic divide.

5.3 DELINEATION OF THE WESTERN BOUNDARY

The western boundary of the Casper aquifer protection area is located west of the contact between the Satanka and the Casper Formations. The western boundary of the protection area was selected after careful consideration of the effectiveness of the Satanka Shale as a hydrogeologic confining layer over the Casper aquifer.

5.3.1 Geologic Considerations

The Satanka Shale was described in Section 2.0. It is important to note that:

The base of the Satanka Shale is interbedded fractured shale and sandstone;

Both the Casper Formation and the Satanka Shale are locally fractured and faulted due to structural deformation; and

The extent of structural deformation in the Casper Formation and the Satanka Shale is variable both geographically and stratigraphically in the Laramie Basin.

5.3.2 Hydrologic Considerations

The existing hydrogeologic data were evaluated and a determination was made that the Satanka Shale generally acts as a confining layer for the Casper aquifer in the Laramie Basin. While the data distribution is less than ideal and is subject to multiple working hypotheses, the following observations of spring and well data indicate that the lower 50 feet of the Satanka Shale can be permeable and in hydraulic connection with the Casper aquifer.

The water at Simpson Springs flows from the Casper aquifer through approximately 50 feet of fractures in the basal Satanka Shale; and

Water levels measured in T15N, R73W, Section 1 reveal only a small difference in hydraulic head between the Satanka Shale and the Casper Formation.

The Technical Review Committee is concerned that the Casper aquifer may be vulnerable to contamination if 50 feet or less of Satanka lies between the Casper Formation and the ground surface. The Technical Review Committee agreed that at least 75 vertical feet of Satanka Shale (50 percent more than the thickness of the zone of apparent connectivity) is needed to safely and effectively shield the Casper aquifer from contaminants that may be spilled or introduced at or near the ground surface.

The actual location of the western boundary for the protection area is the distance from the Casper-Satanka contact that provides 75 feet of shale cover when the dip of the formation and slope of the ground surface are considered. Figure 5-1 illustrates the procedure to predict the offset of the western boundary from the contact. As the dip in the Satanka becomes greater, the offset distance gets shorter. The stratigraphic remainder of the Satanka Shale is considered to be an effective confining layer above the Casper aquifer.

The western boundary of the protection area is the easternmost edge of the line indicated in Plate I.

5.4 DELINEATION OF THE PRIMARY AND SECONDARY AQUIFER PROTECTION AREAS

The Technical Review Committee agrees that the total outcrop of the Casper Formation should be divided into two subareas, designated as the Primary Protection Area, and the Secondary Protection Area. The Primary Protection Area, owing to its greater natural vulnerability and to the greater number of existing wells, should have a greater degree of protection than the Secondary Protection Area.

The outcrop area of the delta and epsilon sandstone members of the Casper Formation was designated to be the Primary Protection Area based on the following considerations:

The intergranular permeability of the delta and epsilon sandstone members is much greater than the intergranular permeability of the underlying alpha, beta, and gamma members;

There is proximity of outcrops of the delta and epsilon sandstone members of the Casper Formation to the municipal groundwater supply wells for the City of Laramie; and

The primary stratigraphic location of the municipal groundwater supply wells and springs for the City of Laramie are the epsilon and delta members of the Casper Formation.

Because the delta sandstone member is one of the most permeable of the five members, the Technical Review Committee agreed to extend the eastern boundary of the Primary Protection Area 200 feet east of the base of the delta sandstone outcrop. This provides a buffer to prevent contaminants from directly entering the exposed edge of the delta member of the Casper Formation. In those situations in which the 200 foot buffer creates an enclosed or nearly enclosed area of Secondary Protection Area, the entire area will be designated as a Primary Protection Area. The westernmost edge of the line will mark the boundary.

The remainder of the area of outcrop of the Casper Formation, easterly to the topographic divide of the Laramie Range, is designated as the Secondary Aquifer Protection Area.

5.5 NORTH AND SOUTH BOUNDARIES OF THE AQUIFER PROTECTION AREA

The north and south boundaries of the aquifer protection areas have been arbitrarily defined as the extent of the mapped area as shown on Lundy's (1978) geologic base map. As development occurs in these areas, the Aquifer Protection Boundaries should be extended using the same criteria developed above.

6.0 AQUIFER PROTECTION MAP

The Aquifer Protection Map, developed using the procedures outlined in Section 5, is presented as Plate I. Plate I is also presented on the Laramie Regional Drinking Water Protection Program Web page at <lariat.org/Aquifer/index.html>. If discrepancies exist between the Plate and the Web page, the Plate will remain the controlling document.

Plate I shows the limits of both the Primary and Secondary Aquifer Protection Areas. The actual boundary between the two areas is the western side of the line indicated on Plate I.

7.0 DATA SHORTFALLS AND FUTURE RECOMMENDATIONS

7.1 LIMITATIONS OF THE DELINEATION

The delineation of the Aquifer Protection Areas described above is limited to the Casper aquifer. Other aquifers, although significant to local groundwater supplies, are not considered in this delineation report.

Protection area boundaries were established based on the consensus of the Technical Review Committee that examined available reports and data pertinent to the description of the aquifer and the delineation of the contributing recharge area. The Technical Review Committee comprised people with intimate knowledge of the land and water resources of the area, including professionals in the fields of geology, engineering, and earth science.

The northern and southern extents of the Aquifer Protection Area were selected arbitrarily as the limit of the area evaluated by Lundy (1978). As the Laramie Regional Drinking Water Protection Program matures and new sources of water are developed along with review of new hydrogeologic data, areas to the north and south should undergo the same protection as the region outlined in this report.

7.2 SITE SPECIFIC MODIFICATIONS TO THE PLAN

While establishing boundaries for the aquifer protection area, the Technical Review Committee recognized that the location of zone boundaries may be altered in the future as more information becomes available. Site specific changes to the boundaries of the aquifer protection area should only be allowed:

When a site investigation shows significant variation from the assumptions presented herein; and

Based on the recommendations of a qualified water resource professional licensed by the State of Wyoming to practice engineering and/or geology.

In any determination, the criteria established in this report should be consistently applied to any proposed modification to the protected areas.

7.3 REVISING AND UPDATING THE PLAN

The Wyoming Wellhead Protection (WHP) Program Guidance Document requires that a local Wellhead Protection Plan must be updated every two years. Following this guideline, revisions to the Aquifer Protection Areas should be made when new information is available concerning:

- Hydrologic characteristics of the Casper aquifer;
- Changes in water supply, or pumping volumes;
- New potential sources of contamination;
- Changes in land use within the delineated protection areas;
- New management strategy development or implementation;
- Contingency planning and emergency response; and/or
- Planning or developing of new water supplies.

7.4 SPECIAL AREAS OF CONSIDERATION

There are several areas within the delineated zone that require special consideration.

7.4.1 Transportation Corridors

Interstate-80 is located in a particularly vulnerable area of the Casper aquifer. Special contingency planning provisions should be developed to ensure that potential impact to the water supply is minimized in case of vehicular accidents or accidental spills. Similar considerations should be made for railroad lines and pipelines.

7.4.2 The Existing Wellfields

The Turner Wellfield is located adjacent to Grand Avenue. The wells were drilled through the Satanka Shale to the beta member of the Casper Formation. The Satanka Shale comprises layered shale, siltstone and sandstone. It is possible that water could infiltrate into an upper sandstone unit and flow into the well. A safety zone of at least a 100-foot radius should be established around each of the wellheads (based on the Wyoming WHP Guidance Document) to reduce the possibility of this source of contamination.

Pope Springs and Soldier Springs are two naturally occurring artesian springs that are fed, in part, by fracture flow in the lower Satanka Shale. Subsequently, these springs have been developed by construction of wells. A similar safety zone should also be established around each wellhead in the wellfields to preclude accidental contamination of the wells.

Many land and home owners in the area could be impacted by contamination upgradient of their wells. The Laramie Regional Drinking Water Protection Program will help minimize the potential impact of contaminants both on and off of their property. It is recommended that homeowners be educated concerning the importance of avoiding conducting potentially hazardous activities within a 100-foot radius of their private wells. Eliminating septic systems, fertilizer applications, and other chemical releases (e.g., automotive fluids) within 100 feet of wells will serve to protect private water supplies in the area, as well as Laramie's municipal water supply.

7.5 POTENTIAL CONTAMINATION FROM CURRENT LANDHOLDERS IN THE AQUIFER PROTECTION ZONES

The possibility of contamination from current landholders in the protected areas does exist. Potential sources of contamination include nitrates from applied fertilizers, herbicides, pesticides, effluent from septic systems and accidental and/or intentional releases of chemicals. These and other potential sources can be identified during the contaminant inventory conducted as a separate phase of the Laramie Regional Drinking Water Protection Program. It may be reasonable for the City and County to determine the existence of, and lateral extent of, any potential contaminant deemed a viable threat to the city's water supplies.

7.6 PROJECTED LAND USE

It has been assumed that the projected land uses will be similar to current practice (i.e., residential and agricultural). Even light industry is restricted to several distinct locations. Any change to this condition should be evaluated to prevent potential detriment to the aquifer.

Much of the area regarded for protection is currently being subdivided for residential development. In 1997, the Wyoming State Legislature approved legislation that provides for review of planned water supply and sewer systems for proposed new subdivisions by the Department of Environmental Quality (WDEQ) and the Wyoming State Engineer's Office (SEO). The WDEQ and SEO are tasked with reviewing applications submitted though County Commissions to determine the adequacy and safety of the planned systems.

The application process, which is described in a document published by the WDEQ/Water Quality Division, entitled "Wyoming's Subdivision Program, Guidance Document (1998)", should be followed by the Albany County Commission for new subdivisions proposed in the Aquifer Protection Areas.

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CHAPTER 3

DELINEATION REPORT (VERSION 2.0)

Introduction

Drinking Water Protection Programs

National Perspective

Public drinking water supplies have always influenced the location and development of communities by both defining and directing their growth. Historically, the location of a good source of drinking water was a key factor in determining the location of centers of population. Safe drinking water is essential to the quality of community life because of the link between public health and the quality of the public water supply.

Since the 1986 Amendments to the Safe Drinking Water Act, which established the Wellhead Protection (WHP) Program, the United States Environmental Protection Agency (EPA) has supported states and communities in their efforts to protect their sources of drinking water. The EPA Source Water Protection (SWAP) goal is that "by the year 2005, 60 percent of the population served by community water systems will receive their water from systems with SWAP programs in place under both WHP and watershed protection programs" (EPA, 1997).

As part of Wyoming's Source Water Assessment and Protection Program, a source water assessment for Laramie was completed in June 2004 (Trihydro, 2004). The SWAP program is a two-part program consisting of source water assessments and source water protection plans. The groundwater portion of the Laramie source water assessment was derived, in large part, from information provided in this delineation report while the CAPP addresses the groundwater protection plan component. The City is working on developing a protection plan for the surface water supply (Laramie River).

Groundwater protection programs in the United States and Canada all follow a similar five-part program guided by public participation, which includes:

6. Forming a local Drinking Water Protection Committee;

7. Identifying land areas that contribute water to public water supplies;

8. Inventorying existing and future potential sources of contamination;

9. Developing a management program to deal with identified existing and future contaminant sources; and

10. Preparing a contingency plan to address contamination incidents and other water supply emergencies.

This chapter focuses strictly on, “identifying land areas that contribute water to public drinking water supplies”. The delineation of these land areas has been conducted using the broader approach of aquifer protection rather than the more restrictive concept of WHP as explained later in the chapter.

Local Perspective

Although several other Wyoming communities have initiated groundwater protection programs, those communities have relied on outside expertise to develop and implement these programs. In contrast, the Laramie Regional Drinking Water Protection Program (LRDWPP) has adopted a “do-it-yourself” approach, as advocated in Wyoming’s Wellhead Protection Program Guidance Document (Wyoming Department of Environmental Quality, 1998). The LRDWPP utilizes the volunteer efforts of over 25 city and county residents divided into five subcommittees, each assigned a task from the groundwater protection program described above. The subcommittee which delineated the aquifer protection area consists of hydrologists, geoscientists, engineers, and others with technical training and background in groundwater protection. Thus, the Laramie Regional Drinking Water Protection Program is proof that community residents can develop a source water protection plan for a minimal investment.

Approximately 50 percent of the City of Laramie and the South Laramie Water and Sewer District drinking water supplies are derived from wells and springs tapping the Casper aquifer. Many residents who live outside the Laramie municipal area rely on groundwater for 100 percent of their drinking water supplies.

The Casper Formation, which provides water to the City of Laramie and Laramie area residents, is exposed along the west side of the Laramie Range (east of the City of Laramie) and is vulnerable to contamination for the following reasons:

11. Points of withdrawal (municipal and domestic wells) are in proximity to the recharge area;

12. The aquifer is fractured and has extensive exposures of porous sandstones;

13. There are existing areas of residential and commercial development on the recharge area and the potential for additional future development in the recharge area; and

14. Interstate 80 (I-80), across which numerous hazardous substances are transported each day, cuts through the entire thickness of the Casper Formation.

Any aquifer protection program must be responsive to the needs and the development of the local community. For a community to remain viable and support development it must have a safe source of drinking water. As such, the aquifer protection plan is a dynamic document and will be revisited in the future. As new data on the Casper aquifer become available, future committee members may decide to revise the aquifer protection area delineation presented in this report.

History of the Laramie Regional Drinking Water Protection Program

The City of Laramie was successful in obtaining a grant from the EPA in 1993 to develop a WHP Plan. Western Water Consultants, Inc. (WWC) of Laramie developed the initial approach to delineating WHP areas for the City's municipal wellfields at City, Pope, and Soldier Springs. The delineations were based on hydrogeologic mapping and time-of-travel contours defined by major faults and assumed hydraulic behavior of faults and folds (WWC, 1993). The EPA grant required development of a WHP ordinance, and a draft was completed in late 1996 (City of Laramie, 1996). Citizens voiced numerous concerns at that time, based upon (1) the prescriptive nature of the ordinance, (2) the dependence of the 1993 WHPA upon the location of identified faults, and (3) the exclusion of limestone quarries, located within the Casper Formation, from the WHPA.

As a result of citizen concerns and challenges to the proposed WHP ordinance, the Laramie City Council and Albany County Commissioners instructed the Laramie/Albany County Environmental Advisory Committee (EAC) to develop an aquifer protection program consistent with the goals of the LRDWPP for the Casper aquifer. The aquifer protection program provides a higher level of safety for public water supplies because it includes the entire aquifer resource and its users in the vicinity of the City of Laramie, rather than focusing solely on the municipal wellfields.

In 1998 the first delineation of the aquifer protection area was developed by the EAC Technical Review Subcommittee. The subcommittee comprised engineers, geologists, hydrogeologists, and one citizen at large. The subcommittee developed consensus regarding a delineation method and the plan was signed by the Technical Review Subcommittee members on July 25, 1999. The delineation report was presented at a joint work session of the Albany County Commissioners and the Laramie City Council. Both governing bodies gave approval of the delineation through Joint Resolution N. 2000-02 on January 4, 2000, which was desired before work continued on subsequent chapters of the plan. A copy of the resolution is contained in Appendix A.

The delineation chapter was later submitted to the Wyoming Department of Environmental Quality-Water Quality Division (DEQ) for preliminary approval of the delineation methods. DEQ staff stated that three deficiencies in the delineation needed to be addressed. The three deficiencies were:

The lack of a Zone 1 protection area for each supply source;

Clear identification of Zone 2 and Zone 3 protection areas and the basis for the northern and southern boundaries of the protection areas did not comply with the criterion for the WHP Guidance Document; and

The lack of a higher level of protection for faults and other vulnerable features.

This version, Version 2.0, of the delineation report has been prepared in an attempt to meet the requirements of the DEQ and to aid in completing a plan that is both protective of the aquifer and readily implemented. A copy of the first aquifer protection plan delineation report, Version 1.0, is contained in Appendix B in its entirety to preserve the integrity of the initial delineation report.

Geology and Hydrogeology of the Laramie Area

The basic geology of an area is described by the structure and stratigraphy of the rocks. Structure refers to the distribution of rock units on the ground surface and in the subsurface. This distribution is determined by the original processes of rock formation and by later events that move and deform the rock. Stratigraphy refers to the composition and sequence of the rock units. Together, structure and stratigraphy define the framework of the earth materials that control the occurrence and movement of groundwater.

Structural Setting

Regional Setting

The City of Laramie and the wells and springs serving the City are located within the Laramie structural basin. The basin is a broad, north-plunging, asymmetrical syncline that is bounded on the west by the Medicine Bow Mountains, on the east by the Laramie Range and on the south by the Front Range. To the north the Laramie basin is bounded by a series of anticlines rather than by mountain ranges.

Local Setting

The Laramie Range, which bounds the Laramie basin on the east, lies immediately east of the City limits. The range was uplifted by compressional forces during the Laramide orogeny between 75 and 50 million years ago. In the Laramie area, this uplift resulted in generally uniform stratigraphic dips of between 3 and 5 degrees to the west, with the rocks striking nearly north-south. However, the uplift was not entirely uniform and faults and folds locally interrupt the dip regime (Lundy, 1978).

Faults

There are two fault types in the Laramie area. The apparent oldest set of faults is the reverse faults and monoclines, which were associated with the compression and uplift of the Laramie Range. There are also normal faults, with associated folds, which were formed by extensional stress. Lundy (1978) and VerPloeg (1998) have mapped the locations of faults in the Laramie area. Mapping in the Laramie area by VerPloeg is continuing at the present time through the efforts of the Wyoming State Geological Survey.

In most cases, the faults and folds observed in the Casper Formation do not propagate vertically through the entire thickness of the overlying Satanka Shale. Exceptions are the Sherman Hill and Laramie faults, in which offset lithologies indicate shearing through the lower, more brittle part of the Satanka Shale.

Reverse Faults:

The Horse Creek, Red Hills and Laramie Faults are all reverse faults. Lundy (1978) also indicates that the Spur and Pilot Hill monoclines are cored by reverse faults. The reverse faults tend to have north to northwest trends and are steeply dipping. These features were the result of northeasterly compressional stresses (VerPloeg, 1998). The offset along the fault planes range up to 250 feet and most of the faults have upward offset on the west side of the structure (Lundy, 1978). Folding of the sedimentary rocks extends away from the fault plane on the Horse Creek reverse fault a distance of less than 50 feet (Lundy, 1978). The width of the deformation associated with the fault reportedly increases in some areas but no widths are provided.

Normal Faults:

Several major normal faults are mapped in the Laramie area. These faults include the Lincoln, Soldier, Pope, Sherman Hills, Quarry, Jackrabbit, City Springs and Spur faults. These major faults trend northeast to east-west. The faults were probably the result of relaxation of the compressional stresses that formed the reverse faults (VerPloeg, 1998). Numerous minor faults also occur in the Laramie area. Many of these are mapped; however, others may exist but have small displacements and/or are covered by Quaternary alluvial and colluvial deposits. There are no apparent trends in the orientation of the minor faults. The displacement across the normal faults ranges from a few inches to as much as 200 feet (Lundy, 1978), with most of the faults having downward displacement on the south block (VerPloeg, 1998). The dip on the fault plane of the normal faults are steep, ranging from 60 to 80 degrees (Lundy, 1978). Lundy (1978) reports that the rocks adjacent to the faults are folded in zones tens of feet wide and the offsets on the folds are approximately the same as the offset on the faults.

Folds

Folding in the Laramie area predominantly occurs as east-west trending, west-plunging anticlines and monoclines. The Simpson Springs anticline and the Spur Monocline are examples of east-west trending folds in the Laramie area. There are also numerous folds mapped by Lundy (1978) and VerPloeg (2000) that are associated with faults. These structural features include the Horse Creek, Jackrabbit, Soldier and Quarry monoclines.

Specific Structural Features

As early as 1976 the potential role of faults and folds in supplying groundwater to historic springs and municipal wellfields in the Laramie area was recognized (Huntoon, 1976). The occurrence of springs and the large production characteristics at each of the municipal wellfields are believed to be related to a particular fault, fold or fault/fold system. The discussion that follows provides a cursory overview of the faults and folds associated with the historic springs and municipal wellfields in the Laramie area.

The Spur Anticline trends northwest to southeast and has a northwest plunge. Dips on the north side of the anticline range from 30 to 50°, while the dips on the south side vary from 4 to 10° (WWC, 1997). The anticline is cored by a high-angle reverse fault and has a stratigraphic displacement of up to 250 feet (Lundy, 1978). This structural feature was targeted by the City during development of the Spur wellfield.

The City Springs Fault is a normal fault with downward relative displacement on the northwest side of the fault. The fault trends northeast-southwest and has measured stratigraphic displacements of between 20 and 150 feet (Lundy, 1978). The Spur Fault is a northeast-southwest trending normal fault. Displacement along the Spur Fault ranges from 50 to 200 feet, with the downward relative displacement being on the northwest side of the fault (Lundy, 1978). The Spur Fault intercepts the City Springs Fault approximately one-mile northwest of the City Springs. Jackrabbit Fault is an east-west trending fault that grades eastward into a monocline. Downward displacement on the fault is to the south and ranges from 30 to 80 feet (Lundy, 1978). Jackrabbit and City Springs Faults intersect approximately two miles northwest of the City Springs. The Quarry Fault is also an east-west trending normal fault that is mapped as occurring in conjunction with a monocline (Lundy, 1978). The displacement of the fault is downward to the south and has a maximum displacement of 60 feet (Lundy, 1978). The western terminus of the Quarry and City Springs Faults converge in the vicinity of City Springs.

The Pope wellfield is located near the western end of the Pope Fault. The stratigraphic displacement is up on the north side of the fault. The total displacement of the Pope Fault has not been measured.

The Soldier Fault is an east-west trending normal fault that grades into a monocline on its eastern end. The fault has a measured displacement of 40 feet downward on the northern side of the structure (Lundy, 1978).

Stratigraphy

In the Laramie area several geologic units are present. Those units that are of concern include the sequence from the Sherman Granite to the Satanka Shale. The following section provides a summary of these units.

Precambrian Rocks

The Precambrian Sherman Granite is a coarsely-crystalline igneous rock which is predominantly exposed east of the crest of the Laramie Range (Figure 3-2). It was formed by the slow cooling of magma (liquid rock) and is a large mass of interlocking minerals. Other Precambrian rocks in the Laramie area include granite, gneiss, anorthosite and gabbro, which are intruded by the Sherman Granite. These rock types are in contrast to the overlying formations that are layered sedimentary rocks derived from chemical precipitation and deposition of detrital material.

Fountain Formation

The Pennsylvanian Fountain Formation is an irregularly distributed sedimentary unit which is thin (less than 50 feet) to absent in the Laramie area (Lundy, 1978). It is comprised of continental, arkosic sandstone, with minor amounts of siltstone. Where the Fountain Formation is present it unconformably overlies the Precambrian basement rocks. Because the unit is not locally continuous, where it is present, it is grouped with the overlying Casper Formation in this report.

Casper Formation

The Pennsylvanian-Permian Casper Formation unconformably overlies the Fountain Formation, where the Fountain is present or the Precambrian basement rocks where the Fountain is absent. The Casper Formation is comprised of marine and eolian sandstones, interbedded with marine limestone and minor amounts of shale (Figure 3-1). Limestone comprises approximately 15 percent of the formation. The Casper Formation is exposed on the western slope of the Laramie Range, east of the City of Laramie (Figure 3-2). It is approximately 700 feet thick and is informally subdivided from the bottom to the top into five members, designated alpha through epsilon, each of which consists of a sandstone layer bounded at the top by a regionally continuous limestone (Lundy, 1978).

Satanka Shale

The Permian Satanka Shale unconformably overlies the Casper Formation and is predominantly red shale with interbedded siltstone and sandstone layers and is approximately 250 to 320 feet thick in the Laramie area. The lower 20 feet of the Satanka Shale has several thin red and white sandstone beds, which are lithologically similar to the sandstones of the underlying Casper Formation. The Satanka Shale is exposed along the western margin of the Laramie Range, near the eastern corporate limits of the City of Laramie.

Hydrostratigraphy

The term “formation” is used in this report to describe the lithologic materials that comprise the unit. The term “aquifer” is used to describe the water bearing and transmission characteristics of the formation, even where the formation is unsaturated. As listed in the Glossary, an aquifer is “a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells and springs.” This definition can be interpreted to include only the saturated portion of a formation. Figure 3-3 provides a general description of the hydrogeologic role of the formations present in the Laramie area. The following sections provide a detailed description of the hydraulic role of the geologic units in the Laramie area.

Sherman Granite

Unaltered Sherman Granite has practically no intergranular or intercrystalline permeability. Like most crystalline rocks, permeability within the Sherman

Granite is limited to areas where the granite is extensively weathered and/or fractured by faults and joints (Richter, 1981). Groundwater movement within the Sherman Granite is typified by conduit flow. Many domestic wells obtain drinking water from the granite, but well yields are typically small and dependent on the permeability of the fractures. Short-term pump tests of wells completed in the Sherman Granite indicate that the minimum yield is zero, where the rocks are not fractured, and the maximum anticipated yield is approximately 20 gallons per minute in weathered or fractured granite (WSEO Records, various).

To date, there has not been a systematic study of the hydrogeology of the Sherman Granite and its hydraulic relationship to the overlying Casper aquifer. Because of the much lower permeability and limited storage capacity of fractures in the Sherman Granite compared to the sandstones of the Casper Formation, the Sherman Granite is treated here as a confining unit below the Casper aquifer.

However, if faults in the Casper Formation are continuous between the two units, there may be some hydraulic connection between them. Preliminary chemical analyses of strontium concentrations and isotopic ratios from groundwaters within the Casper aquifer suggest there may be some mixing of groundwaters of the Sherman Granite and the Casper aquifer (Frost and Toner, 1996). It is believed that any hydraulic contribution from the Sherman Granite to the Casper aquifer is minor due to the impermeable nature of the unfractured crystalline rock and the limited storage capacity of fractures where they occur in the granite. Therefore, the Sherman Granite is characterized as an aquitard or aquiclude (see Glossary).

Satanka Shale

The hydraulic relationship between the Satanka Shale and the underlying Casper aquifer is a critical element in the delineation of a protection area for the Casper aquifer. The hydrogeology of the Satanka Shale has not been studied in detail, but observations made during studies of the Casper aquifer provide some data regarding the hydraulic relationship between the Satanka Shale and the underlying Casper aquifer (Lundy, 1978; Huntoon and Lundy, 1979; WWC, 1993, 1994, 1997a,b; and Weston, 1995).

Taken in its entirety, the Satanka Shale is a regional confining layer overlying the Casper aquifer. However, permeable sandstones in the Satanka Shale provide water to many domestic and stock wells in the Laramie area. Approximately 300 feet of interbedded shale, siltstone and sandstone isolates the Casper aquifer from overlying aquifers, including permeable beds within the Satanka Shale.

The hydraulic head in the Casper aquifer is typically 20 to 40 feet greater than the head in the permeable layers within the Satanka Shale. The Casper aquifer is confined where overlain by a sufficient thickness of the Satanka Shale (JMM, 1989; WWC 1993, 1994, 1997a,b; and Weston, 1995). Hydraulic separation between the Casper aquifer and permeable layers in the Satanka Shale has been documented during pumping tests conducted at the Spur Wellfield, LaPrele Park Prospect and the Turner Wellfield, where no observable head declines occurred in the monitored intervals in the Satanka Shale as the Casper aquifer was pumped (WWC, 1993, 1996, 1997a,b).

Important for the Laramie Regional Drinking Water Protection Program is the fact that interconnected fractures in the lower 50 feet of the Satanka Shale can be permeable. In contrast to the observations above, there are some localities where groundwater from the Casper aquifer has been observed to flow upward into the lower 50 feet of the Satanka Shale at Simpson, Soldier and Pope Springs (Plate I). Consequently, it is assumed that the lower 50 feet of the Satanka Shale is in hydraulic communication with the Casper aquifer.

Casper Aquifer

The Casper aquifer is the hydrogeologic unit that supplies water to the wells and springs utilized by the City of Laramie as a drinking water resource. The Sherman Granite provides an effective lower confining layer for the Casper aquifer and the low permeability shales of the Satanka Shale provide an effective upper confining layer, where there is a sufficient thickness. The permeabilities within the Casper sandstones are very large in contrast to the overlying and underlying geologic unit. The Casper aquifer is bounded above and below by effective confining units and is the sole source of groundwater for the wells and springs. The discussion of the hydrogeology of the Casper aquifer is expanded in the following sections.

Extent of the Aquifer

The Casper aquifer is those parts of the Casper Formation that are fully saturated with water. As shown in Figure 3-4 the upper part of the Casper Formation is unsaturated on the west slope of the Laramie Range. The unsaturated thickness of the Casper Formation generally decreases from east to west. While the entire thickness of the Casper is not saturated except where it is confined by the Satanka Shale there is some thickness of the Casper Formation that is saturated throughout the majority of the outcrop. The aquifer therefore extends from the crest of the Laramie Range to the east into the Laramie basin. While the aquifer is present throughout the Laramie basin, for the purposes of this protection program the western edge of the aquifer is presumed to be coincident with the 1,000 milligrams per liter (mg/L) Total Dissolved Solids (TDS) contour mapped by Richter (1981). In the vicinity of Laramie, this contour is approximately nine miles west of the city limits. This proposed western boundary is established because water with a TDS greater than 1,000 mg/L is not suitable for municipal use and provides a reasonable boundary for the aquifer. The Casper aquifer extends approximately 50 miles north-northwest of Laramie before it is interrupted by a thrust fault. To the south of Laramie, the Casper aquifer extends past the Wyoming-Colorado border, a distance of at least 21 miles.

Depth and Saturated Thickness of Aquifer

The Casper Formation crops out from the crest of the Laramie Range west to where it is covered by the overlying Satanka Shale. In the vicinity of Laramie the outcrop is approximately four to five miles wide from east to west (see Plate 1). Assuming an average dip of 4°, the estimated depth to the top of the Casper aquifer near the western city limits of Laramie is approximately 1,500 feet.

The saturated thickness of the Casper aquifer varies significantly throughout the aquifer. Generally the saturated part of the aquifer is relatively thin at the crest of the Laramie Range and gradually thickens westward towards the contact of the Casper and Satanka. The minimum saturated thickness is nearly zero along the crest of the Laramie Range and the maximum saturated thickness is 600 feet immediately west of the Casper-Satanka contact according to Thompson (1979) and 700 feet thick near the Spur wellfield according to WWC (1997). However, the deep canyons and elevated regions along the flank of the Laramie Range result in irregular saturated thicknesses in the aquifer. An isopach map of the saturated thickness and depth to water in the Casper aquifer is available for review in the Albany County Planning Office in the County Courthouse. The map was created from readily available data. There is a paucity of data available because of a low spatial concentration of wells and because the hydraulic head in the wells has not been measured at the same time. As funding becomes available, it is anticipated that measurements will be taken from the wells and the maps will be updated.

Media Type and Groundwater Flow Characterization

The Casper aquifer is comprised of two media types; porous sandstone and fractured sandstone and limestone. Flow within these materials includes both porous and conduit flow. Porous flow occurs within the unfractured, permeable sandstones of the Casper aquifer. Conduit flow occurs within both the sandstones and limestones where the permeabilities has been enhanced by fractures and/or dissolution.

The intergranular permeability of the sandstones that comprise the five members of the Casper Formation is variable, with the greatest permeability occurring in the epsilon and delta members and the lowest permeability in the alpha member. The variation is due to the greater abundance of very fine sand, silt and calcite cement that fill the pore spaces in the lower sandstone members. Intergranular permeability is responsible for providing water to wells on the order of 1 to 100 gallons per minute (gpm).

Conduit flow refers to the flow of water through cavities or fractures associated with dissolution, faults, folds, joints, and partings along bedding planes. Conduit flow is typically orders of magnitude greater than intergranular permeability and is capable of yielding large quantities of water to wells, as demonstrated by the Laramie municipal water supply wells and associated springs. Production from the municipal wells that penetrate the fractured aquifer is on the order of 1,500 to 2,500 gpm. These high-yield wells tap fractures associated with faults and folds that have deformed the Casper Formation. At the Spur and Turner wellfields, where the rocks have been extensively fractured, the upper and lower members of the Casper Formation are hydraulically connected with each other through the fracture network.

Porosity

The intergranular porosity of the rocks comprising the Casper aquifer varies significantly. Lundy (1978) reports that the porosity of the well-cemented sandstones are approximately 22 percent, while the porosity of the epsilon sandstone ranges from 15 to 30 percent. The average porosity of the sandstones is 19 percent according to Lundy (1978). No porosity values are available for the limestones within the Casper aquifer. The porosity is extremely low where the limestones are not fractured but secondary porosity does exist where they are fractured. WWC (1993) estimates that the average effective porosity of the fractures within the Casper Formation is 0.02 percent.

Hydraulic Conductivity, Transmissivity, and Storativity

Pump testing of wells completed in the Casper aquifer in the Laramie area demonstrates that there are significant variations in the permeabilities of the sandstones comprising the Casper aquifer. Lundy (1978) indicates that the hydraulic conductivity of the epsilon member ranges from 1.3 to 2.6 feet per day (transmissivity= 600 to 970 gallons per day per foot (gpd/ft)) and the hydraulic conductivity of the gamma member is approximately 1.5 feet per day (transmissivity= 435 gpd/ft). The hydraulic conductivity of the aggregate members alpha through epsilon ranges from 0.21 to 0.32 feet per day (transmissivity= 900 to 1,390 gpd/ft) and of the aggregate members gamma through epsilon ranges from 0.11 to 0.13 feet per day (transmissivity= 315 to 375 gpd/ft).

The most striking variation in permeabilities within the Casper aquifer are observed when comparing fractured versus unfractured aquifer media. The hydraulic conductivity of the Casper aquifer where unfractured ranges from 0.10 to 2.6 feet per day (transmissivity= 135 to 970 gpd/ft). Where the aquifer is fractured the hydraulic conductivity ranges from 17 to 40 feet per day (transmissivity= 8.23 x 104 to 1.95 x 105 gpd/ft) (Lundy, 1978).

Testing of the Spur Wells by WWC (1997) indicated that the transmissivity of the Casper aquifer varied significantly in relatively small distances. The transmissivity varied from 1.4 x 105 to 6.4 x 105 gpd/ft. All of the reported transmissivities were calculated from drawdowns in monitoring wells located close to the Spur anticline. Pump tests conducted on the Turner Well No. 41T1 yielded a hydraulic conductivity of 14 feet per day (transmissivity = 6.81 x 104 gpd/ft) (WWC, 1993). In both the Spur and Turner well testing events, the drawdown was shown to be highly anisotropic, with the greatest drawdown occurring parallel to the geologic structure. The testing indicates that the greatest permeability occurs along the structure and that the permeability decreases significantly short distances from the structure.

Storage coefficients for the Casper aquifer are highly variable. Those reported by Lundy (1978) range from 0.001 to 0.006, which indicates the aquifer is confined to slightly leaky. Pump test data at the Spur wellfield indicate that the storage coefficient varies from 0.01 to 0.0091 (WWC, 1997). However, the storage coefficient for the wells changed significantly with time during pumping, which may be the result of the effects of partial penetration or from varying degrees of interconnection via fracture systems. A storage coefficient was calculated by WWC from barometric efficiency data collected from the Spur wellfield. The resulting storage coefficient was 5 x 10-4, which indicates that the aquifer is confined at that location (WWC, 1997). The fact that the static water level in the Spur wells is significantly above the top of the Casper Formation also provides evidence that the aquifer is confined at that location.

Specific permeability enhancements associated with all of the faults and folds in the Casper aquifer shown on Plate I cannot be determined with certainty; some structures may enhance aquifer permeability while others may reduce permeability. Although the effects that each structure has on aquifer permeability are not known, it is important to recognize the hydraulic complexity imparted to the Casper aquifer by geologic structures such as faults and folds.

Recharge

Recharge refers to the replenishment of the Casper aquifer by the infiltration of water derived from rainfall and snowmelt through the unsaturated zone. This process occurs to some degree wherever the Casper Formation is exposed at the surface. Consequently, the entire surface exposure of the Casper Formation is assumed to be the recharge area for the Casper aquifer.

Lundy (1978) observed surface water infiltrating directly into the exposed gamma sandstone which has relatively large intergranular permeability; whereas, surface water tends to shed off exposed limestones, which generally have low permeability. In addition to infiltration into the porous sandstones, infiltration into the subsurface is enhanced by fractures, joints and faults exposed at the surface, particularly in drainage channels eroded along fracture zones. It is assumed that the vast majority of recharge to the Casper Formation occurs in drainages. Lundy (1978) indicates that recharge primarily occurs during the months of March through August, during which time spring runoff and summer storms occur. The average annual recharge to the Casper aquifer is estimated to be 1.4 inches per year (Lundy, 1978). However, the annual recharge is highly variable. Recharge to the Casper aquifer during the winter of 1983-1984, which was a documented El Nino year, was the greatest magnitude on record. The water levels in the Huntoon #1 monitoring well increased by 21 feet. The spring snowfall in 1984 was significantly greater than average and melted slowly, which maximized infiltration of the snowmelt. The hydrograph of the Huntoon #1 monitoring well, which was included in the 1941 Turner Well No. 2 Evaluation Report (WWC, 1996) indicates that the average spring recharge raises the water level in the Casper aquifer by approximately one foot.

Careful examination of water level data by WWC (1997) during a violent summer storm showed temporary increases in water levels in most of the monitoring wells observed during the pumping test of the Spur production wells located in Township 16 North, Range 73 West. The change in water levels was rapidly dissipated and the drawdown in the wells quickly returned to the pre-storm levels. The transient event had no long-term effects on water levels in the aquifer, which may indicate that summer storm events do not contribute significantly to recharge of the Casper aquifer.

In an effort to provide relative ages of groundwater contained within the Casper aquifer, Dr. Carol Frost and Rachel Toner collected samples from the Casper aquifer from a number of wells and springs in the Laramie area for tritium analyses (Toner, 1999). Tritium is often used to obtain relative age of groundwater and is a hydrogen isotope that was created in large quantities in the 1950's and 1960's as a result of above-ground testing of nuclear weapons. Tritium has a short half-life and has not been produced in large quantities since above-ground nuclear weapons testing was discontinued in the 1960's. Thus, the presence of tritium in groundwater samples indicates that the groundwater was exposed at the surface subsequent to the 1950's. The analyses do not provide the means of determining the exact age of a water sample; but rather provide a maximum potential age of the water, if tritium is detected.

The analyses of water samples collected by Toner detected the presence of tritium in samples collected from sites east of Third Street. This indicates that the groundwater in the Casper aquifer east of Third Street has been recharged within the past several decades. Water collected from the Wyoming Research Institute (WRI) Casper well, located west of Third Street, had no detectable tritium which indicates that the water withdrawn from the WRI well was recharged prior to the 1950's.

Hydraulic Gradient

Published potentiometric surface maps indicate that groundwater in the Casper aquifer in the vicinity of Laramie generally flows from east to west, from areas of high elevation at the crest of the Laramie Range toward lower elevations within the Laramie basin (Lundy, 1978; Thompson, 1979; WWC, 1993 and 1997). The gradient has a slight northwesterly component between Simpson Springs and City Springs according to the potentiometric map created by Thompson (1979) and is altered locally to a more radial pattern in the vicinity of the City's municipal wellfields and the springs, which discharge large quantities of water from the Casper aquifer. Flow patterns are also locally altered to some degree by the permeability imparted by fracturing associated with some faults and folds.

The hydraulic gradient ranges from a high of approximately 400 feet per mile where the aquifer is unsaturated to 25 feet per mile where the aquifer is fully saturated and confined by the overlying Satanka Shale (Lundy, 1978).

Confining Conditions

East of where the Casper Formation is fully saturated, the exposed sandstone units may be confined or unconfined depending on their location, as shown in Figure 3-4. The limestones that separate the sandstones have negligible permeabilities and serve as local confining layers that define subaquifers within the Casper aquifer. Therefore, the informal members, designated in descending order (epsilon, delta, gamma, beta, and alpha), comprise subaquifers within the Casper aquifer (Figure 3-2). However, the confining ability of the limestones may be compromised where fractures from faults and folds have created hydraulic connection between the members (WWC, 1993 and 1997).

Regionally, the Satanka Shale serves as the upper confining bed for the Casper aquifer. The lower 50 feet of the Satanka Shale is comprised of well-cemented sandstone beds. The brittle nature of that interval and the lithologic similarity to the underlying Casper Formation results in some mixing of groundwater from those units, especially in fractured areas. Where the Satanka Shale has thicknesses greater than 50 feet, shaley strata provide confinement, with the degree of confinement increasing with greater thicknesses of the Satanka Shale. Evidence of confinement includes the discharge of large quantities of water at Simpson, Soldier, Pope and City Springs. Additionally, differences in hydraulic head of up to 30 feet were observed at the Spur Wellfield, with the head in the Casper aquifer being greater than the head in the Satanka Shale (WWC, 1997).

Vulnerable Features

Several features found within the Casper Formation in the Laramie area render it potentially vulnerable to contamination at the ground surface. Throughout much of the surface area of the Casper Formation protection is provided for the aquifer by either overlying soils, low permeability limestones, several tens to hundreds of feet of unsaturated rocks and/or low permeability shale. Features that cause weakness for possible natural protection include: faults, folds, fractures, shallow depths to groundwater and drainages. The basis for consideration of these features as potentially vulnerable features is included in the following paragraphs.

Faults

Faults are fractures or fracture zones along which displacement of strata has occurred. If the displacement has resulted in either breaches in confining beds and/or development of large secondary permeability, then the aquifer may be more vulnerable to contamination than in unfaulted areas. Where the faults intercept the ground surface and have large apertures there is the potential for rapid infiltration of surface water into the aquifer. This rapid infiltration, in turn, has the potential for rapid contamination of the aquifer. Kleinfelder (1996) indicates that the aperture of fractures must be greater than one centimeter for rapid movement of groundwater to occur. The potential for contamination of the aquifer as a result of rapid infiltration is magnified in areas where groundwater is shallow.

While faults are typically mapped as a single line they frequently do not occur as a discrete feature. Fractures extend variable distances from the major fault trace. WWC (1993) reports that at some faults the fracture zone extends less than 10 feet from the fault trace, while other faults have associated fractures extending 50 to 150 feet from the fault trace.

Folds

Folds are bends in the bedding of rocks that result from ductile deformation. Folds found in the Laramie area include anticlines, synclines and monoclines. In many folds, fractures are developed in brittle or competent rocks. These fractures usually occur along the crest of the fold and have the potential for transmitting large quantities of water. Where these fractures extend to the ground surface there is the potential for rapid transmission of contaminants. As with faults, the potential for contamination along the crests of folds is magnified where groundwater occurs at a shallow depth.

Exposed Bedrock

Exposed bedrock that comprises an aquifer serving a public water system is generally more vulnerable to contamination than the same materials buried at a depth. Burial of the aquifer materials provides the opportunity for some degree of mitigation of potential contaminants prior to the contaminants entering the aquifer. In some locations sufficient thicknesses of low-permeability materials effectively prevent the downward migration of contaminants into the aquifer.

Drainages

Drainages are the site of most of the recharge occurring to the Casper aquifer east of Laramie. Water tends to shed off of the low-permeability limestones that cover the majority of the land surface along the western flank of the Laramie Range. The water drains off the limestones and collects in drainages. As the runoff flows through the drainages, rapid recharge occurs as the water crosses permeable sandstones and/or fractures. Where rapid recharge occurs, rapid contamination can also occur.

Shallow Depth to Groundwater

Areas where the depth to groundwater is relatively shallow are also potentially vulnerable to contamination. With all other factors being equal, there is the potential for greater natural remediation where the depth to groundwater is deep. Areas where groundwater is close to the ground surface have the potential, where no confining layer is present, for rapid transport of contaminants from spills of hazardous substances.

More detailed information regarding the geology and hydrogeology of the Casper aquifer may be obtained from Morgan (1947), Huntoon (1976), Lundy (1978), Huntoon and Lundy (1979), Thompson (1979), WWC (1993, 1994, and 1997a,b) and Ver Ploeg (1996).

Well Data

Well data, as required by the Wyoming WHP Guidance Document, are provided in Table 3-1. The data are derived from City of Laramie Public Works Department files and from the well construction reports.

Pump Data

Pump data for the Laramie municipal wells, as required by the Wyoming WHP Guidance Document, are provided in Table 3-2. The data were gathered from City of Laramie Public Works Department Files and from well construction reports.

Delineation Methods

The Wyoming WHP guidance document, which was used to determine appropriate delineation methods for this plan, requires that three different protection areas be established. The protection areas are labeled Zones 1, 2, and 3 as shown on Figure 3-5.

Zone 1 protection areas are to be established around each of the water supply sources. The purpose of the Zone 1, or Accident Prevention Zone, is to prevent the accidental introduction of contaminants into the aquifer in the immediate vicinity of the well. The Wyoming WHP Guidance Document indicates that the Zone 1 protection area is to be an arbitrary fixed radius of 50 or 100 feet, depending upon well completion and vulnerability to contamination. However, these radii are minimum distances and can be increased to provide additional protection if necessary.

Zones 2 and 3 are entitled the Attenuation and Remedial Action Zones, respectively. The purpose of Zone 2 is to protect the well from contact with pathogenic microorganisms and to allow for remediation or clean up of a spill that may occur in the vicinity of the wellhead. Zone 2 is typically based on a 2-year time of travel. The purpose of Zone 3 is to protect the aquifer from contaminants that may migrate to the well and to allow time for remediation of the contaminant or replacement of the water resource. Zone 3 is typically based on a 5-year time of travel. For the Casper aquifer near Laramie, times of travel were not used to delineate the protection areas.

Where the aquifer yielding water to wells and springs is characterized by fracture or conduit flow, the Zone 3 delineation is delineated before Zone 2 and is defined by flow system boundaries. Hydrogeologic mapping is used to identify those parts of the aquifer that might reasonably be expected to yield water to the municipal wells. After creating Zone 3, vulnerability mapping was used to delineate Zone 2. The Zone 2 delineation identifies those areas that are particularly vulnerable to contamination within the larger area delineated by hydrogeologic mapping.

The Casper aquifer in the Laramie area is an anisotropic, fractured sandstone and limestone aquifer that has no apparent hydrogeologic or flow boundaries between wellfields, and has the potential for rapid transport of groundwater over large distances. These factors, combined with a lack of data and the extreme expense of gaining appropriate data, limits the ability to utilize numerical or semi-analytical delineation methods for creating protection areas based on times of travel (EPA, 1991). To delineate protection areas for the Casper aquifer, hydrogeologic and vulnerability mapping was used.

The protection area for the Casper aquifer in the Laramie area was based on the review of existing data which allowed for the determination of the geologic boundaries of the aquifer and the areas within those boundaries that require different levels of protection. The aquifer protection area delineation is dependent on three primary factors:

The amount of available information regarding aquifer characteristics;

The accuracy of the existing information; and

The delineation methodology selected and applied in the process.

Published information concerning the Casper aquifer in the Laramie area was reviewed, often by the authors of the original documents, and updated with the most recent published and unpublished information available from mapping, drilling and aquifer testing. The aquifer protection area delineation that follows represents the consensus view of the Technical Review Subcommittee as the best representation of the aquifer protection area required for the Casper aquifer.

Delineation Process

The purpose of aquifer protection is to safeguard the public water supplies for both present and future uses. The purpose of the delineation process is to define and map the aquifer protection areas. An aquifer protection area considers the entire groundwater resource, including both existing and potential groundwater supply development areas. Within this framework, this section describes the decisions made by the EAC Technical Review

Subcommittee to define and map the aquifer protection areas for the Casper aquifer in the Laramie area.

Fundamental Findings

Based on the information presented above, the following characteristics were viewed as the fundamental conclusions regarding the Casper aquifer. The Technical Review Subcommittee reached agreement on these issues during the original delineation process:

15. Groundwater flow within the Casper aquifer includes both porous flow (intergranular) and conduit flow (faults, fractures, joints and dissolution cavities);

16. The epsilon and delta members of the Casper Formation have higher primary permeability than the underlying gamma, beta and alpha members;

17. Fractures associated with faults, folds and bedding planes dramatically enhance the permeability of the sandstones and limestones of the Casper aquifer;

18. The Casper aquifer is underlain by the Sherman Granite which acts as an aquitard or aquiclude;

19. The Casper aquifer is unconfined or semi-confined in most of the outcrop area of the Casper Formation;

20. The recharge area for the Casper aquifer is the entire exposed outcrop area of the Casper Formation along the western slope of the Laramie Range. Recharge mechanisms for the Casper aquifer include direct infiltration from precipitation and snow melt and infiltration of surface water run-off, particularly in natural drainage channels;

21. The aquifer generally is confined when covered by the Satanka Shale; and

22. The lower 50 feet of the Satanka Shale is fractured and in hydraulic connection with the Casper Formation.

Based on the above criteria, the Technical Review Subcommittee agreed on the locations of the east and west boundaries of the Zone 2 and 3 aquifer protection areas. The effort undertaken by the Technical Review Subcommittee in the time frame 2000 to 2002 added a delineation of the north and south boundaries of the Zone 2 and 3 protection areas, Zone 1 delineations for each of the city of Laramie groundwater supply sources, and provisions for conducting site-specific delineations.

The aquifer protection delineation discussed below is based on the Technical Review Subcommittee's present understanding of the hydrogeology and extent of the Casper aquifer, its recharge mechanics and the dynamics of groundwater movement between the aquifer and underlying and overlying geologic strata. The current state of hydrogeologic knowledge of the Casper aquifer is limited to available data and is subject to refinement as new data are collected and become available.

Zone 1 Protection Area

Many of the municipal wells serving the City of Laramie are drilled in the immediate vicinity of springs. The springs are located at topographic lows where the potentiometric surface of the Casper aquifer intersects topography or where weaknesses in the confining layer are breached and groundwater from the Casper aquifer can move up through the overlying Satanka Shale to the ground surface. At many locations the springs are not distinct, but are visible as large, wet grassy areas. When the wells are not pumped for extended periods of time the springs flow; however, when the municipal wells are pumped and the cone of depression associated with pumping propagates to the springs a reversal of gradient occurs and the springs cease to flow. When the reversal of gradient occurs groundwater moves from the spring site to the well. Additionally, any contaminants introduced in the immediate vicinity of the springs can follow the same pathway as the groundwater and be pumped by the well into the municipal water system. To adequately protect the wells that provide drinking water to the City of Laramie the Zone 1 protection areas were created to be large enough to encompass the springs that are in the immediate vicinity of the wells. The delineation procedures followed for each of the water supply sources are described below.

Spur Wellfield

The Zone 1 protection areas for the Spur Wells have each been established as 100-foot radii around each well. The radii have been assigned to conservatively protect the aquifer in the vicinity of the wellheads, where the Casper aquifer occurs at a shallow depth.

Turner Wellfield

The Zone 1 protection area for the Turner wellfield was completed through field mapping. A Global Positioning Satellite (GPS) receiver was used to map the depression associated with the location of the historic City Springs location, the locations of the spring boxes at the site that are dug into the Casper aquifer and the Turner wells. A 100-foot buffer was then drawn around each of the mapped features and the resulting polygons were then combined where overlap occurred.

Pope Wellfield

The Zone 1 protection areas for the Pope wellfield was also completed using mapping with a GPS unit. The now-abandoned cistern, which was constructed over the Pope Springs was mapped and a 100-foot buffer was created around that feature. Each of the four wells comprising the Pope wellfield has also been assigned a 100-foot radius for the Zone 1 protection area. The protection areas for the wells and cistern do not overlap; however, the five delineated zones comprise the protection area for the wellfield.

Soldier Wellfield

The Zone 1 protection area for the Soldier wellfield was completed through field mapping. A GPS receiver was used to map the depression associated with the location of the historic Soldier Springs location and the Soldier well. A 100-foot buffer was then drawn around the edge of the depression and the water supply well.

The locations of the Zone 1 protection areas are depicted in Figure 3-6.

Delineation of the Eastern Boundary of Zone 3

The eastern boundary of the Casper aquifer protection area is located at the topographic divide along the crest of the Laramie Range. This determination is based on the following rationale:

23. The Sherman Granite serves as a confining layer under the Casper aquifer;

24. The topographic divide is generally very close to the easternmost outcrop of the Casper Formation, which is the contact between the Casper Formation and the underlying Sherman Granite; and

25. The topographic divide of the Laramie Range is generally coincident with the groundwater divide based on the presence of springs that discharge along the contact between the Casper Formation and the Sherman Granite. Consequently, groundwater stored in the Casper Formation east of the topographic divide probably flows eastward.

The eastern boundary shown on Plate I is the topographic divide on the crest of the Laramie Range.

Delineation of the Western Boundary of Zone 3

The western boundary of the Casper aquifer protection area is located west of the contact between the Satanka and the Casper Formations. The western boundary of the protection area was selected after careful consideration of the effectiveness of the Satanka Shale as a hydrogeologic confining layer over the Casper aquifer.

The existing hydrogeologic data were evaluated and a determination was made that the Satanka Shale generally acts as a confining layer for the Casper aquifer in the Laramie area. While the data distribution is less than ideal, the following observations of spring and well data indicate that the lower 50 feet of the Satanka Shale can be permeable and in hydraulic connection with the Casper aquifer.

26. The base of the Satanka Shale is composed of interbedded fractured shale and sandstone;

27. The water at Simpson Springs flows from the Casper aquifer through approximately 50 feet of fractures in the basal Satanka Shale; and

28. Water levels measured in Section 1, Township 15 North, Range 73 West reveal only a small difference in hydraulic head between the Satanka Shale and the Casper Formation.

Based on the above data, the Technical Review Subcommittee believes that the Casper aquifer may be vulnerable to contamination if 50 feet or less of Satanka lies between the Casper Formation and the ground surface. The Technical Review Subcommittee agreed that at least 75 vertical feet of Satanka Shale (50 percent more than the thickness of the zone of apparent connectivity) is needed to safely and effectively shield the Casper aquifer from contaminants that may be spilled or introduced at or near the ground surface.

The actual location of the western boundary for the protection area is the distance from the Casper-Satanka contact that provides 75 feet of Satanka shale cover when the dip of the formation and slope of the ground surface are considered. Figure 3-7 illustrates the procedure to predict the offset of the western boundary from the contact. As the dip in the Satanka becomes greater, the offset distance gets shorter. The stratigraphic remainder of the Satanka Shale is considered to be an effective confining layer above the Casper aquifer.

The western boundary of the protection area is the easternmost edge of the line indicated in Plate I.

Delineation of the North and South Boundaries of Zone 3

South Boundary

The southern boundary of Zones 2 and 3 extends from the intersection of the western Zone 2 boundary and the Simpson Springs anticline, as mapped by Ver Ploeg (1999). The boundary then follows the crest of the anticline to the mapped eastern limit of the anticline then proceeds due east to the crest of the Laramie Range, which is the eastern boundary of Zone 3.

The reasoning for the placement of the southern boundary is as follows:

The springs along the base of the west flank of the Laramie Range, including City Springs, Pope Springs, Soldier Springs, Simpson Springs and others further south, are the surface manifestations of the intersections of east-west trending structural features and a confining bed. The geologic structures contain fractures that allow for the rapid transmission of water downgradient to the point where the water level in the Casper aquifer intersects a confining layer and the aquifer is full (i.e. the potentiometric surface intersects the ground surface). The elevations of the springs increase to the south, with the City Springs being lowest in elevation. This means that the entire Casper aquifer south of the City Springs has the potential to contribute water to City Springs. However, the southern springs, which are higher in elevation, do not cease flowing during the year and we do not observe a draining of the aquifer from south to north, which would indicate that the groundwater is flowing north. While there is not a flow system boundary in the Casper aquifer between any of the springs, there is a significant difference in permeability in the rocks that contribute water to the springs, such that the non-fractured rocks have permeabilities that are orders of magnitude less than the fractured rocks. It has long been asserted that the faults and folds in the Casper aquifer act as “collectors” of groundwater. Groundwater flowing downgradient through the low-permeability rocks that encounters the fractured rocks preferentially moves downgradient in the fracture system and is discharged at the springs. A small quantity of water may cross the fractured zones, but the vast majority of the water is discharged at the springs. As such, the east-west trending structures that feed water into springs act as localized hydrogeologic boundaries.

The boundary is provided on Plate 1.

North Boundary

The reasoning for the placement of the northern boundary is as follows:

Pump testing of the Spur wells indicates that the majority of the water is derived from the Casper aquifer from fractures along the crest of the Spur

Anticline (WWC, 1997). Aquifer parameters determined from observation wells indicates that the transmissivity of the aquifer between the Spur wells and observation well C-105 is approximately 4.32 x 105 gallons per day per foot, which is extremely high. The data also indicates that the aquifer between the two wells is confined to leaky. Geologic mapping of the area north of the Spur wells indicates the presence of small faults that trend east-west, but there are no surface discharges to indicate the aquifer is highly transmissive along the faults. Therefore, it appears that the aquifer is relatively isotropic north of the Spur wells.

Using the WHPA model (Blandford, Huyakorn, and Wu, 1991), with inputs of: the above transmissivity, confined conditions, aquifer thickness of 700 feet, porosity of 15%, hydraulic gradient of 0.001, long-term pumping rate of 975 gpm, model run time of 5 years, and direction of flow from the north, the result is a capture zone that extends approximately 3,200 feet north of the wells. This capture zone represents a worst-case scenario because it assumes that all of the water is being derived from the north and ignores the contribution of water from the Spur Anticline. Extending the boundary to a point 4,800 feet north of Spur Well No. 2 provides for a 50 percent factor of safety.

The northern boundary is depicted on Plate 1.

Delineation of the Primary and Secondary Protection Areas

The Technical Review Subcommittee agreed that the total outcrop of the Casper Formation should be divided into two sub-areas, designated as the Primary Protection Area and the Secondary Protection Area. The Primary Protection Area, owing to its greater natural vulnerability and to the greater number of existing wells, should have a greater degree of protection than the Secondary Protection Area. The Primary Protection Area is equivalent to Zone 2 of the WHP Guidance Document and the Secondary Protection Area corresponds to Zone 3 for the same document.

The outcrop area of the delta and epsilon sandstone members of the Casper Formation was designated to be the Primary Protection Area (Zone 2) based on the following considerations:

29. The intergranular permeability of the delta and epsilon sandstone members is greater than the intergranular permeability of the underlying alpha, beta and gamma members;

30. The shallower depth to groundwater near the western edge of the Casper outcrop;

31.There is proximity of outcrops of the delta and epsilon sandstone members of the Casper Formation to the municipal groundwater supply wells for the City of Laramie; and

32. The primary stratigraphic location of the municipal groundwater supply wells and springs for the City of Laramie are the epsilon and delta members of the Casper Formation.

Because the delta sandstone member is one of the most permeable of the five members, the Technical Review Subcommittee agreed to extend the eastern boundary of the Primary Protection Area 200 feet east of the base of the delta sandstone outcrop. This provides a buffer to prevent contaminants from directly entering the exposed edge of the delta member of the Casper Formation. In those situations in which the 200-foot buffer creates an enclosed or nearly enclosed area of Secondary Protection Area, the entire area will be designated as Zone 2 or the Primary Protection Area. The westernmost edge of the line will mark the boundary.

All faults in the recharge area were not included in Zone 2 because not all faults are of the same potential hazard to city wells. There are other features, such as exposed sandstone, that are of a more immediate concern. Including every known fault into Zone 2 would be unnecessarily proscriptive to development. Because of these considerations, site-specific studies are recommended in Zone 2 and Zone 3.

The Wyoming DEQ identified four faults that appeared to have a reasonably high potential to allow adverse impact to municipal springs and wells. These faults are City Springs Fault, Jackrabbit Fault, Quarry Fault, and Sherman Hills Fault. It was suggested that unless there is geologic/hydrogeologic evidence or documentation to convincingly demonstrate that there is no increased vulnerability (e.g. due to cementation, etc) related to these faults, then they must be included in Zone 2. These fault complex locations are approximate and are simplified for ease of representation.

The remainder of the area of outcrop of the Casper Formation, easterly to the topographic divide of the Laramie Range, is designated as Zone 3 or the Secondary Aquifer Protection Area.

Site-Specific Delineations as a Result of Potentially Vulnerable Features

Within the large geographic areas defined as Zones 2 and 3, features have been identified that may render the Casper aquifer vulnerable to contamination. Typically vulnerable features are included within the Zone 2 protection area. However, not all of these features render the aquifer vulnerable to the same degree in all areas. To reduce the potential of having excessively proscriptive, and therefore untenable management strategies enacted where there is no need, it is recommended that site-specific studies be conducted when development occurs within Zones 2 and 3. Development here is defined as any modification to the natural land surface that may result in the introduction of contaminants and/or increasing the vulnerability of the aquifer to contamination. These site-specific studies will be conducted by a licensed professional geologist and/or engineer during the permitting phase. The purpose of the site-specific study will be to determine the vulnerability of the aquifer to contamination by the proposed development as a result of the presence of the following features on the subject property: faults, folds, drainages and shallow groundwater.

The reasoning for requiring site-specific studies is that the presence of one of these features on a particular property does not necessarily mean that aquifer contamination will occur or is more likely to occur, but rather it has the potential for increasing the vulnerability. Additionally, a combination of these features may result in significantly greater vulnerability.

The initial investigation for the site-specific delineation will consist of a literature search and 100-year flood plain delineation, if necessary. The investigator will consult available geologic mapping, including Lundy (1978), VerPloeg (1996, a, b) and any other readily available geologic mapping from the University of Wyoming Geology Library and the Wyoming Geological Survey, to determine the presence of mapped faults and/or folds on the subject property. Drainages passing through the subject property will be assessed for the potential for contributing to groundwater contamination. Where 100-year flood plain mapping is unavailable, the professional geologist and/or engineer will calculate the 100-year flood plain for the drainage. The flood plain mapping will be provided on a site map with a scale not to exceed 1 inch equals 200 feet.

The initial site investigation will also include an assessment of the depth to groundwater on the property. An attempt should be made to determine the groundwater at its highest annual elevation, which typically occurs in late spring. Water level(s) in a well on the site property are preferable for determining depth to groundwater. Water levels from wells on adjoining properties may be used if a well has not been drilled on the subject property. If a well is not available for obtaining water levels then maps depicting the potentiometric surface of the Casper aquifer may be used. Mapping from Lundy (1978), Thompson (1979) and Western Water Consultants (1993 and 1997), or newer mappings are accepted for determining the depth to groundwater. The depth to groundwater should be contoured across the building site at a scale not to exceed 1 inch equals 200 feet.

After conducting the site investigation, a brief report of the findings should be developed that provides an assessment of the presence and the vulnerability of the features listed above. If none of the features are found on the subject property then the site assessment will be considered complete.

For installation of on-site small wastewater facilities (e.g., septic systems) the cumulative potential effects of the new system, plus surrounding and upgradient systems, should be determined through nitrate-loading or fate and transport modeling as set forth in the DEQ Subdivision Rule.

If any of the above features are found on the property to be developed, then the site plan should show any proposed facilities with a 100 foot setback from any of the vulnerable features and not within the delineated 100-year floodplain. If the features are outside of setbacks, then the process is complete.

The setbacks recommended by the EAC are similar to those required for the Edwards Aquifer Protection Plan (EAPP) for the Texas Natural Resource Conservation Commission (Chapter 213 Edwards Aquifer and Chapter 285 On-site Sewage Facilities, see: www.tnrcc.state.tx.us/EAPP). The EAPP defines sensitive or recharge features as being “permeable geologic or manmade features located on the recharge zone where: a) a potential for hydraulic interconnectedness between the surface and the Edward Aquifer exists; and b) rapid infiltration to the subsurface may occur”. The EAPP has special requirements for development such as on-site sewage facilities in the recharge zone whereby they require separation distance to recharge features be 50 feet for septic tanks and 150 feet for a leachfield.

If the facilities fall within the established setbacks then the property owner has two potential options. These options are set forth in Chapter 3, Section 17 of the DEQ-Water Quality Division Rules and Regulations (DEQ, 1999), which are as follows:

“All other applications for a permit to construct a treatment works, disposal systems or other facility capable of causing or contributing to pollution shall contain the following:

a) Documentation that the facility poses no threat to groundwater. If an applicant proposes a facility of this nature and can provide documentation, a subsurface investigation is not required. The documentation shall consist of data which demonstrates that:

Facility construction will not allow a discharge to groundwater by direct or indirect discharge, percolation, or filtration; or

The quality of wastewater will not cause any violation of groundwater standards; or

Existing soils or geology will not allow a discharge to groundwater.

(b) If the documentation required above cannot be provided, a subsurface study shall be provided … to demonstrate the groundwater standards contained in applicable Wyoming Water Quality Rules and Regulations are adhered to…"

Aquifer Protection Area Maps

The Aquifer Protection Map, developed using the procedures outlined in the Delineation Process Section, is presented as Plate I and on Figure 3-5. Plate I shows the boundaries of both the Primary and Secondary Aquifer Protection Areas. The boundary between the two areas is the western side of the line indicated on Plate I. Figure 3-6 shows the Zone 1 boundaries on a smaller scale allowing for easier identification.

Written Description of Aquifer Protection Areas

Zone 1 Protection Areas

Spur Wellfield

The Zone 1 protection areas for the Spur Wells consist of a 100-foot arbitrary fixed radius around each of the wells.

City Springs Wellfield

The Zone 1 protection area for Turner Well No. 1 consists of a 100-foot arbitrary fixed radius. The Zone 1 protection area for Turner Well No. 2 is an irregularly shaped polygon that includes the well, historic spring boxes and the topographic low associated with the historic natural discharge points for the City Springs. The protection area has a maximum length of 320 feet in the north-south direction and a maximum length of 680 feet in the east-west direction.

Pope Wellfield

The Zone 1 protection areas for the Pope Wellfield consists of 100-foot fixed radii to Pope Well Nos. 1, 2, 3, and 4. The protection areas for Pope Well Nos. 2 and 3 have been merged because they have overlap. The Zone 1 protection area for the wellfield also includes a 100-foot setback from the edges of the cistern that is located over the historic Pope Springs.

Soldier Wellfield

The Zone 1 protection areas for the Soldier Wellfield are comprised of a 100-foot arbitrary fixed radius around the Soldier Well wellhead and a 100-foot setback from the topographic depression associated with the historic Soldier Springs. The maximum length of the protection area is 200 feet in the north-south direction and 600 feet in the east-west direction.

Zone 2 Protection Area

The Zone 2 protection area is an irregularly shaped area that has a maximum east-west width of approximately 17,000 feet and a maximum north-south length of 71,000 feet.

Zone 3 Protection Area

The Zone 3 protection area is an irregularly shaped area that has a maximum east-west width of approximately 26,500 feet and a maximum north-south length of 71,000 feet.

Available Data Limitations and Future Recommendations

Site Specific Modifications to the Plan

While establishing boundaries for the aquifer protection area, the Technical Review Subcommittee recognized that the location of zone boundaries may be altered in the future as more information becomes available. Site specific changes to the boundaries of the aquifer protection area should only be allowed:

When a site investigation shows significant variation from the assumptions presented herein; and

Based on the recommendations of a qualified water resource professional licensed by the State of Wyoming to practice engineering and/or geology.

In any determination, the criteria established in this report should be consistently applied to any proposed modification to the protected areas.

Recommended Investigations

To aid in refining the aquifer protection delineation process and to increase our understanding of the Casper aquifer, the Technical Review Subcommittee recommends that future studies be undertaken. The studies, in no particular order include:

Tracer tests of major faults associated with the City springs and wells;

Delineation of 100-year flood plains within the Zones 2 and 3 protection areas;

Establishing routine measurement of water levels and water quality in wells completed in the Casper aquifer in the Laramie area and development of potentiometric maps;

Research of recharge mechanisms and vulnerability analysis of aquifer to contamination from the ground surface;

Investigation of degree of hydraulic interaction between the Sherman Granite and Casper aquifer; and

Investigation of degree of hydraulic interaction between the Casper aquifer and the Satanka Shale.

Revising and Updating the Plan

The Wyoming Wellhead Protection (WHP) Program Guidance Document requires that a local Wellhead Protection Plan must be updated every two years. This will be ensured by having EAC members with expertise in engineering, hydrology, and geology. Members of the EAC will have knowledge of site-specific studies and other professional studies. The City Utility Division Manager (UDM) has regular contact with the University of Wyoming through other projects and duties and can keep abreast of any current research projects that could affect the aquifer protection plan.

Every two years, the UDM will have a meeting with professional geologists, engineers, and University of Wyoming professors who conduct work in the protection area. These professionals will be asked to present any findings relevant to the protection area. This Casper Aquifer Protection Plan (CAPP) will be modified, if necessary, based upon these meetings. A new delineation map will be developed if changes are significant, otherwise the delineation map will be annotated or appended.

Following this guideline, revisions to the Aquifer Protection Areas should be made when new information is available concerning:

33. Hydrologic characteristics of the Casper aquifer;

34. Changes in water supply, or pumping volumes; and/or

35. Planning or developing of new water supplies.

The chairman of the EAC will draft a letter every two years advising DEQ and anyone else who has a copy of the APP of all changes in the plan. Updated tables or pages will be sent, as appropriate. EAC subcommittees and the UDM will be responsible for reviewing these changes based on personal and professional knowledge, as well as active investigation. The UDM will be responsible for incorporating changes to the CAPP master copy.

Significant technical changes will be reviewed and approved by three Wyoming licensed professional engineers or geologists.

The APP may at some point be converted to a .pdf file and put on the Internet. This medium could be another way to disseminate updates.

APPENDIX F

RECOMMENDED STUDIES

Groundwater Monitoring Program

The intent of the groundwater monitoring program is to establish baseline water-quality data, monitor water-quality changes in the Casper Aquifer, and develop a database that will allow assessment of the condition of the Casper Aquifer. The program should be designed to provide a long-term systematic approach to monitoring the Casper Aquifer.

Below is a proposed scope of work for this program. The City may hire a consultant to design the monitoring program or may use this document as guidance for creating a Monitoring and Sampling Plan. This is not intended to be a Monitoring and Sampling Plan. The recommendations include the key elements of a comprehensive monitoring plan and should be used to guide the development a formal Monitoring and Sampling Plan. The Plan should:

1. establish a network of measuring points for comprehensive monitoring of water levels and water quality.
2. specify procedures for constructing measuring points.
3. establish a monitoring schedule.
4. specify water-quality constituents to include in sampling.
5. specify the analytical methodologies to be used in laboratory analyses.
6. specify field protocols including: procedures for purging, sampling, decontamination, and collection of field quality assurance samples.

Sampling Locations

In order to reduce costs the City should use existing wells were possible. However, there will be areas where additional monitoring wells will be required. The map (Figure F-1) shows the proposed locations of all monitoring wells. The exact locations may need to be moved due to access restrictions.

Following is a description of the existing monitoring wells and additional areas that are recommended to be monitored (Table 1F). In general monitoring locations are placed along the one (1) year time-of-travel as modeled by Western Water Consultants (1993) and where access is available. Two monitoring wells are downgradient of limestone quarries. Three monitoring wells are downgradient of subdivisions. Three monitoring wells are along I-80. The monitoring wells that are downgradient of specific potential contaminant sources (quarries, subdivisions, and I-80) will allow long-term monitoring of these activities while the other wells will allow more general long-term monitoring of the aquifer.

1. Existing City-owned monitoring wells.
    a. Soldier MW-5
    b. Spur MW-12
2. Other existing monitoring wells.
    a. TW-1, Wyoming Water Development Comm. (permit no. P95556W, FID 85548)
    b. Huntoon #2, Wyoming Water Resources Research Institution (permit no. P44232W, FID 35392).
3. New dedicated monitoring wells.
    a. Monitoring wells along the 1 year time-of-travel boundary have the following names in Figure F-1: Turner MW-1, Turner MW-2, Turner MW-3, Turner MW-4, Turner MW-5, Pope-Soldier MW-1, Pope-Soldier MW-2, and Simpson MW-1. The wells along the 1 year time-of-travel boundary are intended to be sentinel wells which will be used to collect long-term data, provide an early warning if contamination occurred, and allow the City Utility to conduct additional sampling if water-quality was degraded compared to historical data.
    b. Monitoring wells downgradient of different density residential developments. Figure F-1 depicts the new monitoring well Turner MW-6. The monitoring wells below residential development will allow long-term monitoring of the aquifer and data to help determine the impact of residential land use on the aquifer.
    c. Two wells downgradient of existing mining activities. These two wells should be installed by Mountain Cement but should be maintained and monitored by the City. Figure F-1 shows these wells as MC-3 and MC-4. The monitoring wells below mining operation will allow determination of the impacts, if any, of limestone mining on the aquifer.
    d. Monitoring wells along I-80. These wells are named I80 MW-1, I80 MW-2, and I80 MW-3 in Figure F-1. The monitoring wells placed along I-80 can be used, in addition to long-term monitoring, as wells which would be sampled if a hazardous material spill occurred on I-80. The City should work with WYDOT to see if funding is available for installing, maintaining, and monitoring these wells through WYDOT offices.

Table 1F. Monitoring wells for the groundwater monitoring program.

Purpose	Existing wells	Proposed wells
General (1 year time-of travel) monitoring	Soldier MW-5 Spur MW-12	Simpson MW-1 Pope-Soldier MW-1 Pope-Soldier MW-2 Turner MW-1 Turner MW-2 Turner MW-3 Turner MW-4 Turner MW-5
I-80 monitoring	None	I80 MW-1 I80 MW-2 I80 MW-3
Residential development monitoring	TW-1 Huntoon #2	Turner MW-6
Quarry monitoring	None	MC-3 MC-4

Sampling Parameters and Frequency

The wells will be monitored, at a minimum, quarterly and would include both water level measurements and water-quality samples. It is recommended that the contaminants listed in the National Primary Drinking Water Standards and National Secondary Drinking Water Standards be monitored for all wells on a yearly basis. The quarterly sampling should include all inorganic compounds and microorganisms on the National Primary and Secondary Drinking Water Standards, petroleum hydrocarbons, conductivity, and temperature. The petroleum hydrocarbons will be used as a surrogate for organic compounds. If a petroleum hydrocarbon is detected, the City should initiate additional organic parameter testing at the impacted well.

I-80 MITIGATION MEASURES

I-80 poses a high level of risk to the Casper Aquifer due to the hazardous wastes that are transported along this route and because I-80 itself cuts into the Casper Aquifer. The study for mitigating risks along I-80 should include the following items.

1. An assessment of the most likely areas for semi-tractor and trailer accidents to occur. This assessment should include grade information, seasonal highway conditions, and lack of breakaway ramps for semi-tractor and trailers.
2. An assessment of the hydrologic conditions. One challenge in designing a mitigation strategy is to reduce the amount of stormwater introduced to the mitigation strategy while providing containment of hazardous materials.
3. A cost-benefit analysis that takes into account the use of the Casper Aquifer as a drinking water source for both City and County residents.
4. Training of emergency personnel once the mitigation strategy is in place. The emergency personnel should understand how the mitigation strategy works and how their response plays into mitigating the threat to the aquifer.

The I-80 mitigation study should include participation by WYDOT. Funding opportunities may include federal and state money since I-80 is an interstate.

LAND USE IMPACTS ON WATER QUALITY

Currently, residential land use within the CAPA is of high concern because there are numerous septic systems. Additionally, these residents may use pesticides and generate household hazardous wastes. The impacts of residential land use are not well understood in the CAPA due to the vulnerable features discussed in Chapter 3 of the CAPP. Following are guidelines for analyzing these impacts.

1. Collect water quality samples and water levels from existing residential wells and new monitoring wells. Samples should be collected from monitoring wells located downgradient from subdivisions with a variety of lot densities to understand how residential lot and septic system densities impact water quality.
2. Survey surrounding land owners regarding the following items:
    a. septic system maintenance and age;
    b. household chemical use;
    c. landscaping practices; and
    d. water use.
3. The water-quality parameters to be analyzed should include:
    a. field parameters such as pH, temperature, and conductivity;
    b. nitrates (to understand septic system impacts and fertilizers);

c. commonly applied pesticides; and
d. e. coli (total and fecal coliform).

4. Analyze different residential densities to determine the level of development the Casper Aquifer can safely sustain. This analysis may include fate/transport modeling and/or field data collection that determines how different densities affect water quality.

This study of the impact of residential use on the Casper Aquifer can be used to guide future management strategies and changes, if any, to the ordinance.

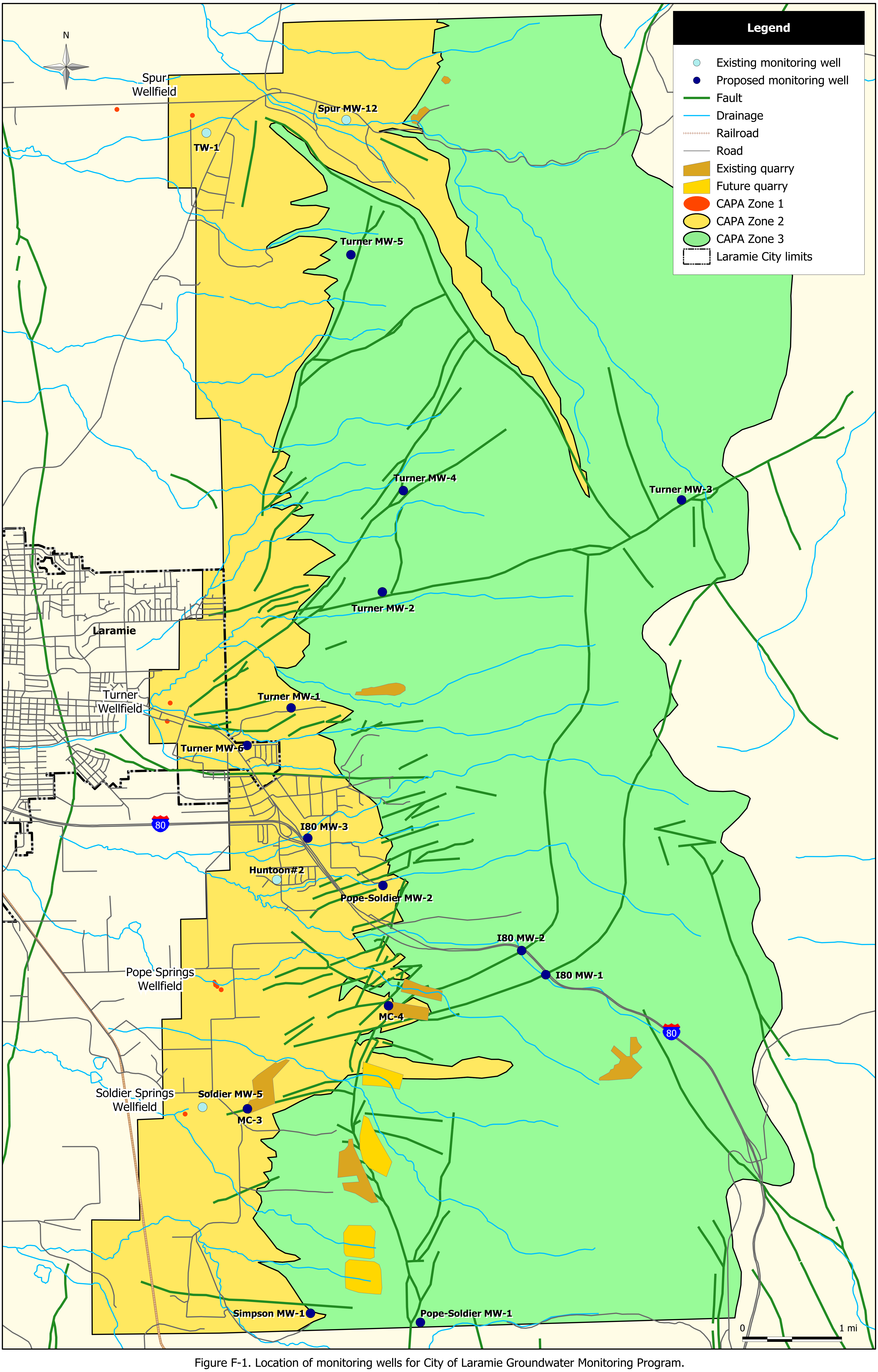


Figure F-1. Location of monitoring wells for City of Laramie Groundwater Monitoring Program.

APPENDIX G

CONTAMINANT SOURCE IDENTIFICATION FORMS, FORM IV, AND SUSCEPTIBILITY ASSESSMENT

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	
WHPA Zone #	Zones 2, 3
Type of Survey	Windshield and Field Survey

Site Information

Site Name/ Owner	Laramie Rifle Range
Site Location	T16N, R73W: Sec12 N1/2
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Lead bullets	N/A	N/A	soluble lead	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2, 3
Type of Survey	Windshield Survey and Albany County Assessors Database

Site Information

Site Name/ Owner	Residential Areas
Site Location	various
Nature of Property	Residential and Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Septic systems	0019	455	nitrates, fecal coliform	High
2) Sewer lines	0021	various	nitrates, fecal coliform	High
3) Water supply wells	0039	455	serve as contaminant conduit to aquifer	High
4) Abandoned wells	0040	3	serve as contaminant conduit to aquifer	High
5) Livestock waste disposal areas	0010	various	nitrates, fecal coliform	Medium
6) Public utilities	0110	N/A	gas lines, oils, solvents	Low
7) Mosquito sprays	0027	N/A	malathion @ 3 oz/acre	Low
8) Common household products	0016	various	various hazardous household materials in open dump areas near residences	Low
9) Lawns and gardens	0017	N/A	fertilizers and herbicides	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2, 3
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Interstate 80
Site Location	T15N, R73W: Sec1,12; T15N, R72W: Sec7, 18, 17, 16, 21,22, 26, 27
Nature of Property	Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Transport of various hazardous materials	0083	various	hazardous material spills and fuel spills by an accident	High
2) Highway- I-80	0028	1	de-icing	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 1
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	City Springs
Site Location	T16N, R73W: Sec35 S1/2
Nature of Property	other

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Water	0002	1	springs serve as conduit for contaminants to potentially enter the aquifer	High

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Pope Wellfield
WHPA Zone #: Zone 1
Type of Survey: Windshield Survey

Site Information

Site Name/ Owner: Pope Springs
Site Location: T15N, R73W: Sec14 E1/2
Nature of Property: other

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Water from springs	0002	1	springs serve as conduit for contaminants to potentially enter the aquifer	High

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Soldier #1
WHPA Zone #: Zones 1, 2, 3
Type of Survey: Windshield Survey

Site Information

Site Name/ Owner: Soldier Springs
Site Location: T15N, R73W: Sec23 S1/2; Sec26 N1/2; Sec24 W1/2
Nature of Property: other

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Water from springs	0002	1	springs serve as conduit for contaminants to potentially enter the aquifer	High

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Pope and Solider wellfields
WHPA Zone #: Zones 2, 3
Type of Survey: Field Survey

Site Information

Site Name/ Owner: Union Pacific Railroad - Hermosa/ Spur Line
Site Location: T15N, R73W: Sec26 SW1/4, SW1/4; Sec35 W1/2; T14N, R73W: Sec2 W1/2; Sec11 W1/2
Nature of Property: Commercial and Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Transported chemicals and hazardous material	0083	various	chemical and hazardous material spills are possible	Medium
2) Railroad tracks	0074	1	creosote seepage from ties	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: All Wellfields
WHPA Zone #: Zones 2, 3
Type of Survey: Field Survey

Site Information

Site Name/ Owner: Quarries/ Mountain Cement
Site Location: T16N, R73W; T15N, R72W; T15N, R73W
Nature of Property: Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Surface mining operations	0101	4	Refueling spills, residue from blasting compounds (diesel fuel & ammonium nitrate)	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: All Wellfields
WHPA Zone #: Zone 1, 2, 3
Type of Survey: Windshield Survey, County Assessor's Office, State Engineers Office

Site Information

Site Name/ Owner: Wells
Site Location: Throughout CAPA
Nature of Property: Residential, municipal, stock, irrigation, monitoring

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) wells	0039	Approximately 400	Wells serve as conduit for contaminants to potentially enter the aquifer	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 3
Type of Survey	UST database

Site Information

Site Name/ Owner	Pilot Hill Radio Repeater
Site Location	T15N, R72W: Sec10 NE1/4, SE1/4
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) underground storage tank	0078	1 active, 1 removed	Diesel	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Dollar Tree, Staples, Snowy Range Academy, Express Pharmacy
Site Location	4005 and 4027 E. Grand Ave.
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Storm water runoff	0032	1	urban runoff, gasoline, oil, road salt	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Gem City Bone & Joint
Site Location	1909 Vista Drive
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Medical facility	0068	1	Medical wastes	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Animal Hospital
Site Location	4619 Bobolink Ln
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Veterinary service	0080	1	Medical wastes	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Greenhouse
Site Location	4633 Mockingbird Ln
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Greenhouse/nursery	0065	1	Fertilizers, herbicides, insecitides, fungicides	Medium

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: All Wellfields
WHPA Zone #: Zone 2, 3
Type of Survey: Windshield Survey

Site Information
Site Name/ Owner: Transportation routes
Site Location: Throughout CAPA
Nature of Property: Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1)transportation routes	0028	1	De-icing materials, automotive wastes	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Turner Wellfield
WHPA Zone #: Zone 2
Type of Survey: UST database

Site Information
Site Name/ Owner: J. T. Peele
Site Location: 2038 Skyline Drive
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) underground storage tank	0078	1	3,000 gallon diesel tank, removed 1989	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Pope and Solider wellfields
WHPA Zone #: Zone 3
Type of Survey: UST database

Site Information
Site Name/ Owner: Sherman Hill Microwave Site
Site Location: 13 miles W on Happy Jack Road and Exist 323 on I-80
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) underground storage tank	0078	1	350 gallon gasoline tank (removed 1994)	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Pope and Solider wellfields
WHPA Zone #: Zone 3
Type of Survey: NPDES database

Site Information
Site Name/ Owner: Etchepare Quarry
Site Location: T15N, R72W: Sec 21
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Wastewater discharge	N/A	1	NPDES mineral mining discharge, construction sand and gravel	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Spur Wellfield
WHPA Zone #: Zone 2
Type of Survey: NPDES database

Site Information
Site Name/ Owner: Ninth Street Pit #2
Site Location: T17N, R73W, Sec 36: SW1/4, SW1/4
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Wastewater discharge	N/A	1	NPDES mineral mining discharge, construction sand and gravel	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Wood/looging site
Site Location	T15N, R72W: Sec 21
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Wood/logging site	N/A	1	Fuel from operating equipment	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Dental Office
Site Location	3421 E. Garfield St.
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Dental office	0068	1	Medical wastes	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Detailing Shop
Site Location	3424 E. Garfield St.
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Auto detailing shop	0048	1	Solvents, automotive wastes, detergents, paints	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Jacoby Golf Course
Site Location	3501 Willet Drive
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Golf course	0058	1	fertilizers and herbicides	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2, 3
Type of Survey	Windshield Survey, County Assessor's Office

Site Information

Site Name/ Owner	Agricultural Land Use
Site Location	Throughout CAPA
Nature of Property	Agricultural

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Livestock waste disposal areas	0010	Multiple	Livestock sewage wastes, nitrates	Low
2) Chemical storage areas and containers	0012	Multiple	Pesticide and fertilizers residues	Low
3) Agricultural wells	0014	Multiple	Pesticides, fertilizers, bacteria, nitrates	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Urban Runoff/ Super Wal-Mart
Site Location	T16N, R73W: Sec35 SW1/4, SE1/4
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Storm water drains	0032	1	urban runoff, gasoline, oil, road salt	Medium
2) Auto repair shop	0048	1	waste oils, solvents	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2
Type of Survey	Field Survey

Site Information

Site Name/ Owner	Municipal Sewer Lines
Site Location	T15N, R73W: Sec1
Nature of Property	Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Municipal sewer lines	0029	various	nitrates, fecal coliform, treatment chemicals	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Car Dealership-Laramie GM Auto Center
Site Location	T16N, R73W: Sec35 S1/2
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Car dealership	0052	1	automotive wastes, waste oils, solvents, miscellaneous wastes	High

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Car Dealership-Laramie Ford
Site Location	T16N, R73W: Sec35 S1/2
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Car dealership	0052	1	automotive wastes, waste oils, solvents, miscellaneous wastes	High

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2, 3
Type of Survey	Interview

Site Information

Site Name/ Owner	Mosquito Spraying
Site Location	Throughout CAPA
Nature of Property	Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Mosquito spraying	0027	Multiple	Pesticides (Bti, Malathion)	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Gas Station-Tumbleweed Express
Site Location	T15N, R73W: Sec1 SW1/4, NE1/4
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Gasoline service station	0062	1	UST	High

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Spur Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Equine Riding Facility
Site Location	25 Domino
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Equine riding facility	0010	1	Animal wastes	Low

Form IV:

<u>Potential and Known Source Hazard, Controls, Assessment and Management</u>
is provided as a worksheet to list existing controls and possible management strategies to ensure that potential and known sources identified within the Aquifer Protection Plan are adequately managed.

Potential Source #: **1 -Residential Areas throughout CAPA**
Priority Rank: High

Potential Source Type: Septic systems and residential wells, household hazardous wastes, pesticides, fertilizers
Implementation Date: 2008-2015
Strategy: Groundwater monitoring program, overlay zoning, licensing of contractors, household hazardous wastes collections, education

Potential Source #: **2 – Interstate-80**
Priority Rank: High
Potential Source Type: Hazardous materials spill, deicing materials
Implementation Date: 2008-2012
Strategy: Groundwater monitoring program, mitigation measures study, signs

Potential Source #: **3- Springs**
Priority Rank: High
Potential Source Type: Conduit to groundwater
Implementation Date: 2008-2010
Strategy: Groundwater monitoring program, overlay zoning, sunset on development of conventional on-site septic systems., signs

Potential Source #: **4-Wells**
Priority Rank: High
Potential Source Type: Conduit to groundwater
Implementation Date: 2008-2010
Strategy: Groundwater monitoring program, overlay zoning, sunset on development of conventional on-site septic systems, signs, well sealing and abandonment

Potential Source #: **5-Laramie GM Auto Center**
Priority Rank: High
Potential Source Type: UST, automotive waste generator
Implementation Date: 2008-2012
Strategy: Groundwater monitoring program, overlay zoning, education

Potential Source #: **6-Laramie Ford**
Priority Rank: High
Potential Source Type: UST, automotive waste generator
Implementation Date: 2008-2012
Strategy: Groundwater monitoring program, overlay zoning, education

Potential Source #: **7-Tumbleweed Express**
Priority Rank: High
Potential Source Type: UST
Implementation Date: 2008-2012
Strategy: Groundwater monitoring program, overlay zoning, education

Potential Source #:	**8-Union Pacific Railroad**
Priority Rank:	Medium
Potential Source Type:	Hazardous materials spill
Implementation Date:	2008-2012
Strategy:	Signs, MOA/MOU, education

Potential Source #:	**9-Pilot Hill Radio Repeater**
Priority Rank:	Medium
Potential Source Type:	UST
Implementation Date:	2008-2012
Strategy:	Overlay zoning, education

Potential Source #:	**10-Dollar Tree, Staples, Snowy Range Academy, Express Pharmacy**
Priority Rank:	Medium
Potential Source Type:	Urban runoff
Implementation Date:	2008-2012
Strategy:	Overlay zoning, education, stormwater design, groundwater monitoring program

Potential Source #:	**11-Super Wal-Mart**
Priority Rank:	Medium
Potential Source Type:	Urban runoff, automotive wastes
Implementation Date:	2008-2012
Strategy:	Overlay zoning, education, stormwater design, groundwater monitoring program

Potential Source #:	**12-Gem City Bone & Joint**
Priority Rank:	Low
Potential Source Type:	Medical wastes
Implementation Date:	2008-2012
Strategy:	Education, existing regulations

Potential Source #:	**13-Animal Hospital**
Priority Rank:	Low
Potential Source Type:	Medical wastes
Implementation Date:	2008-2012
Strategy:	Education, existing regulations

Potential Source #:	**14-Green House**
Priority Rank:	Low
Potential Source Type:	Fertilizers
Implementation Date:	2008-2012
Strategy:	Overlay zoning, education

Potential Source #:	**15-Quarries**
Priority Rank:	Low
Potential Source Type:	Fuel spills, blasting materials
Implementation Date:	2008-2012
Strategy:	Groundwater monitoring program, overlay zoning, MOU/MOA

Potential Source #: **16-Laramie Rifle Range**
Priority Rank: Low
Potential Source Type: Soluble lead
Implementation Date: 2008-2012
Strategy: Education, MOU/MOA

Potential Source #: **17-Municipal Sewer Lines**
Priority Rank: Low
Potential Source Type: Nitrates, bacteria
Implementation Date: 2008-2015
Strategy: Overlay zoning, inspections

Potential Source #: **18-Mosquito Spraying**
Priority Rank: Low
Potential Source Type: Bti and Malathion
Implementation Date: 2008-2012
Strategy: Education

Potential Source #: **19-Equine Riding Facility**
Priority Rank: Low
Potential Source Type: Animal wastes
Implementation Date: 2008-2012
Strategy: Education, groundwater monitoring program

Potential Source #: **20-Transportation Routes**
Priority Rank: Low
Potential Source Type: Road salts
Implementation Date: 2008-2012
Strategy: Education, groundwater monitoring program

Potential Source #: **21-J. T. Peele**
Priority Rank: Low
Potential Source Type: UST (removed 1989)
Implementation Date: 2008-2012
Strategy: Overlay zoning, education

Potential Source #: **22-Sherman Hill Microwave Site**
Priority Rank: Low
Potential Source Type: UST (removed 1994)
Implementation Date: 2008-2012
Strategy: Overlay zoning, education

Potential Source #: **22-Etchepare Quarry**
Priority Rank: Low
Potential Source Type: NPDES Wastewater discharge
Implementation Date: 2008-2012
Strategy: Education

Potential Source #: **22-Ninth Street Pit #2**
Priority Rank: Low
Potential Source Type: NPDES Wastewater discharge
Implementation Date: 2008-2012
Strategy: Education

Potential Source #: **23-Wood/logging site**
Priority Rank: Low
Potential Source Type: Fuel spills
Implementation Date: 2008-2012

Strategy: Education

Potential Source #: **24-Dental Office**
Priority Rank: Low
Potential Source Type: Medical wastes
Implementation Date: 2008-2012
Strategy: Education, existing regulations

Potential Source #: **25-Detailing Shop**
Priority Rank: Medium
Potential Source Type: Automotive wastes, solvents
Implementation Date: 2008-2012
Strategy: Overlay zoning, education

Potential Source #: **26-Jacoby Golf Course**
Priority Rank: Medium
Potential Source Type: Pesticides, fertilizers
Implementation Date: 2008-2012
Strategy: Overlay zoning, education, stormwater design, groundwater monitoring program

Potential Source #: **27-Agricultural Land Use**
Priority Rank: Low
Potential Source Type: Animal wastes, fertilizers, pesticides
Implementation Date: 2008-2012
Strategy: Overlay zoning, education, groundwater monitoring program

Susceptibility Assessment **September 14, 2001 (Wellhead Protection)** **Source:** City of Laramie 2000

	Spur #1	**Spur #2**	**Soldier #1**	**Turner #1**	**Turner #2**	**Pope #1**	**Pope #2**	**Pope #3**	**Pope #4**
Part I: System Information									
Well Owner	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie
City	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie
County	Albany	Albany	Albany	Albany	Albany	Albany	Albany	Albany	Albany
PWS Name	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie
PWS ID#	5600029	5600029	5600029	5600029	5600029	5600029	5600029	5600029	5600029
Well Depth	305'	323'	289'	240'	350'	156'	162'	158'	350'
Source Name	Spur #1	Spur #2	Soldier #1	Turner #1	Turner #2	Pope #1	Pope #2	Pope #3	Pope #4
SEO Permit #	UW 106547	UW 107279	UW 105576	P55507W * see notes	P55508W *see notes	P153C	P154C *see notes	P155C *see notes	P55506W *see notes
Connections	n/a	n/a	n/a	7138 (1998)	7138 (1998)	n/a	n/a	n/a	n/a
Population Served	n/a	n/a	n/a	26,400 residents	26,400 residents	30,747 residents	??	??	??
Location	T16N, R73W,S2, NE,NE	T16N,R73W,S2,NW,NW	T15N,R73W,S23,SE,SW	T15N,R73W,S14,NE,SE	T16N,R73W,S35,SE,SW	T15N,R73W,S14,NE,SE	T15N,R73W,S14,NE,SE	T15N,R73W,S14,NE,SE	T15N,R74W,S14,NE,SE
	41,23',40", 105,32',32"	41,23',44",105,33',22"	41,14',56", 105,32',53"	41,18',40",105,31',39"	41,20',03", 105,31',53"	41,16',15", 105,31',55"	41,16',19", 105,31',08"	41,16',13", 105,31',58"	41,16',19", 105,31',05"
	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)
Part II: Well Construction and Aquifer Characteristics									
Date Constructed	8/16/1997	11/10/1997	6/9/1997	9/1/1982	8/1/1982	about 6/37	about 6/15/38	Early summer 1939	8/1/1982
Well Driller	Watson Well-Rob Watson	Watson Well	Johnson's P and E-Shepard	Watson Well	Watson Well	Unknown	Unknown	Unknown	Watson Well
Type of Well	Air Rotary Drill	Air Rotary Drill	Air Rotary Drill	Drill	Air Rotary Drill	Drill	Drill	Drill	Drill
SEO Completion Report?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Pumping Rate	1400 gpm	1400 gpm	1450 gpm (SEO permits 1800gpm)	2500 gpm **see notes	1600 gpm **see notes	220 gpm	520 gpm **see notes	900 gpm **see notes	1750 gpm **see notes
Treated?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chlorinated?	Yes, 0.6-0.7mg/L	Yes, 0.6-0.7mg/L	Yes, 0.6-0.7mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L
Wellhead Elevation	7292.33 ft (well log)	7271.48 ft (well log)	7322.97 ft (well log)	7273 ft (well log)	7266 ft (well log)	7335.5 ft (well log)	7338.8 ft (well log)	7338.8 ft (well log)	7351 ft (well log)
Depth to Top of Screened Interval	n/a	n/a	44.1 ft	n/a	n/a	n/a	n/a	n/a	n/a
Depth to Groundwater	31.11 ft below wellhead	11.15 ft below wellhead	2.0 ft above wellhead	6.0 ft below wellhead		15.5 ft below wellhead	12 ft below wellhead	13 ft below wellhead	31 ft below wellhead
Determined how?	Well log	Well log	Well log	Well log	Well log	Well log	Well log	Well log	Well log
Flowing Well or Spring?	No	No	Yes	No	Yes	No	No	No	No
Shut-in pressure	n/a	n/a	5.6 psi, 13 ft above wellhead	n/a	0.65 psi, 1.5 above w.h.	n/a	n/a	n/a	n/a
Surface Impoundment, etc.?	n/a	n/a	Yes	n/a	Yes	??	??	??	??
Evidence of a confining layer?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
>20 ft depth to groundwater?	No	No	Yes	Yes	Yes	No	No	No	Yes
Accident Prevention Zone	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius
Wellhead Control and Access	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse-fenced	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse	Encolsed in wellhouse
Surface Casing and Annular Seal									
Surface Casing Present?	Yes	Yes	Yes	Yes	Yes	Unknown	Unknown	Unknown	Yes
Depth of Surface Casing	18'	40.5'	20.3'	100'	100'	n/a	n/a	n/a	100'
Casing Material	.375" steel	.375" steel	Cement	Steel	Cement	n/a	n/a	n/a	cement
Annular Seal Present?	Yes	Yes	Yes	Yes	n/a	Yes	n/a	n/a	n/a
Depth of Annular Seal	80.5'	256'	79.5'	100'	n/a	64.0'	n/a	n/a	n/a
Annular Seal Material	cement	cement	.25"-.375" steel	cement, gravel pack	n/a	8" thick cement	n/a	n/a	n/a
Surface Seal and Well Opening									
Surface (protective) Casing Present?	Yes	Yes	Yes	Yes	Yes	Yes	Open Hole	Yes	Yes
Height of casing above ground	1.8'	0'	24"	12"	12"	12"	13"	11"	12"
Surface Casing Material	Steel 16"diam.,0.375"wall	Steel 16"dia,.375" wall	Steel, 16" dia	Steel, 16" dia	16" dia, ASTM A53 Grd B	n/a	64' of 8"-unknown material	66' of 15"-unknown material	100' of 16" diam, ?
Well Cap in Place?	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Well Cap Locked?	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Surface Seal Present?	Yes	Yes	Yes	n/a	n/a	n/a	n/a	n/a	n/a
Surface Seal Material	Cement	Cement	Cement	n/a	n/a	n/a	n/a	n/a	n/a

Part III: Assessment of Water Quality									
All potential contaminant sources within the *Accident Prevention Zone and Zones 2,3*	abandoned water wells, septic systems	abandoned water wells, septic systems	abandoned water wells, septic systems, dumps	pesticide application, abandoned water wells, septic systems	pesticide application, abandoned water wells, septic systems	pesticide application, abandoned water wells, septic systems, biosolid application	pesticide application, abandoned water wells, septic systems, biosolid application	pesticide application, abandoned water wells, septic systems, biosolid application	pesticide application, abandoned water wells, septic systems, biosolid application
Water Quality Records Since 1986									
Nitrate as N	No records	No records	1.57 ppm (CCR 2000)	1.91 ppm (CCR 2000)	1.91 ppm (CCR 2000)	1.57 ppm (CCR 2000)	1.57 ppm (CCR 2000)	1.57 ppm (CCR 2000)	1.57 ppm (CCR 2000)
VOC's	No records	No records	0	0	0	0	0	0	0
SOC's (Pesticides, etc.)	No records	No records	0	0	0	0	0	0	0
Bacterial Contamination	No records	No records	never detected	never detected	never detected	never detected	never detected	never detected	never detected
	Spur #1	**Spur #2**	**Soldier #1**	**Turner #1**	**Turner #2**	**Pope #1**	**Pope #2**	**Pope #3**	**Pope #4**
Part IV: Geographic or Hydrologic Factors Contributing to a Non-Circular Zone of Contribution									
Evidence of a potential hydrologic barrier?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aquifer Material:									
Logs, reports reviewed for faulting, etc.?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Do sources indicate faults,fractures and/or karst conditions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Do sources indicate primarily *course sand and gravel*?	No	No	No	No	No	No	No	No	No
Are high-capacity wells within the *Accident Prevention Zone and the WHPA*?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Extraction wells pumping at >500 gal/min?	Yes, in Zone 2	Yes, Zone 2	Yes, Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2
Groundwater recharge wells or heavy irrigation within the *APZ*?	No	No	No	No	No	No	No	No	No
NOTES:									
*				Turner #1: 1st ENL Permit #5600029, 2nd ENL Permit #72689	Turner #2: 1st ENL Permit #P59131W		Pope #2: 1st ENL Permit #72690	Pope #3: 1st ENL Permit #55505, 2nd ENL Permit #72691	Pope #4: 1st ENL Permit # 72692
**				Original well appropriation for 1400 gpm, 1st ENL for 800 gpm, and 2nd ENL for 300 gpm, for a total of 2500 gpm.	Original well appropriation for 1400 gpm, 1st ENL for 200 gpm, for a total of 1600 gpm.		Original well appropriation for 600 gpm, 1st ENL for 75 gpm, for a total of 675 gpm.	Original well appropriation for 600 gpm, 1st ENL for 250 gpm, 2nd ENL for 50 gpm, for a total of 900 gpm.	Original well appropriation for 1750 gpm, 1st ENL for 50 gpm, for a total of 1800 gpm.

APPENDIX H

BEST MANAGEMENT PRACTICES FOR SINGLE-FAMILY RESIDENCES

INTRODUCTION

The actions we take each day, in and around our homes, may have a profound effect on our drinking water quality. Small amounts of pollution from many different sources can significantly affect our groundwater resource. Yard maintenance, waste storage, car washing and maintenance, and improper septic system use and maintenance are some of the activities that can adversely impact water quality. The best management practices (BMPs) discussed in this section are practical ways to keep our drinking water from becoming polluted in the first place. It is recommended that all residences within the Aquifer Protection Area use these BMPs.

SEPTIC SYSTEMS

The U.S. Environmental Protection Agency estimates that 30 percent of U.S. households use septic tanks or other on-site wastewater treatment methods (EPA, 1999). Conventional septic systems are designed to operate indefinitely if properly maintained. However, if a septic system is not well maintained, its functional life may be 20 years or less. Maintaining your system is a good investment compared to the expense and inconvenience of replacing a failed system. Conducting regular inspections and maintenance for 20 years will typically cost one-fifth to one-tenth as much as removing and replacing the system at the end of the 20-year period. (EPA, 1999).

Symptoms of a failing septic system include strong odors, ponding of improperly treated wastewater, and backup of wastewater into the home. Less obvious is the measurable decline in water quality that occurs when a system is not operating properly. By conducting regular inspections and maintenance, you may avoid the greater expense and property disruption of replacing a failed system.

BEST MANAGEMENT PRACTICES

Have your system inspected once every two years and pumped at least every three years, or more frequently if the inspection indicates that pumping is necessary.

- Avoid placing solvents, poisons, and other household chemicals into the septic system or household drains. These substances may kill the beneficial bacteria within the tank and drain field; they may also contaminate drinking water.
- Dispose of garbage in the trashcan rather than using an in-sink "garbage disposal."
- Avoid organic solvents marketed as septic system cleaners or substitutes for sludge pumping (e.g. Krane Products: Septic Helper or Septic 2000). Some communities have ordinances forbidding the use of these substances, because the chemicals can migrate to the groundwater causing aquifer contamination.
- Avoid putting solids or greasy material down drains or toilets: paper towels, cigarettes, cat litter, feminine hygiene products, and residual cooking fat should be placed in the garbage.
- Install low volume plumbing fixtures to prevent overloading the system.
- If you are not a full time resident, consider installing a composting toilet in lieu of a traditional septic system. Septic drain fields used seasonally often develop incomplete biological mats, which lowers system performance.

AUTOMOBILE WASHING

Most residents wash their cars in the driveway or on the street. Wash waters typically flow to a storm drain or ditch, which discharges storm water directly to the nearest drainage, stream, or lake.

BEST MANAGEMENT PRACTICES

- Wash your car directly over your lawn or make sure the wash water drains to a vegetated area. This allows the water and soap to soak into the ground instead of running off into a local water body.
- Ideally, no soaps or detergents should be used, but if you do use one, select one without phosphates.
- Commercial products are available that allow you to clean a vehicle without water. They were developed for areas where water is scarce, so a water saving benefit is realized as well as reduced pollution.
- Use a nozzle on your hose to save water.
- Do not wash your car if rain is expected.
- Consider not washing your car at home. Take it to a commercial car wash that has a recycle system and discharges wastewater to the sanitary sewer for treatment.

AUTOMOBILE MAINTENANCE

Many of us are "weekend mechanics". We enjoy the cost savings of changing our own oil and antifreeze, and generally making our car perform its best. There are many potentials for storm water pollution associated with these activities, however, the following BMPs will help you minimize pollution while servicing your car.

BEST MANAGEMENT PRACTICES

- Recycle all oils, antifreeze, solvents and batteries. The Albany County Road and Bridge Dept. and the City of Laramie Street Division will accept used automobile oil to burn in a waste-oil heater. After you change oil in your vehicle, pour the liquid into a clean, unbreakable container with a good sealable cap, such as a one-gallon plastic jug. Do not mix the used oil with water or other products. Used antifreeze should be drained into a sturdy container. Contact Road and Bridge (742-2534) for further instructions and disposal times.
- The best way to dispose of used automotive batteries is to return your old battery to the company from whom you are purchasing a new one. Automotive batteries are also accepted at the Laramie landfill. Alkaline batteries may be placed in your normal trash. Nickel cadmium (NiCad) or lithium rechargeable batteries should be recycled at the Laramie landfill.
- Solvents such as paint thinner can be reused by allowing the solids to settle to the bottom of the container, then pouring off the clear liquid into a well-labeled container for reuse later. The solids can then be dried and thrown away.
- The Household Hazardous Waste Collection at the Laramie landfill occurs during the summer months. In addition, there are local businesses that may pay you for some of your “waste products.” Call shops listed in Laramie Area Recycle/Disposal Location list or call the Water Outreach Coordinator for more information at 721-5208.
- Never dump new or used automotive fluids or solvents on the ground, in a storm drain or street gutter, or in a water body. Eventually, they will make their way to the Laramie River.
- Do not mix wastes. The chlorinated solvents in some carburetor cleaners can contaminate a huge tank of used oil, rendering it unsuitable for recycling. Always keep your wastes in separate containers that are properly labeled and store them out of the weather.
- To dispose of oil filters, punch a hole in the top and let drain for 24 hours. This is where a large funnel in the top of your oil storage container will come in handy. After draining, wrap in 2 layers of plastic and dispose of in your regular garbage or recycle by taking it to the

Laramie Landfill on a designated Household Hazardous Waste Collection Day.

- Use care in draining and collecting antifreeze to prevent accidental spills. Spilled antifreeze can be deadly to cats and dogs that ingest it.
- Perform your service activities on concrete or asphalt or over a plastic tarp to make spill cleanup easier. Keep a bag of kitty litter on hand to absorb spills. Sprinkle a good layer on the spill, let it absorb for a little while and then sweep it up. Place the contaminated litter in a plastic bag, tie it up, and dispose of it in your regular garbage. Take care not to leave kitty litter out in the rain; it will form a sticky goo that is hard to clean up.
- If you are doing bodywork outside, be sure to use a tarp to catch material resulting from grinding, sanding and painting. Dispose of this waste by double bagging in plastic and placing in your garbage.

STORAGE OF SOLID WASTES AND FOOD WASTES

Improper storage of food and solid waste at residences can lead not only to water pollution problems, but problems with neighborhood pets and vermin as well. Following the BMPs listed below can help keep your property a clean and healthy place to live.

BEST MANAGEMENT PRACTICES

- All waste containers kept outside should have lids.
- Leaking waste containers should be replaced.
- Store waste containers under cover if possible, or on grassy areas.
- Inspect the storage area regularly to pick up loose scraps of material and dispose of them properly.
- Recycle as much as you can. The ARK Industries provides recycling bins at some Laramie supermarket parking lots. Most glass, steel and aluminum containers, plastic milk and pop bottles, and newspapers can be recycled at these convenient locations. The Laramie Area Recycle/Disposal Locations List provides information about where to recycle many other materials. For more information call the Water Outreach Coordinator 721-5208.
- Purchase products that have the least amount of packaging materials.
- Compost biodegradable materials such as grass clippings and vegetable scraps instead of throwing them away. Your flowerbeds will love the finished compost, and we won't fill up our landfills so quickly. See the section on composting for BMPs relating to that activity.

COMPOSTING

Composting is a positive activity as long as some common sense rules outlined below are followed. If you choose to compost, the following BMPs should be utilized.

BEST MANAGEMENT PRACTICES

- Compost piles must be located on an unpaved area where runoff can soak into the ground or be filtered by grass and other vegetation.
- Compost piles should be located in an area of your yard not prone to water ponding during storms, and should be kept well away from water bodies and drainage paths.
- Avoid putting hazardous or non-decomposable waste in the pile.
- Build covered bins of wood, chicken wire or fencing material to contain compost so it can't be washed away. Albany County Cooperative Extension Office at 721-2571 to get free composter designs and materials lists.
- A fun alternative to traditional composting is worm composting. You can let worms do all the work for you by keeping a small vermiculture box just outside your kitchen. For more information on getting started with worms, contact the Albany County Cooperative Extension Office at 721-2571 or visit the Albany County Public Library.

YARD MAINTENANCE AND GARDENING

This section deals with yard maintenance activities. Over watering, over fertilizing, improper herbicide application and improper disposal of trimmings and clippings can all contribute to serious water pollution problems. Following the BMPs listed below will help alleviate pollutant runoff.

BEST MANAGEMENT PRACTICES

- Follow the manufacturer's directions exactly for mixing and applying herbicides, fungicides and insecticides, and use them sparingly. Never apply when it is windy or when rain is expected. Never apply over water, within 100 feet of a wellhead, or adjacent to streams or other water bodies. Triple-rinse empty containers, using the rinsate for mixing your next batch of spray, and then double-bag and dispose of the empty container in your regular garbage.
- Never dispose of grass clippings or other vegetation in or near storm drains, natural drainages, streams, or lakes.
- Follow manufacturer's directions when applying fertilizers. More is not better, either for your lawn or for local water bodies. Never apply fertilizers over water or adjacent to ditches, streams or other water bodies. Remember that organic fertilizers have a slow release of nitrogen, and less potential to pollute than synthetic fertilizers.

- Save water and prevent pollution problems by watering your lawn sensibly. Lawns and gardens typically need the equivalent of 1" of rainfall per week. You can check on how you're doing by putting a wide mouth jar out where you're sprinkling, and measure the water with a small plastic ruler. Over watering to the point of runoff can carry polluting nutrients to the nearest water body.
- Consider planting a vegetated buffer zone adjacent to any water bodies on your property. Call the Laramie Rivers Conservation District at 745-3698 for advice and assistance in developing a planting plan.
- Make sure all fertilizers and pesticides are stored in a covered location. Rain can wash the labels off of bottles and convert 50 pounds of fertilizer into either a solid lump or a river of nutrients.
- Compost all yard clippings, or use them as mulch to save water and keep down weeds in your garden. See the Composting section for more information.
- Practice organic gardening and virtually eliminate the need to use pesticides and fertilizers. Contact Albany County Cooperative Extension at 721-2571 for information and classes on water-friendly gardening.
- Pull weeds instead of spraying and get some healthy exercise, too. If you must spray, use the least toxic formulations that will get the job done.
- Work fertilizers into the soil instead of letting them lie on the ground surface exposed to the next rainstorm.

HOT TUB AND POOL CLEANING AND MAINTENANCE

Despite the fact that we immerse ourselves in it, the water from pools and hot tubs is far from chemically clean. Nutrients, pH, and chlorine can adversely affect fish and wildlife in water bodies. Following these BMPs will ensure the cleanliness of your pool and the environment.

BEST MANAGEMENT PRACTICES

- Pool and hot tub water should be dechlorinated if it is to be emptied into a ditch, on the ground, or a lawn or to the storm drainage system. Contact your chemical supplier to obtain the neutralizing chemicals you will need. The rate of flow into the ditch or drainage system should be regulated so that it does not cause problems such as erosion, surcharging or flooding. Water discharged to the ground or a lawn should not cross property lines and or produce runoff. If you live in a sewered area, you must discharge pool water to the sanitary sewer.

- If pool and hot tub water cannot be dechlorinated, it should be discharged to the sanitary sewer. Prior to draining, the wastewater treatment plant must be notified to ensure they are aware of the volume of discharge and the potential effects of chlorine levels. A pool service company can help you determine the frequency of cleaning and backwash of filters.
- Diatomaceous earth used in pool and hot tub filters should never be disposed of in surface waters, on the ground, into storm drainage systems or septic systems. Dry it out as much as possible; bag it in plastic, and dispose of at the landfill.

HOUSEHOLD HAZARDOUS MATERIAL USES, STORAGE, AND DISPOSAL

Once we really start looking around our houses, the amount of hazardous materials we have on site is a real eye-opener. Oil-based paints and stains, paint thinner, gasoline, charcoal starter fluid, cleaners, waxes, pesticides, fingernail polish remover, and wood preservatives are just a few that most of us have around the house.

When products such as these are dumped on the ground or in a storm drain, they can be washed directly to receiving waters where they can harm fish and wildlife. They can also infiltrate into the ground and contaminate drinking water supplies. The same problem can occur if they are disposed of with your regular garbage; the containers can leak at the landfill and contaminate groundwater. The same type of contamination can occur if hazardous products are poured down a sink or toilet into a septic system or the City sewer system. Many compounds will "pass through" the wastewater treatment plant without treatment and contaminate receiving waters, or they can harm the biological process used at the treatment plant, reducing overall treatment efficiency.

With such a diversity of hazardous products present in all homes in Albany County, a large potential for serious environmental harm exists if improper methods of storage, usage and disposal are employed. Using the following BMPs will help keep these materials out of our soils, sediments and waters.

BEST MANAGEMENT PRACTICES

- Dispose of hazardous materials and their containers properly. Never dump products labeled as poisonous, corrosive, caustic, flammable, inflammable, volatile, explosive danger, warning, caution or dangerous outdoors, in a storm drain, into sinks, toilets or drains. Call the Water Outreach Coordinator at 721-5208 for more information.
- With some products, disposal can be avoided altogether if you can purchase a small volume of the material, so that none is left over. If

you have extra at the end of project, you may be able to find a friend or neighbor who can use it.

- Household hazardous wastes are accepted at the Laramie landfill during the summer months
- Check containers containing hazardous materials frequently for signs of leakage. If a container is rusty and has the potential of leaking soon, place it in a secondary container before the leak occurs and prevent a clean-up problem.
- Store hazardous materials containers under cover and off the ground. Keep them out of the weather to avoid rusting, freezing, cracking, labels being washed off, etc. Hazardous materials should be stored out of the reach of children. Never transfer to or store these materials in food or beverage containers that could be misinterpreted by a child as something to eat or drink.
- Keep appropriate spill cleanup materials on hand. Kitty litter is good for many oil-based spills.
- Ground cloths and drip pans must be used under any work outdoors that involves hazardous materials such as oil-based paints, stains, rust removers, masonry cleaners, and others bearing label warnings as outlined above.
- Latex paints are not a hazardous waste, but are not accepted in liquid form at the landfill. To dispose, leave uncovered in a protected place until dry, then place in the garbage. If you wish to dry waste paint quickly, just pour kitty litter in the can to absorb the paint. Once paint is dry, leave the lid off when you place it in the garbage so your garbage collector can see that it is no longer liquid.
- Use less toxic products whenever possible. The Water Outreach Coordinator (721-5208) has information detailing alternatives to toxic products.
- If an activity involving the use of a hazardous material can be moved indoors out of the weather, then do so. Make sure you can provide proper ventilation, however. Follow manufacturer's directions in the use of all materials. Over-application of yard chemicals, for instance, can result in the washing of these compounds into receiving water bodies. Never apply pesticides when rain is expected.
- When hazardous materials are in use, place the container inside a tub or bucket to minimize spills.

RESIDENTIAL WELLHEAD MAINTENANCE

The following suggestions are taken from DEQ's 1998 Rural Wellhead Protection Fact Sheet:

Existing wells must be maintained and operated correctly to prevent well deterioration and aid in preventing contamination of your water supply. Similar to your car or tractor, your well needs regular maintenance. This maintenance includes simple measures; such as, keeping the wellhead area clean and accessible, and moving any pollutants as far away from the well as possible. Other more extensive measures may involve hiring a qualified pump installer or well technician to inspect the operation of the pump and the integrity of the well casing. Many problems can be prevented by following proper well design and installation practices during the construction of the well. Your well should also be sampled regularly to verify that no contaminants are present in the water.

BEST MANAGEMENT PRACTICES

General procedures for protecting your water supply wells should include use of backflow preventers and plastic nurse tanks, and maintaining a slope or curb that directs surface runoff away from the wellhead. Minimum maintenance on a well should include an annual check of the well and any treatment system. It is your responsibility to maintain your well in good condition to protect the quality of groundwater.

BACKFLOW PREVENTERS

If you mix pesticides or fertilizers in tanks next to your wellhead or do fertigation and/or chemigation at irrigation wellheads, a backflow prevention device is required. Fertigation is the process of adding fertilizers to irrigation water at the wellhead. Chemigation is the addition of chemicals such as pesticides to irrigation water at the wellhead. Chemigation at a wellhead is not recommended, and it may require the issuance of a Chapter III Permit from the Wyoming Department of Environmental Quality, Water Quality Division (WDEQ/WQD).

A backflow prevention device will prevent chemicals from flowing back into the well or back-siphoning, which can directly contaminate the groundwater when the well pump is turned off. Simple backflow preventers are also recommended for common household water uses such as laundry tubs, sinks, dishwashers, washing machines, and outside hydrants used to fill tanks. Maintaining an air gap between the hoses/ faucets and the well will prevent the backflow of contaminated water. Any household appliances that require a cross-connection between potable and non-potable water need to have backflow preventers.

NURSE TANKS

It is highly recommended that any fertilizers, pesticides, or other chemicals be mixed and loaded in an area that is as far away from the wellhead as feasible; a minimum distance of 100 ft. is recommended. The use of inexpensive nurse tanks is recommended to allow mixing in the field. They can be filled with water at the wellhead and transported to the field far from the wellhead for mixing. Sprayer tanks can then be filled from the nurse tanks in the field. Nurse tanks and chemical storage containers should be thoroughly rinsed before being stored or thrown away. The rinsing water should be disposed of in an acceptable manner, such as applying it to fields at normal application rates.

SURFACE WATER PROTECTION

A finished cement cap is typically placed at the wellhead. The cement cap is sloped away from the well to prevent water from surface runoff accumulating at the top of the casing. If an existing well does not have this cement cap, it is recommended that a cap be installed to a depth extending just below the frost line. The ground surface needs to be built up and mounded around the wellhead. If water accumulates and ponds in a low area near the well, berms or curbs need to be placed in appropriate locations surrounding the well to divert runoff from the wellhead. Soil berms and mounds need to be checked periodically and repaired as needed.

WELL MAINTENANCE

Regular maintenance checks should be completed on your well. You may need to disinfect your well, pressure tanks, and distribution system. Artesian or flowing wells normally require more maintenance because the valves and casings must prevent leakage and withstand the pressure exerted by the water.

WELL DISINFECTION

Before drilling, a contractor should disinfect all bits, tools, pumps and any other material that may enter the drill hole during the drilling process. All filter pack material and drilling water should be disinfected. A common disinfection chemical treatment is chlorination, which normally requires some type of agitation to effectively kill bacteria. The contractor should also disinfect the well, pump, and piping after completion of the well. The process of disinfecting a well involves the addition of a disinfection agent, such as a form of chlorine like calcium hypochlorite or sodium hypochlorite tablets, combined with physical agitation to disinfect the entire well borehole. After agitation, the disinfecting solution should be left in the well for at least four hours. The piping, storage tanks, pump, pressure tanks, and distribution system should also be disinfected by pumping the disinfecting solution into the system and leaving it in the system for at least two hours. Before placing the well system back into service the chlorine residue needs to be flushed from the system.

WELL YIELD

Every well should have a pump test done after it is installed. The owner of the well should keep copies of these tests and any other well records. Information about your well may be available from the Wyoming State Engineer's Office ((307) 777-7354). Periodically, the well performance should be tested by measuring the highest sustainable well pumping rate in gallons per minute for a period of continuous pumping. If 10 - 15% reductions are measured in yield, the cause(s) of decreased yield need to be identified and corrected. If a 25% or greater reduction in yield is measured, the money required to fix the problems may be better applied to the installation of a new well.

The type of aquifer that a well is installed in will affect how frequently maintenance is required to increase well yields. Shallow wells located in alluvial sands and gravels will require more frequent maintenance. Municipal water supply wells in alluvial aquifers require maintenance every 2 - 5 years. Reductions in well yields may be caused by the following problems: 1) plugging of the screen or the formation around the well caused by incrustation or biofouling; 2) plugging of formation by fine particles; 3) pumping sand; 4) collapse of well casing or screen; and 5) a damaged pump.

WELL REHABILITATION

Correcting the problems described above will typically require a qualified water well contractor. Many of the problems described above may be prevented by following proper well design and installation practices. The procedure for cleaning up plugging caused by mineral deposits requires treating the well with strong acids that should only be attempted by qualified well technicians. Biofouling may be prevented by disinfecting all downhole equipment and materials during well installation. Physical plugging of wells and the pumping of sand can be prevented by proper well design and thorough well development during installation. Adding polyphosphates or surfactants added to a well, combined with thorough physical agitation will help to remove fine material from the formation. Corrosion of a well casing and screen can be prevented by using the correct well casing materials. Installation of cathodic protection may be required on existing wells to reduce corrosion rates. Well pumps may be damaged in wells without well screens and/or filter packs or wells with improperly sized well screens and/or filter packs. Replacing the pump in an improperly constructed well is not a good solution, since the new pump will eventually fail. A better alternative may be to replace the screen or place an inner screen in the well. If it is difficult and expensive to improve the performance of an existing well, it may be wiser and more economical to drill a new well.

WELL SAMPLING

Well water should be sampled on at least an annual basis. Sample your well any time you think a health problem may be caused by a disease producing microorganism in your water supply, or if you notice significant changes in the taste, smell, or color of the water. At a minimum, the laboratory should analyze for the following parameters: pH, nitrates, ammonia, total coliform bacteria, and total dissolved solids. If you suspect any other contaminants, such as hydrocarbons from petroleum leaks or spills, or spills of pesticide liquids, include these specific parameters in the test. If any parameters in your well exceed acceptable limits, always retest immediately to verify the first test.

The state of Wyoming has two state laboratories (see References/Contacts) in Cheyenne and Laramie that will analyze your samples. Your UW Cooperative Extension Service (UWCES) county office or local health department should have a current listing of local private laboratories that will also conduct water analyses.

If your water system contains over (1) coliform bacteria per 100 milliliters, it may not be safe to drink due to bacteriologic contamination. Contact a qualified well contractor to disinfect your well; tanks, and distribution system. If the sample was taken at your water tap, the bacteria may be present within your pressure tank or distribution system. Exposure of the well or piping system is sometimes necessary in order to perform various procedures such as repairs or maintenance. Please remember that whenever the well or piping system is exposed, it may be invaded by foreign matter that contains bacteria. The well system should be disinfected prior to placing it back into service.

All back-siphoning occurrences or major spills or leaks must be reported to the WDEQ/WQD. To report and receive assistance, please call the 24-hr Emergency Contact of the DEQ/Water Quality Department, at (307) 777-7781. If you are calling between 8 a.m. - 5 p.m., please ask to talk with someone concerning the spill response program.

REFERENCES/CONTACTS

REFERENCES

DRINKING WATER QUALITY STANDARDS

U.S. Environmental Protection Agency's Safe Drinking Water Hotline. Call toll free 1-800-426-4791 from 8:30 A.M. to 5:00 P.M. Eastern Time.

CONTACTS

STATE/FEDERAL AGENCIES

Wyoming Dept. of Environmental Quality, Water Quality Division, 122 W. 25th St. 4W, Cheyenne, WY 82002, (307)777-7781.

Wyoming State Engineers Office, 122 W. 25th St. Herschler Bldg., 4E, Cheyenne, WY 82002, (307)777-7354.

Geological Survey of Wyoming, P.O. Box 3008, University Station, Laramie, WY 82071-3008, (307)766-2286.

U.S. Geological Survey, Water Resources Division, 2617 E. Lincolnway, Cheyenne, WY 82007, (307)772-2153.

U.S. Environmental Protection Agency, Region VIII, 999 18th St., Suite 500, Denver, CO 80202-2466, 1-800-227-8917.

University of Wyoming Water Resources Center, P.O. Box 3067, University Station, Laramie, WY 82071-3067, (307)766-2143.

STATE LABORATORIES/ INFORMATION:

Wyoming Department of Agriculture Analytical Services Laboratory, 1174 Snowy Range Road, Laramie, WY 82070. (307) 742-2984.

Wyoming Department of Health/Preventative Medicine Division - Public Health Laboratory, Cheyenne, WY. (307)777-7431. If you live in Laramie Co., contact a sanitarian in the Cheyenne Laramie Co. Health Department to perform the sampling of your water well. (307) 633-4090.

County Health Departments or County Extension Agents.

APPENDIX I

ALBANY COUNTY AQUIFER PROTECTION RESOLUTION AND CITY OF LARAMIE AQUIFER PROTECTION ORDINANCE

Aquifer Protection Plan approved by the Albany County Board of County Commissioners on June 18, 2002

Section 9. Aquifer Protection Overlay Zone.

A. Legislative Findings. Approximately 60% of the City of Laramie's municipal water supply and 100% of the water to approximately 450 rural residences comes from wells and springs in the Casper Formation aquifer. The Casper Formation is exposed along the west side of the Laramie Range and is vulnerable to contamination for these reasons:

1. Points of withdrawal (municipal and domestic wells) are in close proximity to the recharge area;

2. The aquifer is fractured and has extensive exposures of porous sandstones; and

3. Interstate Highway 80 cuts through the entire thickness of the Casper Formation. Numerous hazardous substances are transported each day over I-80.

4. The Casper Formation is exposed at the ground surface on the west flank of the Laramie Range.

The City of Laramie/Albany County Environmental Advisory Committee (EAC) has members with expertise in groundwater science. The Environmental Advisory Committee has developed the Casper Aquifer Protection Plan. One of the EAC's priority recommendations is the establishment of an overlay zone which defines setbacks from recharge features and prohibition of inappropriate land uses.

The Casper Formation is overlain by the Satanka Formation. The bottom fifty feet of the Satanka Formation are fractured and are probably in hydraulic communication with the Casper Formation. Generally the Satanka Formation serves as a confining layer above the Casper aquifer, retarding the flow of water upward out of the Casper Formation and the flow of water downward to the Casper Formation. The EAC recommends a safety factor of seventy-five feet of Satanka Formation above the Casper Formation as adequate to reduce the risk of contamination to acceptable levels.

To safeguard the Casper aquifer wells and springs which provide 60% of the City of Laramie's municipal water and 100% of the water to approximately 450 rural residences, the Board of County Commissioners adopts this resolution.

B. Aquifer Protection Overlay Zone Established.

1. There is established within the unincorporated area of Albany County an aquifer protection overlay zone (APO zone). The APO zone is effective outside of the

City of Laramie corporate limits at all locations where the upper boundary of the Casper Formation is not covered by at least 75 feet of the overlying Satanka Formation naturally in place, whether the reduction in thickness of the Satanka Formation is due to natural causes or is man-made.

2. Initial delineation of the APO zone shall be as described by the Aquifer Protection Plan approved by the Board of County Commissioners on June 18, 2002. Copies of the illustrations which accompany the Aquifer Protection Plan shall be kept in appropriate County offices. All property within zones 2 and 3 are zoned APO by default. Property west of the western boundary of Zone 2 shall be included in the APO zone if in the opinion of the Planner or designee based upon geologic evidence, there is less than 75 feet of Satanka Formation overlying the Casper Formation at that location. If such determination is made, the APO zone area shall be amended accordingly.

3. Any aggrieved person who believes that all or part of a parcel of property included in the APO should not be included may request that the Planner or designee redetermine whether the property is correctly included. Redetermination shall not be made except upon clear and convincing evidence that at least 75 feet of undisturbed Satanka Formation overlies the Casper Formation at the location in dispute. Evidence based upon opinion alone without sound geologic field control is unacceptable. Before making a decision, the County may submit the evidence to qualified professionals for analysis, and may obtain independent evidence bearing upon the question. Costs of professional consultation to the County shall be reimbursed to the County by the aggrieved person.

4. Any person aggrieved in fact by an administrative decision under this section may appeal the decision to the Planning and Zoning Commission for review and recommendation to the Board of County Commissioners for determination.

C. Allowed and Prohibited Uses.

1. Within APO zone, the underlying zoning classification shall control all aspects of the property's zoning except that no property may be used for any use prohibited in subsection 3.C. below.

2. For the purposes of this regulation, "hazardous material" means (i) any hazardous substance as defined in 40 CFR 302.4 and listed therein at Table 302.4; (ii) any hazardous waste as defined in Wyoming law including, but not limited to, the Wyoming Department of Environmental Quality hazardous waste rules and regulations as may be amended from time to time; (iii) any pesticide as defined in Wyoming law; or (iv) any oil or petroleum.

3. Each prohibited activity listed in Column 1 of the table below in this section is prohibited in the APO zone.

Table of Prohibited Activities

Column 1 Prohibited Activity **The following activities are prohibited in the APO zone:**	**Column 2 Examples** **The following are examples of** **business or activity which conduct** **the prohibited activity.**
1. Activities involving any equipment for the underground storage or transmission of oil or petroleum to the extent that it is not pre-empted by federal law; or hazardous material.	Any business or facility. Some examples include automotive service station, gasoline station, fleet garage
2. The discharge to ground water of any waste product.	Any business or facility.
3. Car or truck washing, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	Car or truck washes.
4. Production or refining of chemicals, including without limitation hazardous materials or asphalt.	Chemical, petroleum, asphalt, or pesticide manufacturer.
5. Clothes or cloth cleaning service which involves the use, storage, or disposal of hazardous materials including without limitation dry-cleaning solvents.	Dry cleaner.
6. Generation of electrical power by means of fossil fuels except generation by means of natural gas or propane	Fossil-fueled electric power producer.
7. Production of electronic boards, electrical components, or other electrical equipment involving the use, storage, or disposal of any hazardous material or involving metal plating, degreasing of parts or equipment, or etching operations.	Electronic circuit board, electrical components or other electrical equipment manufacturer.
8. On-site storage of oil or petroleum for the purpose of wholesale or retail sale.	Bulk plant.
9. Embalming or crematory services which involve the use, storage or disposal of hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	Funeral home or crematory.
10. Furniture stripping operations which involve the use, storage, or disposal of hazardous materials.	Furniture stripper.
11. Furniture finishing operations which involve the use, storage, or disposal of hazardous materials, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	Furniture repair.
12. Storage, treatment, or disposal of hazardous waste permitted under Wyoming law.	Hazardous waste treatment, storage, or disposal facility.
13. Clothes or cloth cleaning service for any industrial activity that involves the cleaning of clothes or cloth contaminated by hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	Industrial laundry.
14. Any biological or chemical testing, analysis or research which involves the use, storage, or disposal of hazardous material.	Laboratory: biological, chemical, clinical, educational, product testing, or research.

15. Pest control services which involve storage, mixing, or loading of pesticides or other hazardous materials.	Lawn care or pest control service
16. Salvage operations of metal or vehicle parts.	Metal salvage yards, vehicle parts, salvage yards, or junk yards.
17. Photographic finishing which involves the use, storage, or disposal of hazardous materials.	Photographic finishing laboratory.
18. Production, fabrication of metal products which involves the use, storage, or disposal of hazardous materials including (A) metal cleaning or degreasing with industrial solvents; (B) metal plating; (C) metal etching.	Metal foundry, metal finisher, metal machinist, metal fabricator, or metal plating.
19. Printing, plate making, lithography, photoengraving, or gravure, which involves the use, storage, or disposal of hazardous materials.	Printer or publisher.
20. Pulp production, which involves the use, storage or disposal of any hazardous materials.	Pulp, paper, or cardboard manufacturer.
21. Accumulation or storage of waste oil, anti-freeze or spent lead-acid batteries.	Recycling facility which accepts waste oil, spent anti-freeze, or spent lead-acid batteries.
22. Production or processing of rubber, resin cements, elastomers, or plastic, which involves the use, storage or disposal of hazardous materials.	Rubber, plastic, fabric coating, elastomer, or resin cement manufacturer.
23. Any activity listed in this column that is conducted at a residence for compensation.	Residential occupations.
24. Storage of pavement de-icing chemicals unless storage takes place within a weather-tight waterproof structure for the purpose of retail sale, or for the purpose of de-icing parking areas or access roads to parking areas.	Salt storage facilities.
25. The accumulation, storage, handling, recycling, disposal, reduction, processing, burning, transfer, or composting of solid waste except for a potable water treatment sludge disposal area.	Solid waste facility or intermediate processing center.
26. Finishing or etching of stone, clay, concrete or glass products, or painting of clay products which involves the use, storage, or disposal of hazardous materials.	Stone, clay or glass products manufacturer.
27. Dying, coating or printing of textiles, or tanning or finishing of leather, which involves the use, storage, or disposal of hazardous materials.	Textile mill, tannery.
28. Repair or maintenance of automotive or marine vehicles or internal combustion engines of vehicles, involving the use, storage, or disposal of hazardous materials, including solvents, lubricants, paints, brake or transmission fluids, or the generation of hazardous wastes.	Vehicle service facilities which may include: new or used car dealership, automobile body repair or paint shop, aircraft repair shop, automobile radiator, or transmission repair; boat dealer; recreational vehicle dealer; motorcycle dealer; truck dealer; truck stop; diesel service station; automotive service station, municipal garage, employee fleet maintenance garage, or construction equipment repair or rental.
29. On-site storage of hazardous materials for the purpose of wholesale or retail sale.	Wholesale trade, storage or warehousing of hazardous substances, hazardous wastes, pesticides or oil or petroleum.
30. Production or treatment of wood, veneer, plywood, or	Manufacturer of wood veneer, plywood, or reconstituted wood

reconstituted wood, which involves the use, storage or disposal of any hazardous material.	products.
31. Injection wells All UIC except Class V subclasses 5B1, 5B2, 5B4, 5B5, 5B6, and 5B7, as defined in WDEQ Chapter 16 as beneficial use UIC wells, should be prohibited in the Casper Aquifer protection area.	
32. Water wells which are not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface, or in accordance with the state engineer's requirements or recommendations, whichever is stricter.	Residential uses.
33. Application of pesticides and herbicides which do not become non-hazardous within 48 hours of application or which are not applied according to the manufacturer's instructions..	
34. Application of fertilizer at greater than the agronomic uptake rate of the vegetation fertilized.	
35. Quarrying and sand and gravel mining to the extent that such prohibition is not violative of state law, particularly Wyoming statutes, S. 18-5-201.	

D. Setbacks from vulnerable features.

1. *Vulnerable features* in the Casper Formation are:

a. Faults and fracture zones which intercept the ground surface and have apertures of greater than one centimeter. Fractures may extend as far as 150 feet from the fault trace.

b. Folds which extend to the ground surface.

c. Exposed bedrock.

d. Bedrock not overlain by a sufficient thickness of low-permeability materials to prevent the effective downward migration of contaminants into the aquifer.

e. Defined drainages.

f. Shallow depth to ground water, defined as any location where no effective confining layer is present over the water-bearing strata within the Casper Formation and the depth to water is less than 70 feet.

2. No person shall install, maintain, or use any on-site wastewater treatment system or wastewater storage system or any private connection to a public wastewater system within 100 feet of a vulnerable feature in the Casper Formation.

3. Within the APO, no permit shall be issued for any wastewater system until the applicant demonstrates to the Planner or designee that there are no vulnerable features in the Casper Formation within 100 feet of any point of the proposed system. Proof shall be at least the signed

and stamped written opinion of a Wyoming licensed professional engineer or Wyoming licensed professional geologist. The Planner or designee may review independently obtained evidence and records in arriving at a decision under this subsection. If material not supplied by the applicant is used in the decision, the applicant shall be given notice of the material used and an opportunity to comment on it before a final decision is reached. Aggrieved parties may appeal the decision to the Board of County Commissioners.

E. Design standards for on-site wastewater treatment systems.

1. Installation, design, repair, and removal of septic systems located within the APO zone must be in accordance with plans and specifications certified by a professional engineer registered to practice in the State of Wyoming. This resolution does not grant the right to install a septic system or small wastewater treatment system otherwise forbidden by County resolutions.

2. Each septic system and leach field within the APO shall be inspected by a person qualified by education or training to inspect small wastewater systems

a. During installation before backfilling;

b. At least once each three years.

If upon inspection a septic system is found not to be adequately designed or constructed to serve the use to which it is connected without undue risk to the aquifer it shall not be used for the disposal of wastewater until it is cleaned, repaired, or otherwise made to operate adequately, so as not to present an undue risk to the aquifer.

F. Pre-existing nonconforming uses.

Pre-existing nonconforming uses within the APO zone are subject to the terms of this resolution and not to other general resolution provisions on pre-existing nonconforming uses.

1. A pre-existing nonconforming use is a use prohibited by this regulation but which is in place upon property included in the APO zone as of the date the property was included in the APO zone. That date may be the effective date of this resolution, or the date a use becomes nonconforming because of an amendment to this resolution. Septic systems and other privately–owned wastewater treatment systems are controlled exclusively under Sections 4 and 5 above and are not subject to these provisions on pre-existing nonconforming uses.

2. Pre-existing nonconforming uses may continue in the same location they were in when they became nonconforming uses, but shall not be expanded in size or scope. Pre-existing nonconforming uses which are damaged may be repaired and resumed at the same location, size, and scope, provided that after repairs are complete, best available control technology shall be in place to prevent contact between hazardous materials and the surface of the ground.

3. A pre-existing nonconforming use may be expanded under these conditions:

a. The expansion does not increase the hazard to the aquifer; or

b. Control technology built in to the expansion will prevent any increased risk to the aquifer because

1) Substitution is made of one hazardous material for another provided the substituted material is used for the same function and in equal or lesser amounts as the original material;

2) Substitution of equipment or process for equipment or process provided that the substituted equipment or process performs the same function as the original equipment or process, without increasing the storage volume of hazardous materials stored at the subject business or facility;

3) Expansion of wholesale or retail sales volume which increases the use of hazardous materials but which does not increase the storage capacity for hazardous material;

4) Initiation at the subject facility or business of an activity that is not a prohibited activity; or

4. Every pre-existing nonconforming use shall:

a. Store hazardous material in an enclosed structure or under a roof which minimizes storm water entry to the containment area.

b. Provide floors within a structure where hazardous material is stored, coated to protect the surface of the floor from deterioration due to spillage of any such material. A structure which may be used for storage or transfer of hazardous material shall be protected from storm water run-on and ground water intrusion.

c. Store hazardous material within an impermeable containment area which is capable of containing at least the volume of the largest container of such hazardous material present in the area, or 10% of the total volume of all such containers in the area, whichever is larger, without overflow of released hazardous material from the containment area.

d. Store hazardous material in a manner that will prevent the contact of chemicals with any materials so as to create a hazard of fire, explosion, or generation of toxic substances.

e. Store hazardous materials only in a container that has been certified by a state or federal agency or the American Society of Testing Materials as suitable for the transport or storage of the material.

f. Store all hazardous material in an area secured against entry by the public, except items offered for retail sale in their original unopened containers.

g. Not use, maintain, or install floor drains, dry wells, or other infiltration devices or appurtenances which allow the release of wastewater to the ground water.

h. Not discharge any substance or material to the ground in the APO zone unless the discharge is permitted by law.

These requirements are intended to supplement, and not to supersede, any other applicable requirements of federal, state, or local law.

The Planner or designee is authorized to promulgate rules and regulations under the Wyoming Administrative Procedure Act concerning the kind and amount of information which the owner of a pre-existing nonconforming use must provide to enable the Planner or designee to make an informed decision under this section. Appeals from the decision under this section shall be taken to the Board of County Commissioners.

G. Existing law on aquifer contamination unaffected.

The establishment of the APO zone, and the use of APO-zoned properties in accord with this resolution, does not relieve any person from liability provided by law for contamination of the aquifer. This resolution does not supersede or modify the requirements of any federal, state or local law which makes stricter requirements.

H. Severability.

The provisions of this resolution are severable. If any provision is declared to be invalid or unenforceable by any court of competent jurisdiction, those provisions not so declared shall remain in effect.

ORIGINAL ORDINANCE NO. 1748A INTRODUCED BY: CARSON

ENROLLED ORDINANCE NO. 1527

AN ORDINANCE TO REPLACE LARAMIE MUNICIPAL CODE CHAPTER 17.82 THE AQUIFER PROTECTION OVERLAY ZONE IN ITS ENTIRETY FOR THE LONG TERM PROTECTION OF THE CITY OF LARAMIE'S MUNICIPAL WATER SUPPLY.

Whereas, the Council for the City of Laramie (City) has reaffirmed that safeguarding the City's drinking water provided by the Casper Aquifer is critical to the protection of public health, safety and welfare within the City;

Whereas, the Casper Aquifer supplies more than sixty percent (60%) of the City's fresh drinking water and one hundred percent (100%) of the fresh drinking water to the rural homeowners that fall within the Casper Aquifer Recharge Area;

Whereas, the delineated recharge area of the Casper Aquifer encompasses approximately seventy-two (72) square miles that lie east of the City and extends to the crest of the Laramie Range. The northern boundary is five (5) miles north of the City limits and the southern boundary is approximately six (6) miles south of the City limits. The City's four (4) municipal wellfields are included in the area. Exposure of the Casper Formation in the delineated area results in increased vulnerability to contamination from land uses;

Whereas, inappropriate development on the Aquifer Protection Overlay Zone can adversely affect the quality of the City's drinking water through the intentional or unintentional release of contaminants which is harmful to the health, safety and welfare of City residents;

Whereas, pursuant to Wyo. Stat. § 15-1-601 the City has the authority to adopt zoning and zoning districts to regulate development;

Whereas, the City has the authority pursuant to W.S. § 15-7-101 (a) (ii) and (iii) to regulate water systems supplying water to its inhabitants;

Whereas, pursuant to W.S. § 15-1-103 (a) (xli), the City further has the authority to adopt an ordinance which is necessary for the health, safety and welfare of the City, and necessary to give effect to the powers authorized by the State;

Whereas, the City, in Resolution 2002-02, charged the Environmental Advisory Committee (EAC) to study and monitor the groundwater quality and formulate an aquifer protection plan;

Whereas, in 2002, the City adopted the Casper Aquifer Protection Plan that provides scientific analysis, conclusions and policies for the protection of the Casper Aquifer;

Whereas, in 2002, the City adopted Ordinance No. 1404, establishing the Aquifer Protection Overlay Zone providing development standards for properties within the boundaries of the Casper Aquifer Protection Area;

Whereas, on August 21, 2007, the City Council adopted the Laramie Comprehensive Plan which states that protection of the Casper Aquifer is of high priority, listed as a vulnerable feature and is the primary water supply for City residents;

Whereas, on August 31, 2006 due to growing concerns on the quality of the Casper Aquifer, members of the public petitioned the Laramie Planning Commission to amend the Land Use Element to protect the Casper Aquifer from land uses that are incompatible with vulnerable areas and the water quality of the Casper Aquifer;

Whereas, on September 13, 2006, the Laramie Planning Commission acknowledged the petition, took public comments and forwarded the petition to the City Council for acknowledgment and direction;

Whereas, on October 3, 2006, the City Council acknowledged the petition, took public comments and remanded the petition back to the Laramie Planning Commission for further review, analysis and its recommendation on possible amendments to the Aquifer Protection Overlay Zone. It was also determined that a temporary moratorium to suspend new building permits for development and subdivisions in the Aquifer Protection Overlay Zone is necessary until an updated Plan is completed and/or ordinance amending Chapter 17.82 of the Laramie Municipal Code is adopted;

Whereas, on October 25, 2006, the City Planning Commission held a public hearing, which notice was given at least fifteen (15) days prior to hearing, and determined that a temporary moratorium suspending new building permits for development and subdivisions in the Aquifer Protection Overlay Zone is necessary until an updated Plan is completed and/or an ordinance amending Chapter 17.82 of the Laramie Municipal Code is adopted;

Whereas, the City has the authority to implement a temporary moratorium under Wyo. Stat. § 15-1-103 (a) (xxxi), to take any action to regulate as deemed necessary any public water sources or supplies within the City;

Whereas, on November 8, 2006, the City Council enacted Enrolled Ordinance No. 1500, placing a temporary moratorium on new building permits and subdivisions within the Aquifer Protection Overlay Zone, for a period not to exceed ninety (90) days, or until the effective date of the ordinance amending the Aquifer Protection Overlay Zone, or until the adoption of an updated Casper Aquifer Protection Plan by the City Council;

Whereas, on February 6, 2007, the City Council enacted Enrolled Ordinance No. 1506 extending Enrolled Ordinance No. 1500, to March 12, 2008 to ensure there is sufficient amount of time for the adoption of an ordinance amending the Aquifer Protection Overlay Zone and publication of said ordinance;

Whereas, The City Council passed City Resolution 2006-78 authorizing the update of the Casper Aquifer Protection Plan;

Whereas, on February 7, 2008 notice of the joint Laramie Planning Commission and Albany County Planning and Zoning Commission meeting to be held on February 11, 2008 was mailed to all City property owners within the proposed Aquifer Protection Overlay Zone and within 300 feet of the proposed Aquifer Protection Overlay Zone;

Whereas, on February 11, 2008 the City of Laramie Planning Commission and the Albany County Planning and Zoning Commission held a joint meeting to discuss updates to the Casper Aquifer Protection Plan, Aquifer Protection Ordinance and Resolution and took public comment;

Whereas, on February 25, 2008 the City of Laramie Planning Commission recommended approval of the Casper Aquifer Protection Plan and Aquifer Protection Ordinance to the City Council;

Whereas, on February 26, 2008 the Laramie City Council held a work session related to updates to the Casper Aquifer Protection Plan and Aquifer Protection Ordinance and took public comment;

Whereas, on March 4, 2008 the Laramie City Council held 1st reading of the Aquifer Protection Ordinance and took public comment;

Whereas, on March 5, 2008 notice of the March 25, 2008 public hearing was mailed to all City property owners within the proposed Aquifer Protection Overlay Zone and within 300 feet of the proposed Aquifer Protection Overlay Zone;

Whereas, on March 9, 2008 and March 23, 2008 a notice of public hearing was published in the Laramie Boomerang;

Whereas, on March 25, 2008 the Laramie City Council held a public hearing on the Aquifer Protection Ordinance;

Whereas, on May 6 and May 20, 2008 the Laramie City Council held 2nd readings on the Aquifer Protection Ordinance and took additional public comments.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF LARAMIE:

Section 1.
17.82.010 Legislative Findings.

More than half of the City of Laramie's municipal water supply and all of the drinking water supplied to Albany County rural residences comes from wells and springs in the Casper Aquifer. The delineated recharge area of the Casper Aquifer Protection Area (CAPA) encompasses approximately seventy-two (72) square miles that lie east of the City of Laramie and extends to the crest of the Laramie Range. The north and south boundaries are approximately five (5) and six (6) miles north and south, respectively of Laramie's city limits. Approximately 450 Albany County residents and four (4) City of Laramie municipal wellfields draw water from the Casper Aquifer in this area. The vast majority of the CAPA is the recharge area for the Casper Aquifer, and consequently, the Casper Aquifer is vulnerable to contamination from land uses in the CAPA. Exposure of the Casper Aquifer in the delineated area results in increased vulnerability to contamination from land uses. In addition to the general vulnerability of the Casper Aquifer in the area where aquifer materials are exposed at the surface, there are specific features that enhance the vulnerability of the aquifer to contamination.

A. Recharge into the Casper Aquifer system occurs rapidly as snowmelt and runoff infiltrates into porous sandstones and fractures that occur in drainages and on the land surface.

B. There is continuous residential and commercial development pressure east of Laramie where the Casper Aquifer is recharged. Development in this area increases the risk of contamination in two ways:

   1. <u>New contamination sources</u> – Homes and businesses are new sources of potential contamination to the aquifer (volatile organic compounds from fuels and solvents, nutrient fertilizers and pesticides from lawn care, nitrates and pathogens from septic leachate).

   2. <u>New contamination pathways</u> – New wells and excavations which weaken the integrity of the confining layer may provide a direct conduit to the Casper Aquifer or reduce the hydraulic barrier provided by the Satanka Shale that overlies the Casper Aquifer.

C. An unknown quantity of hazardous substances is transported along Interstate 80 (I-80) and I-80 transects the Casper Aquifer recharge area.

D. There is the potential for the rapid transport of contaminants in the saturated zone due to a steep hydraulic gradient and enhanced aquifer permeability from fractures, joints, and dissolution features.

E. The recharge area of the Casper Aquifer is in close physical proximity to withdrawal points for Albany County and City of Laramie residents.

The Laramie City Council adopts this ordinance because the Casper Aquifer provides a critical component of the existing and future drinking water supply for City residents – especially in drought conditions. The importance of the groundwater supply component was demonstrated in the summer of 2002 when the Laramie River supply was reduced significantly due to drought and the City had to rely almost exclusively on groundwater.

Section 2.
17.82.020 Purpose and Intent

Inappropriate development over the Casper Aquifer can deteriorate the quality of the drinking water through the intentional or unintentional release of contaminants which is harmful to the health, safety, and welfare of residents. Therefore, the purpose and intent of this ordinance is to protect the high quality source water in the Casper Aquifer and to decrease the risk of contamination to the Casper Aquifer.

Section 3.
17.82.030 Definitions

For the purpose of this Aquifer Protection Overlay Zone ordinance, the following words and terms shall have the meanings specified herein.

A. "Aquifer" means a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells, springs, and drain tunnels.

B. "City" means City of Laramie, Wyoming.

C. "City Council" means the City Council of the City of Laramie, Wyoming.

D. "Commercial" means an activity involving the sale of goods or services.

E. "Commission" means the Planning Commission of the City of Laramie, Wyoming.

F. "County" means Albany County, Wyoming.

G. "Development" means the preliminary and final platting of land, construction, reconstruction, conversion, structural alteration, relocation, or enlargement of any structure; any mine, excavation, landfill; and/or any change in use, or alteration or extension of the use of land**;** excluded from this definition are additions to single-family residences that do not increase the amount of wastewater effluent, above the capacity of the permitted small wastewater system (effluent amount determined by number of bedrooms), residential accessory buildings, construction of a single-family home on an existing lot that will be attached to a municipal or centralized sewer collection line, or construction that does not require a building permit.

H. "Development Department" means the Community Development Department of the City of Laramie, Wyoming.

I. "Hazardous Material" means any: chemical; combustible liquid; compressed gas; explosive; flammable aerosol, gas, liquid or solid; hazardous chemical; health hazard; mixture; organic peroxide, oxidizer; physical hazard; pyrophoric; unstable (reactive) or water reactive, as defined in 40 CFR 302.4 and listed therein Table 302.4 and any other chemical, material or substance identified by the State or the Commission as hazardous based on available scientific evidence but does not include natural gas or propane used to heat homes and businesses or the associated transmission lines. Hazardous materials include, but are not limited to, petroleum products, solvents, oil-based paint, and pesticides.

J. "Home occupation" means a business, profession, occupation or trade conducted for personal gain or support of the residential occupation and conducted within a residential building or accessory structure to a residential use.

K. "Overlay District" means a district that is superimposed over one or more zoning districts or parts of districts and imposes specified requirements that are in addition to those otherwise applicable for the underlying zone.

L. “Person” means and includes any individual, entity or association of individuals or entities of any kind, and includes without limitation, any developer, homeowner's association, group, partnership, limited partnership, corporation, joint venture, joint enterprise, trade association, regulatory government body including the City or any other legal entity.

M. “Potential contaminant” means any substance which may enter the Casper Aquifer and decrease water quality due to its introduction into the Casper Aquifer. Some examples include storm water, petroleum products, medical wastes, pesticides, and sewage effluent.

N. “Vulnerable feature” means any fault, fracture, fold, evidence of conduit flow, perennial drainage, intermittent drainage or ephemeral drainage.

Words that are not defined in this section shall be defined by the Laramie Municipal Code and then the common usage of the word.

Section 4.
17.82.040 Aquifer Protection Overlay Zone Established and Applicability.

A. An aquifer protection overlay zone (APO zone) has been established within the incorporated City of Laramie, Wyoming and unincorporated area of Albany County. This Chapter is effective inside the City of Laramie corporate limits, and as delineated in the Casper Aquifer Protection Plan (CAPP) and in the attached map.

B. Delineation of the APO zone shall be as described by the CAPP approved by the City Council on June 3, 2008 and a map of the area has been included as Attachment A. Copies of the illustrations that accompany the CAPP shall be kept in appropriate City offices. All property within Zones 1, 2, and 3 are zoned APO by default.

C. Where the boundary line of the APO zone divides a lot or other parcel of land, the requirements established by this ordinance shall apply only to the portion of the lot or parcel that is located within the APO zone.

D. The establishment of the APO zone and the use of the APO zoned properties in accordance with this ordinance do not relieve any Person from liability provided by law for contamination of the Casper Aquifer. This ordinance does not supersede or modify the requirements of any federal law, state law, or local regulation that has more stringent requirements.

E. Where the bounds of the identified CAPA, as delineated, are in doubt or in dispute, any landowner aggrieved by such delineation may appeal the boundary location to the City Planning Commission. Upon receipt of a written appeal, the City Planning Commission shall suspend further action on development plans related to the area under appeal and shall engage, at the landowner's expense, a qualified hydrogeologist to prepare a report determining the proper location and extent of the Casper Aquifer and recharge area relative to the property in question.

F. Pursuant to W.S. § 15-1-609, the decision of the Planning Commission may be reviewed by the district court in the same manner as provided in Rule 12 of the Wyoming Rules of Appellate Procedure, for review of decisions of boards of adjustment.

G. Applications filed and accepted after the effective date of this ordinance shall meet the requirements of this ordinance.

H. Where this ordinance is less strict or where this ordinance is silent as to a particular issue, developments shall conform to the requirements of the underlying zoning district(s) in which the developments are located.

Section 5.
17.82.050 Groundwater Monitoring Program Implementation.

The City of Laramie, in cooperation with Albany County, shall implement the groundwater monitoring program as described in the Casper Aquifer Protection Plan and Groundwater Monitoring Program.

Section 6.
17.82.060 Prohibited Activity.

A. Within the APO zone, the underlying zoning classification shall control all aspects of the property's zoning except that no property may be used for any activities prohibited in sections 17.82.060.B and 17.82.060.C below or otherwise prohibited or limited by operation of this ordinance.

B. No activities are approved in Zone 1 of the APO except natural and undeveloped open space. Zone 1 is delineated as a 100-foot radius from the municipal wells and any historic springs which are associated with the municipal wells and shall include any expansion of Zone 1 hereafter. The existing wellfields include Spur, Turner, Pope, and Soldier. The historic springs protected in Zone 1 are City Springs, Pope Springs, and Soldier Springs. Any future municipal wells shall be included under this section.

C. Each prohibited activity listed in the left column of the Table of Prohibited Activities below is prohibited in the APO Zones 2 and 3. The Table of Prohibited Activities can not and does not include all possible proposed land uses in the APO. Therefore, the City may review all developments for compliance with this ordinance.

Table of Prohibited Activities

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
1. Activities involving any equipment for the storage or transmission of any hazardous material to the extent that it is not pre-empted by federal law.	Petroleum pipelines or gasoline stations.
2. The discharge to groundwater of any waste product.	Any business or facility.
3. Commercial car or truck washes, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Car or truck washes, detail shops or car dealership.
4. Commercial and home occupation production or refining of chemicals, including without limitation, hazardous materials or asphalt.	Chemical, petroleum, asphalt or pesticide manufacturer.
5. Commercial and home occupation clothes or cloth cleaning service which involves the use, storage, or disposal of hazardous materials, including without limitation, dry-cleaning solvents.	Dry cleaner.
6. Commercial and home occupation generation of electrical power by means of fossil fuels except generation by means of natural gas or propane.	Fossil-fueled electric power producer.
7. Commercial and home occupation production or fabrication of metal products, electronic boards, electrical components, or other electrical equipment involving the use, storage or disposal of any hazardous material or involving metal plating, metal cleaning or degreasing of parts or equipment with industrial solvents, or etching operations.	Metal foundry, metal finisher, metal machinist metal fabricator, metal plating, electronic circuit board, electrical components or other electrical equipment manufacturer.
8. Commercial and home occupation on-site storage of oil, petroleum or gasoline for the purpose of wholesale or retail sale.	Bulk plant, gasoline station or oil and lube shop.

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
9. Commercial and home occupation embalming or crematory services which involve the use, storage or disposal of hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Funeral home or crematory.
10. Commercial and home occupation furniture stripping operations which involve the use, storage or disposal of hazardous materials.	Furniture stripper.
11. Commercial and home occupation furniture finishing operations which involve the use, storage or disposal of hazardous materials.	Furniture repair.
12. Storage, treatment, or disposal of hazardous waste.	Hazardous waste treatment, storage or disposal facility.
13. Commercial and home occupation clothes or cloth cleaning service for any industrial activity that involves the cleaning of clothes or cloth contaminated by hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Industrial laundry.
14. Commercial and home occupation of any biological or chemical testing, analysis or research which involves the use, storage or disposal of hazardous material.	Laboratory: biological, chemical, clinical, educational, product testing or research.
15. Commercial and home occupation pest control businesses which involve storage, mixing or loading of pesticides or other hazardous materials.	Lawn care or pest control business.
16. Commercial and home occupation salvage operations of metal or vehicle parts.	Metal salvage yards, vehicle parts, salvage yards or junk yards.
17. Commercial and home occupation photographic finishing which involves the use, storage, or disposal of hazardous materials.	Photographic finishing laboratory.
18. Commercial and home occupation printing, plate making, lithography, photoengraving or gravure, which involves the use, storage or disposal of hazardous materials.	Printer or publisher.
19. Commercial and home occupation pulp production, which involves the use, storage or disposal of any hazardous materials.	Pulp, paper or cardboard manufacturer.

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
20. Accumulation or storage of waste oil, anti-freeze or spent lead-acid batteries.	Recycling facility which accepts waste oil, spent anti-freeze or spent lead-acid batteries.
21. Commercial and home occupation production or processing of rubber, resin cements, elastomers or plastic, which involves the use, storage or disposal of hazardous materials.	Rubber, plastic, fabric coating, elastomer or resin cement manufacturer.
22. Storage of pavement de-icing chemicals unless storage takes place within a weather-tight waterproof structure.	Salt or de-icing storage facilities.
23. Commercial and home occupation accumulation, storage, handling, recycling, disposal, reduction, processing, burning, transfer or composting of solid waste.	Solid waste facility or intermediate processing center. Landfill or dumps on residential or commercial property (such as cars, appliances, lawn mowers).
24. Commercial and home occupation finishing or etching of stone, clay, concrete or glass products or painting of clay products which involves the use, storage, or disposal of hazardous materials.	Stone, clay or glass products manufacturer.
25. Commercial and home occupation dying, coating or printing of textiles, or tanning or finishing of leather, which involves the use, storage, or disposal of hazardous materials.	Textile mill, tannery.
26. Commercial and home occupations involving the repair or maintenance of automotive or marine vehicles or internal combustion engines of vehicles, involving the use, storage or disposal of hazardous materials, including solvents, lubricants, paints, brake or transmission fluids or the generation of hazardous wastes.	Vehicle service facilities which may include: new or used car dealership, automobile body repair or paint shop, aircraft repair shop, automobile radiator, or transmission repair; small-engine repair; boat dealer; recreational vehicle dealer; motorcycle dealer; truck dealer; truck stop; diesel service station; automotive service station, municipal garage, employee fleet maintenance garage or construction equipment repair or rental.
27. Commercial and home occupation of on-site storage of hazardous materials for the purpose of wholesale or retail sale.	Wholesale trade, storage or warehousing of hazardous substances, hazardous wastes, pesticides, oil or petroleum.
28. Commercial and home occupation production or treatment of wood, veneer, plywood, or reconstituted wood, which involves the use, storage or disposal of any hazardous material.	Manufacturer of wood veneer, plywood or reconstituted wood products.

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
29. All Underground Injection Control (UIC) wells except Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, 5B7, 5E3, 5E4, and 5E5 and Class V subclasses 5A1 and 5A2 , if 5A1 and 5A2 facilities do not use any additives, as defined in WDEQ Chapter 16.	Underground injection control facilities.
30. Water wells which are not capped. Water wells which are not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface, or in accordance with the state engineer's requirements or recommendations, whichever is stricter.	Residential, commercial, or agricultural uses.
31. Application of pesticides and herbicides which do not become non-hazardous within 48 hours of application or which are not applied according to the manufacturer's instructions.	Residential, commercial or agricultural uses.
32. Application of fertilizer at greater than the agronomic uptake rate of the vegetation fertilized.	Residential, commercial or agricultural uses.
33. Commercial and home occupation quarrying and sand and gravel mining unless the operations are conducted pursuant to valid permits issued by the Wyoming Department of Environmental Quality, Bureau of Land Management or other federal or state regulatory agency.	
34. Above ground storage of any hazardous material, including oil and petroleum, unless enclosed in secondary containment as described in Section 17.82.120.D of this ordinance.	Agricultural gasoline storage.
35. Installation and use of on-site wastewater treatment systems or septic-systems.	Residential lots with septic systems or on-site wastewater treatment systems.
36. Commercial and home occupation animal feeding operations where a) animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and b) crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.	Feedlot, concentrated animal feeding operation, stockyards or boarding stable.
37. Commercial and home occupation golf courses or intensely managed turf.	Golf course or driving range.

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
38. Commercial and home occupation cemeteries.	Commercial cemeteries of all types.

Section 7.
17.82.070 Vulnerable Features that require a Setback.

A. Vulnerable features that require a setback in the Casper Aquifer are:

1. Folds, faults, fractures or other evidence of conduit flow that extend to the ground surface.

2. Perennial, intermittent, and ephemeral drainages.

B. No development shall be approved within the APO until the applicant demonstrates to the City that there is no portion of a vulnerable feature within 100 feet of any point of the proposed development. At a minimum, the certification must include a signed and stamped site-specific investigation, as described in Section 17.82.080 of this ordinance, by a Wyoming licensed professional engineer, geologist, hydrologist or other qualified professional who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport.

Section 8.
17.82.080 Site-specific Investigation for All Proposed Developments.

A. A site-specific investigation shall be performed for all developments proposed within the APO Zones 2 and 3. The investigation shall be conducted by a professional engineer or professional geologist who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport.

B. The purpose of the site-specific investigation is to identify, as a minimum, the impacts, if any, of the proposed development(s) on the Casper Aquifer.

C. The site-specific investigation shall describe, to the extent possible given the existing data and site-plan information, the existing conditions, all proposed activities, and all proposed management techniques, including any measures necessary to mitigate risks.

D. The site-specific investigation shall consist of:

1. A literature search to determine the presence of mapped faults, folds, fractures, and other evidence of conduit flow on the subject property.

2. A site narrative that includes historical information on previous land use, contaminant releases, abandoned wells, underground storage tanks, and septic systems as well as any other information relevant to the site.

3. A site plan showing the proposed use and zoning of the property including existing and proposed ground contours accurate to a two-foot interval as referenced to the USGS contour map for the area or other specified elevation standard as required by the City, and for a distance of at least five hundred feet beyond any proposed development activity, existing and proposed structures, parking areas, driveways, landscaping areas, setbacks, surface and subsurface drainage facilities, potential contaminant storage locations and methods of storage, above ground storage tanks, best management practices, utilities, roads, stormwater management, and a vicinity map. Where necessary, specific construction details shall be provided to assure adequacy to accepted design standards.

4. Identification of potential contaminants and amounts stored, generated or handled on the subject property.

5. A field inspection shall be conducted to verify the presence or absence of vulnerable features as defined in Section 7.82.070.A. A summary of the field inspection shall include a written report, maps identifying the vulnerable features, and the distance and direction of the nearest well and vulnerable feature. Where subsurface wastewater disposal is proposed, the investigator shall conduct deep pit soil analysis to a depth at least five feet below the proposed bottom of the leaching system to establish that there are no obstructions such as bedrock, water table or other forms of refusal that could interfere with the proper functioning of the wastewater disposal system.

6. A map showing the area and types of exposed bedrock, marshes, perennial drainages, intermittent drainages, ephemeral drainages, creeks, and other bodies of water on the subject property.

7. Where the 100-year flood plain mapping is unavailable, the professional geologist and/or engineer will calculate the 100-year flood plain for the drainage. The flood plain mapping will be provided on a site map with a scale not to exceed 1 inch equals 200 feet.

8. An evaluation of the water supply and sewage system that includes the potential effects or risks of the systems to the Casper Aquifer and its recharge area and the adequacy and safety of the systems. Items such as floor drains and plumbing schematics and the locations of potential contaminants, waste storage, and liquid transfer area locations shall be provided.

9. A map(s) depicting the potentiometric surface of the Casper Aquifer at the subject property using data from historical water level measurements and published potentiometric surface maps. No new wells shall be drilled for the purpose of determining the potentiometric surface.

10. A surface water risk assessment and mitigation plan for any impacts caused by storm water runoff, retention and/or detention basins on the City water supply and the Casper Aquifer.

11. A maintenance plan and agreement for any retention and/or detention basins and associated improvements will be required. Such plan and agreements shall be recorded in the Albany County Clerk's Office.

12. A groundwater risk assessment and mitigation plan to respond to any evidence of contamination or vulnerability which is the result of the development. Such plan shall not limit the liability of any Person for impacts to the Casper Aquifer.

13. Demonstration of compliance with all applicable City Standards.

Section 9.
17.82.090 Conditions of Approval for Development in the Aquifer Protection Overlay Zone.

A. No development shall be permitted in the APO zone unless the effects of such development meet the following criteria.

1. The proposed type of development and area in which the development is proposed meets the standards of this ordinance.

2. No vulnerable feature, as defined in Section 17.82.070.A exists within 100 feet of the proposed development.

3. A site-specific investigation, as defined in Section 17.82.080 has been performed for the property and a written report, including maps, of the site-specific investigation has been submitted to the City.

4. A professional engineer (the City Engineer or other licensed professional engineer), geologist, hydrologist, or other qualified designee who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport, other than the professional that performed the site-specific investigation, must review the site-specific investigation and verify that the proposed development meets the requirements of this ordinance. If review of the site-specific investigation is conducted by anyone other than the City Engineer, the City may be reimbursed for the cost of the review.

   In review of the site-specific investigation, the qualified professional will assess and determine whether the site and development plans meet the overall objectives of the Casper Aquifer Protection Plan and this ordinance.

B. The City may attach conditions of approval to ensure the protection of the groundwater quality, including, but not limited to, further evaluation, reasonable technical improvements, monitoring or other mitigation measures. All conditions of approval shall be reviewed and evaluated by the professional engineer, geologist, hydrologist, or other qualified designee who reviews the site-specific investigation to ensure that the condition(s) of approval are of sound scientific and technical reasoning.

Section 10.
17.82.100 Design Standards for On-Site Wastewater Treatment System/Septic Systems.

A. No new septic systems shall be permitted within the APO zone.

B. Installation, design, repair, and removal of septic systems located within the APO zone must be in accordance with plans and specifications prepared by and certified by a professional engineer skilled in the science of wastewater disposal and licensed to practice in the State of Wyoming. This ordinance does not grant the right to install a septic system or on-site wastewater treatment system otherwise forbidden by City regulations.

C. Each existing septic system shall be pumped to prevent solids, oils, and grease from building up to a level in the tank where these materials will begin washing out to the leach field and clogging the field lines. Pumping shall occur not less than every five years or on a schedule as otherwise recommended by a City licensed wastewater system pumper/hauler. A database regarding the septic systems and their pumping and inspection schedules will be maintained and updated by the City GIS to maintain records and track schedules, which information shall be made available to the County.

D. Each existing septic system and leach field within the APO shall be inspected by the City Engineer or other City qualified designee skilled in the science of wastewater disposal.

1. During installation of replacement system, before backfilling; and

2. At least once every three years.

E. If upon inspection a septic system is found to be inadequately designed or constructed to serve the use for which it is intended, without undue risk to the Casper Aquifer, it shall not be used for the disposal of wastewater until it is cleaned, repaired or otherwise made to operate properly or replaced.

Section 11.
17.82.110 Connection to Municipal or District Sewage Collection Lines.

A. For properties within the APO zone no private on-site wastewater treatment system may be used after the earlier of:

1. One year after installation of a municipal sewer collection line in a right of way or easement that is contiguous to the property on which the system is location; or

2. One year after the inclusion of the property containing the on-site system in a district connected to the City of Laramie's wastewater treatment system or

another wastewater treatment facility and if the sewage collection line is in a right of way or easement that is contiguous to the property.

B. This section shall be consistent with the provisions within the existing City of Laramie -Albany County 201 Wastewater Agreement. If there is a disagreement between this ordinance and the 201 Wastewater Agreement, the stricter of the two shall apply.

Section 12.
17.82.120 Pre-Existing Nonconforming Uses.

Pre-existing nonconforming uses within the APO zone are subject to the terms of this ordinance and to other general ordinance provisions on pre-existing nonconforming uses.

A. A pre-existing nonconforming use is a use prohibited by this regulation but which is in place upon property included in the APO zone as of the date the property was included in the APO zone. That date may be the effective date of this ordinance or the date a use becomes nonconforming because of an amendment to this ordinance. Septic systems and other on-site wastewater treatment systems are controlled by this ordinance and are not subject to these provisions on pre-existing nonconforming uses.

B. Pre-existing nonconforming uses may continue in the same location they were in when they became nonconforming uses, but shall not be expanded in size or scope. Pre-existing nonconforming uses which are damaged may be repaired and resumed at the same location, size, and scope, provided that after repairs are complete, the best available control technology shall be in place to prevent contact between hazardous materials and the surface of the ground or groundwater.

C. A pre-existing nonconforming use may be expanded under these conditions.

1. All provisions in Section 17.82.080 and Section 17.82.090 are met.

2. The expansion does not increase the risk of contamination of the Casper Aquifer.

3. Control technology built in to the expansion will prevent any increased risk to the Casper Aquifer because:

   a. Substitution is made of one hazardous material for another provided the substituted material is used for the same function and in equal or lesser amounts as the original material;

   b. Substitution of equipment or process for equipment or process provided that the substituted equipment or process performs the same function as the original equipment or process, without increasing the storage volume of hazardous materials stored at the subject business or facility;

   c. Expansion of wholesale or retail sales volume which increases the use of hazardous materials but which does not increase the storage capacity for hazardous material; and

d. Initiation at the subject facility or business of an activity that is not a prohibited activity.

D. Every pre-existing nonconforming use shall:

1. Store hazardous material in an enclosed structure or under a roof which eliminates storm water entry to the containment area;

2. Provide floors within a structure where hazardous material is stored, coated to protect the surface of the floor from deterioration due to spillage of any such material. A structure which may be used for storage or transfer of hazardous material shall be protected from storm water run-on and ground water intrusion;

3. Store hazardous material within an enclosed impermeable containment area which is capable of containing at least the volume of the largest container of such hazardous material present in the area or 110% of the total volume of all such containers in the area, whichever is larger, without overflow of released hazardous material from the containment area;

4. Store hazardous material in a manner that will prevent the contact of chemicals with any materials so as to create a hazard of fire, explosion or generation of toxic substances;

5. Store hazardous materials only in containers that have been certified by a state or federal agency or the American Society of Testing Materials as suitable for the transport or storage of the material;

6. Store all hazardous material in an area secured against entry by the public, except items offered for retail sale in their original unopened containers;

7. Not use, maintain or install floor drains, dry wells or other infiltration devices or appurtenances which allow the release of wastewater to the ground water; and

8. Not discharge any substance or material to the ground in the APO zone unless the discharge is permitted by law.

E. These requirements are intended to supplement, and not to supersede, any other applicable requirements of federal, state or local law.

Section 13.
17.82.130 Proper Plugging and Abandonment of Unused Wells.

All wells, including but not limited to groundwater pumping wells and monitoring wells, that are no longer in use by the owner must be properly plugged and abandoned in accordance with Chapter 11, Section 70, Part G of the Wyoming Department of Environmental Quality Rules and Regulations.

Section 14.
17.82.140 Exception From 100-feet Setback from Vulnerable Features for Infrastructure.

The construction of sewer and water lines that are attached to either a centralized wastewater or water system or the City of Laramie's Wastewater or Water system, may be installed within the APO in order to protect water quality. Sewer lines shall be engineered in such a way as to limit the possibility of an undetected leak; this may include double walled pipes and regular pressure testing or other engineering techniques and leak detection systems that reduce the possibility of undetected leaks. Exceptions also include other general utilities used specifically to serve local developments such as electric lines, gas lines for heating, cable television, and telephone lines. Roads may also be excepted if appropriate stormwater drainage and management is included.

Section 15.
17.82.150 Existing Law on Aquifer Contamination Unaffected.

The establishment of the APO zone, and the use of APO-zoned properties in accord with this ordinance, does not relieve any Person from liability provided by law for contamination of the Casper Aquifer. This ordinance does not supersede or modify the requirements of any federal, state or local law which makes stricter requirements.

Section 16.
17.82.160 Severability.

The provisions of this ordinance are severable. If any provision is declared to be invalid or unenforceable by any court of competent jurisdiction, those provisions not so declared shall remain in effect.

Section 17.
17.82.170 This ordinance is effective immediately upon publication.

PASSED AND APPROVED this 3rd day of June 2008.

____
Klaus Hanson,
Mayor and President
Laramie City Council, Laramie, Wyoming

ATTEST:

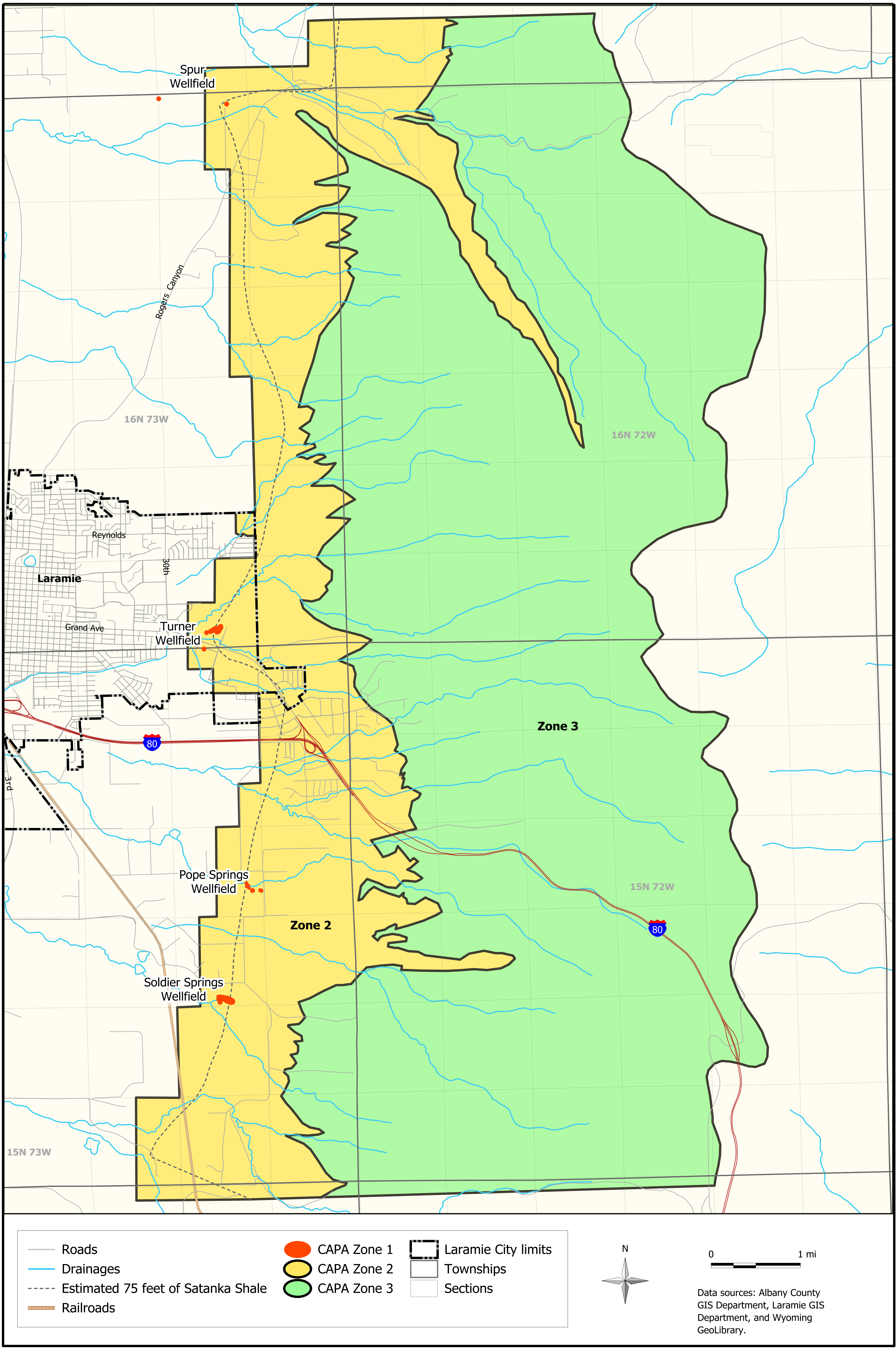
____
Sue Morris-Jones, CMC
City Clerk

Work Session:	February 25, 2008
1st reading:	March 4, 2008
Public hearing:	March 25, 2008
2nd reading:	May 6 and 20, 2008
3rd reading:	June 3, 2008

Duly published in the Laramie Daily Boomerang this ________day of _________, 2008

ATTACHMENT A

Map of the Casper Aquifer Protection Area



Attachment A. Casper Aquifer Protection Area (CAPA) boundaries and zones.

APPENDIX J

COMMERCIAL AND INDUSTRIAL LAND USES THAT GENERATE HAZARDOUS WASTE AND ANNOTATED BIBLIOGRAPHY OF PROHIBITED USES

Appendix B. Commercial/ Industrial Land Uses—Hazardous Waste Generation

POTENTIAL LARGE-SCALE GENERATORS

Business Category (SIC)*	Hazardous Materials/Wastes/Disposal Practices (if known)
Communications Equipment Manufacturer (366)	Nitric, hydrochloric, and sulfuric acid wastes, heavy metal sludges, copper-contaminated etchant (e.g., ammonium persulfate), cutting oil and degreasing solvent (trichloroethane, Freon, or trichloroethylene), waste oils, corrosive soldering flux, paint sludge, waste plating solution
Electric and Electronic Equipment Manufacturer (especially circuit boards) (367)	Cyanides, metal sludges, caustics (chromic acid), solvents, oils, alkalis, acids, paints, calcium flouride sludges, methylene chloride, perchloroethylene, trichloroethane, acetone, methanol, toluene, PCBs, paint sludge
Fabricated Metal Products (344)	Paint wastes, acids, heavy metals, metal sludges, plating wastes, oils, solvents, explosive wastes
Machinery (354) = metalworking & machinery (359) = miscellaneous machinery (except electrical)	(354) - oils, solvents (359) - metals, miscellaneous organics, sludges, oily metal shavings Tool and die shops: lubricant and cutting oils, degreasers (TCE), metal marking fluids ("blueing"), mold release agents Oils and solvents may be reclaimed in shop or sold to recyclers, scrap metal sold to dealer
Plastic Materials and Synthetics (282) = plastic materials & synthetics (2821) = plastics, synthetic resins,	(282) - solvents, oils, miscellaneous organics (phenols, resins), paint wastes, inorganics, cyanides, acids, alkalis, wastewater treatment sludges (2821) - organic liquid wastes containing acids and alkalis, and nonvulcanized elastomers cellulose esters, surfactants, glycols, phenols, formaldehyde, peroxides, etc. May be treated on site or hauled to a hazardous waste facility
Primary Metal Industries (3312) = blast furnaces, steelworks, rolling mills	Heavy metal wastewater treatment sludge, pickling liquor, waste oil, ammonia scrubber liquor, acid tar sludge, alkaline cleaners, degreasing solvents, slag, metal dust
Trucking Terminals or Fleet Vehicles (4231)	Fuel tanks, repair shop wastes (chemical substances may be hauled)

*Up to four digits are used in the SIC codes; codes that contain only two or three digits represent less specific categories and, therefore, should be treated with more caution.

Appendix B. Commercial/ Industrial Land Uses—Hazardous Waste Generation, cont.

POTENTIAL MODERATE-SCALE GENERATORS

Business Category (SIC)*	Hazardous Materials/Wastes/Disposal Practices (if known)
Printing, Publishing, & Allied Industries (27, 731)	Solvents, inks, dyes, oils, miscellaneous organics, photographic chemicals (note that solvents with ink in them may be collected by solvent recovery firms; ink contains heavy metals and may be returned to ink supplier for recovery and reuse; silver in photographic chemicals is recoverable)
Public Utilities (phone, electric power, gas) (481, 491, 492)	PCBs from transformers and capacitors, oils, solvents, sludges, acid solution, metal plating solutions (chromium, nickel, cadmium)
Sawmills and Planing	Treated wood residue and containers (use copper quinolate, mercury, (2421) sodium bazide to control stains and fungus and use tanner gas to prevent lines from freezing). Paint sludges, solvents, creosote, coating, and glueing wastes
Stone, Clay, and Glass Products (32)	Solvents, oils and grease, alkalis, acetic wastes, asbestos, heavy metal sludges, phenolic solids or sludges, metal-finishing sludge
Agriculture (01)	Pesticides (containers and residues), gasoline, motor oil, welding equipment, etc. for farm machinery
Auto Repair (7538)	Waste oils, solvents, acids, paint, waste hydraulic fluids, miscellaneous cutting oils
Local & Interurban Passenger Transit (41)	Waste oil, solvents, miscellaneous wastes, gasoline storage
Gasoline Service Stations	Oils, solvents, miscellaneous wastes (ask if they take back used (554) motor oil and what is done with it)
New and Used Car Dealers (especially those with service departments)	Waste oils, solvents, miscellaneous wastes
Welders (7692)	Oxygen/acetylene tanks
Dry-Cleaning (7216)	Solvents: perchloroethylene, petroleum solvents, Freon-1,1,3 (used in machines in large quantities), distilled solvent, reused spotting chemicals: trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate (residues from distillation put in garbage)
Landfills, Dumps, and Junkyards	Small quantities of chemical wastes, oils, etc. (ask whether the operation has a policy on hazardous wastes if collected by mistake)
Other (Because of information found in inventory)	

*Up to four digits are used in the SIC codes; codes that contain only two or three digits represent less specific categories and, therefore, should be treated with more caution.

Appendix B. Commercial/ Industrial Land Uses—Hazardous Waste Generation, cont.

POTENTIAL SMALL-SCALE GENERATORS

Business Category (SIC)*	Hazardous Materials/Wastes/Disposal Practices (if known)
Special Construction Trades	
(1711) = plumbing, heating, air conditioning	(1711) - solvents, asbestos, miscellaneous (empty containers, etc.)
(1721) = painting, paper hanging, decorating	(1721) - paints, solvents, glues, miscellaneous
(1742) = plastering, drywall, acoustical insulation	1742) - solvents, adhesives, miscellaneous (waste insulation)
(1751) = carpentry	(1751) - solvents, lacquers
(1752) = flooring	(1752) - paint, glues, miscellaneous
(1761) = roofing and sheet metal	(1761) - tars, sealants, miscellaneous
(1795) = wrecking and demolition	(1795) - asbestos, miscellaneous chemicals, miscellaneous
(1799) = other special construction trades	(1799) - epoxy waste, solvents, asbestos, miscellaneous
Swimming Pool Cleaning & Maintenance (7399)	Free and combined chlorine, bromine, iodine, algicides (mercury-based, copper-based, or quaternary), cyanuric acid, calcium or sodium hypochlorite, muriatic acid, sodium carbonate
Miscellaneous Repair Service	Solvents, acids, alkalis, paint sludges, metals, organics, miscellaneous chemicals
Medical Facilities (8071)	X-ray developers and fixers (fixers and x-ray film contain reclaimable silver. Developer contains glutaldehyde, hydroquinone, phenedone, potassium bromide, sodium sulfite, sodium carbonate. Fixer has thiosulfates and potassium allum. Infectious wastes, radiological wastes, biological wastes, miscellaneous chemicals, disinfectants, asbestos, beryllium, acids (from dentists)
Veterinary Services (0742)	Solvents, infectious materials, vaccines, drugs, disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlorhexadene chlorox) X-ray developers and fixers (fixers and x-ray film contain reclaimable silver)
Schools (821)	Solvent, chemicals, pesticides, acids, alkalis, waste oils
Furniture and Fixtures (Manufacture and Repair) (2512, 7641)	Paints, sludges, solvents, empty containers, degreasing sludges, solvent recovery sludges
Funeral Services and Crematories (7261)	Formaldehyde is the main preservative used. Also use wetting agents, fumegants, solvents
Government Offices (919)	Machinery/vehicle servicing, gasoline or heating oil tanks
Home Heating Oil (5183)	Underground storage tanks, truck maintenance garage
Photo Processing Laboratory (7333, 7395)	Biosludges, silver sludges, cyanides, miscellaneous sludges

*Up to four digits are used in the SIC codes; codes that contain only two or three digits represent less specific categories and, therefore, should be treated with more caution.

Appendix B. Commercial/ Industrial Land Uses—Hazardous Waste Generation, cont.

POTENTIAL MINOR GENERATORS	
Business Category (SIC)*	Hazardous Materials/Wastes/Disposal Practices (if known)
Apartment and Condominium (6513)	Swimming pool cleaning and maintenance chemicals, landscaping chemicals (e.g., pesticides and fertilizers), on-site sewage treatment plant (hazardous household wastes)
Pharmacies (591)	Spilled and returned products
Hardware Stores (525) and Carpet Stores (5713)	Hazardous chemical products in hardware and parts stores' inventories. Carpet stores use glues and similar adhesives that are hazardous products returned to stores by customers. If forklift is used at lumber, hardware, or carpet store, there may be fuel tank or repair shop. Wood products, if stained or treated on site, require hazardous chemicals (such as creosote)
Construction Materials (521)	Asbestos
Car Washes (7542)	Miscellaneous chemicals: soap, detergents, waxes
Beauty Shops (723) and Barber Shops (724)	Miscellaneous chemicals in rinses, perm solutions, dyes
Sports Shops (5941) and Hobby Shops (5945)	Gun powder and ammunition, rocket engine and model airplane fuel
Country Clubs (7997)	Pesticides, fertilizers, swimming pool chemicals, vehicle maintenance shops
Bowling Alleys (7933)	Epoxy, urethane-based floor finish
Miscellaneous	

*Up to four digits are used in the SIC codes; codes that contain only two or three digits represent less specific categories and, therefore, should be treated with more caution.

Sources: Horsley and Witten, Inc., and U.S. Environmental Protection Agency, *Wellhead Protection Programs: Tools for Local Government*. Washington, D.C.: EPA, 1989.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
1. Activities involving any equipment for the underground storage or transmission of any hazardous material to the extent that it is not pre-empted by federal law.	
"Public Health Assessment for Ossineke Groundwater Contamination, Ossieke, Alpena County, Michigan, Region 5. CERCLIS No. MID980794440" Reports Announcements & Index (GRA&I), Issue 24, 2095 [NTIS]	An EPA site, National Priorities List, contaminants in Ossineke, MI groundwater posed a health risk to town citizens. A contaminant plume containing, among others, benzene, toluene, and xylenes, had been traced to a gas station and its underground storage tanks. Wells in and near the area had to be replaced.
Delin, G.N., Essaid, H.I., Cozzarelli, I.M., Lahvis, M. H., Bekins, B. A., 1998. Ground Water Contamination by Crude Oil near Bemidji, Minnesota. USGS Fact Sheet 084-98.	A crude-oil pipeline burst near Bemidji, Minnesota resulted in contamination of groundwater. Even after clean-up of the initial spill, crude oil was present in the groundwater and soils.
Robertson, J. F, 1996. Assessment of Petroleum-Hydrocarbon Contamination in the Surficial Sediments and Ground Water at Three Former Underground Storage Tank Locations, Fort Jackson, South Carolina, 1995. USGS Open File Report 96-215.	Hydrocarbons and lead were detected in the areas of the underground storage tanks. One of the sampling sites had lead and hydrocarbon concentrations that were greater than drinking water standards.
2. The discharge to groundwater of any waste product.	
Environmental Protection Agency. “Preliminary Close Out Report-Frontier Hard Chrome, Vancouver, WA”. Yosemite EPA, October 2003, pp. 1-14.	An EPA super fund site in Vancouver, WA that contains a site study in groundwater contamination caused by chromium plating wastes discharged in wastewater via a subsurface injection well. Report contains a complete background of cause and effect, including the estimated cost of remediation.
Vroblesky, D.A., Lorah, M.M., and Oliveros, J.P., 1989. Ground-water, Surface-Water, and Bottom-Sediment Contamination in the O-Field Area, Aberdeen Proving Ground, Maryland, and the Possible Effects of Selected Remedial Actions on Ground Water. USGS Open File Report 89-399.	Arsenic and chlorinated-organic solvents have been detected at the proving ground where munitions and chemical-warfare agents were disposed.
Franks, B. J., ed., 1987. Chapter B: Fate and Transport of Contaminants in Sewage-Contaminated Ground Water on Cape Cod, Massachusetts. In: U.S. Geological Survey Program on Toxic Waste-Ground-Water Contamination: Proceedings of the Third Technical Meeting, Pensacola, Florida, March 23-27, 1987. USGS Open File Report 87-109.	Infiltration beds were used to dispose of secondary treated sewage. Contaminants include chloride, boron, sodium, ammonium, nitrate-nitrogen, detergents, and volatile organic compounds.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
3. Car or truck washing, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	
Lewis, J.C., and Hochreiter, J., 1990. History of Ground-Water Contamination and Summary of Ground-Water Investigations Through 1985 at Four Industrial Sites, Logan Township, New Jersey. USGS Open File Report 90-102.	A waste-oil processing and storage business, a chemical-transportation business, a manufacturer of organic compounds, and a disposal facility for hazardous wastes all contaminated the area's groundwater resources.
4. Production or refining of chemicals, including without limitation, hazardous materials or asphalt.	
Lorah, MM; Clark, JS. "Contamination of ground water, surface water, and soil, and evaluation of selected ground-water pumping alternatives in the Canal Creek area of Aberdeen Proving Ground, Maryland." U.S. GEOL. SURVEY, EARTH SCIENCE INFORMATION CENTER, OPEN FILE REPORTS SECTION, BOX 25286, MS 517, DENVER, CO 80225 (USA). [nd].	Chemical manufacturing, munitions filling, and other military-support activities have resulted in the contamination of ground water, surface water, and soil in the Canal Creek area of Aberdeen Proving Ground, Maryland. Simulations with a ground-water-flow model and particle tracker post processor show that, without remedial pumpage, the contaminants will eventually migrate to Canal Creek and Gunpowder River. Simulations indicate that remedial pumpage of 2.0 million gallons per day from existing wells is needed to capture all particles originating in the contaminant plumes.
Hult, M. F., 1984. Assessment of Ground-Water Contamination by Coal-Tar Derivatives, St. Louis Park Area, Minnesota. USGS Open File Report 84-867.	Coal-tar derivatives contaminated the groundwater. They entered the groundwater through effluent being discharged into wetlands, an on-site well, and from spills that infiltrated the soil.
5. Clothes or cloth cleaning service which involves the use, storage, or disposal of hazardous materials, including without limitation, dry-cleaning solvents.	
"Dry Cleaning Contamination Site Profiles", State Coalition for Remediation of Dry cleaners <http://www.drycleancoalition.org>. (accessed: 08 Jan. 2008) .	Provides links to site profiles for groundwater and soil contamination and remediation due to dry cleaning operations across the united states. Site profiles contain pertinent information on extent of contamination, contaminants responsible, site hydrology, remediation scenario, technologies used in the remediation, cost of remediation, lessons learned etc. The site also includes several technical articles related to dry cleaning contamination.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
Department of Health and Human Services, 2007. Public Health Assessment Addendum: Garden State Cleanersa nd South Jersey Clothing Company Minotola, Atlantic County, New Jersey. http://www.atsdr.cdc.gov/HAC/pha/garden/gar_p1.html (accessed: January 14, 2007).	Significant ground-water contamination from TCE and other volatile organic compounds that were discharged to the soil. The contamination plume has migrated resulting in the contamination of private wells.
6. Generation of electrical power by means of fossil fuels except generation by means of natural gas or propane.	
Baum, E. "Wounded Waters-The Hidden Side of Power Plant Pollution". February 2004. <http://64.233.167.104/search?q=cache:IZTjhrIQEhMJ:www.catf.us/publications/reports/Wounded_Waters.pdf+case+studies+of+groundwater+contamination+from+fossil+fuel-fired+electrical+power+plants&hl=en&ct=clnk&cd=15&gl=us&client=firefox-a> (accessed: 1/10/2008).	A study of the negative impacts to groundwater, surface water soils from fossil fuel-fired power plants. This study discusses the types of hazardous chemicals produced from combustive and non-combustive activities associated with these type of power plants.
Turney, G.L., and Goerlitz, D.F., 1988. Ground-water Contamination at an Inactive Coal and Oil Gasification Plant Site, Gas Works Park, Seattle, Washington. USGS Water Resources Investigation Report 88-4224.	Polynuclear aromatic hydrocarbons, volatile organic compounds, trace metals, and cyanide were detected in groundwater in concentrations up to 200 milligrams per liter.
7. Production or fabrication of metal products, electronic boards, electrical components, or other electrical equipment involving the use, storage or disposal of any hazardous material or involving metal plating, metal cleaning or degreasing of parts or equipment with industrial solvents, or etching operations.	
Environmental Protection Agency, 2003. "Preliminary Close Out Report-Frontier Hard Chrome, Vancouver, WA". Yosemite EPA, October 2003, pp. 1-14.	An EPA super fund site in Vancouver, WA that contains a site study in groundwater contamination caused by chromium plating wastes discharged in wastewater via a subsurface injection well. Report contains a complete background of cause and effect, including the estimated cost of remediation.
Lorah, M.M. and Clark, J.S., 1995. "Contamination of ground water, surface water, and soil, and evaluation of selected ground-water pumping alternatives in the Canal Creek area of Aberdeen Proving Ground, Maryland." USGS Open File Report 95-282.	Chemical manufacturing, munitions filling, and other military-support activities have resulted in the contamination of ground water, surface water, and soil in the Canal Creek area of Aberdeen Proving Ground, Maryland. Simulations with a ground-water-flow model and particle tracker post processor show that, without remedial pumpage, the contaminants will eventually migrate to Canal Creek and Gunpowder River. Simulations indicate that remedial pumpage of 2.0 million gallons per day from existing wells is needed to capture all particles originating in the contaminant plumes.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
Graham, D.D., and Monical, J.E., 1997. Contamination of Ground Water at the Tucson International Airport Area Superfund Site, Tucson, Arizona – Overview of Hydrogeologic Considerations, Conditions as of 1996, and Cleanup Efforts. USGS Water Resource Investigations Report 97-4200.	TCE, heavy metals, and other volatile organic compounds associated with industrial processes were found in groundwater.
8. On-site storage of oil or petroleum for the purpose of wholesale or retail sale.	
"Public Health Assessment for Ossineke Groundwater Contamination, Ossieke, Alpena County, Michigan, Region 5. CERCLIS No. MID980794440" Reports Announcements & Index (GRA&I), Issue 24, 2095 [NTIS]	An EPA site, National Priorities List, contaminants in Ossineke, MI groundwater posed a health risk to town citizens. A contaminant plume containing, among others, benzene, toluene, and xylenes, had been traced to a gas station and its underground storage tanks. Wells in and near the area had to be replaced.
Delin, G.N., Essaid, H.I., Cozzarelli, I.M., Lahvis, M. H., Bekins, B. A., 1998. Ground Water Contamination by Crude Oil near Bemidji, Minnesota. USGS Fact Sheet 084-98.	A crude-oil pipeline burst near Bemidji, Minnesota resulted in contamination of groundwater. Even after clean-up of the initial spill, crude oil was present in the groundwater and soils.
Wright, W. G., and Powell, J. D., 1990. Preliminary Investigation of Soil and Ground-Water Contamination at a U.S. Army Petroleum Training Facility, Fort Lee, Virgina, September-October 1989. USGS Open File Report 90-387.	Leaking tanks, leaking transfer lines, and accidental spills contributed to hydrocarbon contamination of the groundwater at the Fort Lee facility. Free-floating fuel oil was observed in some monitoring wells and concentrations of hydrocarbons ranged from below detection limit to 130 micrograms per liter.
9. Embalming or crematory services which involve the use, storage or disposal of hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	
Cook, J., Klinck, B., Coombs, P, Noy, D., and Williams, G. Burial sites and their impact on groundwater. In: Brining Groundwater Quality Research to the Watershed Scale. (Proceedings of GQ2004, the 4th International Groundwater Quality Conference, held at Waterloo, Canada, July 2004.)	Discusses historical accounts of pollution from cemeteries. Increased concentrations of sodium, chloride, sulphate, and nitrate were found in groundwater underlying a modern day cemetery. Bacteria was also present in the groundwater.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
10. Furniture stripping operations which involve the use, storage or disposal of hazardous materials.	
Moran, M, Squillance, PJ, Zogorski, JS, 2007. "Chlorinated Solvents in Groundwater of the United States." *Environmental Science & Technology*; 1/1/2007, Vol. 41 Issue 1, pp 74-81.	Four chlorinated solvents, including methylene chloride that is commonly found in furniture stripping/refurbishment products --were analyzed in samples of groundwater taken throughout the conterminous United States by the U.S. Geological Survey. Of 55 volatile organic compounds (VOCs) analyzed in groundwater samples, solvents were among the most frequently detected. The probability of occurrence of solvents in groundwater was associated with dissolved oxygen content of groundwater, sources such as urban land use and population density.
11. Furniture finishing operations which involve the use, storage or disposal of hazardous materials, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	
Moran, M, Squillance, PJ, Zogorski, JS, 2007. "Chlorinated Solvents in Groundwater of the United States." *Environmental Science & Technology*; 1/1/2007, Vol. 41 Issue 1, pp 74-81.	Four chlorinated solvents, including methylene chloride that is commonly found in furniture stripping/refurbishment products --were analyzed in samples of groundwater taken throughout the conterminous United States by the U.S. Geological Survey. Of 55 volatile organic compounds (VOCs) analyzed in groundwater samples, solvents were among the most frequently detected. The probability of occurrence of solvents in groundwater was associated with dissolved oxygen content of groundwater, sources such as urban land use and population density.
Katy, R. T., Prinos, S. T., and Paillet, F.L., 1994. Geohydrology and ground-water quality in the vicinity of a ground-water-contamination site in Rockford, Illinois. USGS Water Resources Investigations Report 93-4187.	VOCs were found is a fractured bedrock aquifer in concentrations greater than 2,000 micrograms/liter in several samples.
12. Storage, treatment, or disposal of hazardous waste permitted under Wyoming law.	
Reinhart, Debra." A Review of Recent Studies On the Sources of Hazardous Compounds Emitted From Solid Waste Landfills: a U.S. Experience." Waste Management & Research. (1993); Vol. 11, No. 3, pp. 257-268.	Citing statistics and analysis results for Virginia and Washington, article lists common leachate found through monitoring of disposal sites. Study concentrates on sources of these hazardous contaminants in municipal solid waste landfills that may include small quantity generators of hazardous wastes, household hazardous wastes, and wastes disposed prior to the 1980 enactment of U.S. hazardous waste disposal legislation, and biological and chemical transformation products of buried refuse.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
Desimone, L.A., Barlow, P.M., 1995. Water-Quality and Hydrologic Conditions at a Site of Ground-Water Contamination by Volatile Organic Compounds, South Grafton< Massachusetts, September and October 1994. USGS Open File Report 95-425.	An abandoned textile mill has a plume of volatile organic compounds (VOCs) under the site. The main VOC is tricholroethylene and VOC concentrations range from 1 to more than 40,000 micrograms per liter.
Lewis, J.C., and Hochreiter, J., 1990. History of Ground-Water Contamination and Summary of Ground-Water Investigations Through 1985 at Four Industrial Sites, Logan Township, New Jersey. USGS Open File Report 90-102.	A waste-oil processing and storage business, a chemical-transportation business, a manufacturer of organic compounds, and a disposal facility for hazardous wastes all contaminated the area's groundwater resources.
13. Clothes or cloth cleaning service for any industrial activity that involves the cleaning of clothes or cloth contaminated by hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works.	
Ricard "Laundry-site cleanup clears groundwater". Oakland Tribune. Nov 7, 2006. FindArticles.com. 10 Jan. 2008. <http://findarticlesMartin.com/p/articles/mi_qn4176/is_20061107/ai_n16823175 >. (accessed:: January 10, 2008).	San Leandro. CA, clean up site for groundwater and soil contamination. The site is owned by an industrial laundry facility. Over a decade of hazardous waste seepage contaminated more than a 1,000 drinking water wells. Chemicals present in the groundwater include tetrachlorethylene (PCE) as well as numerous other hazardous materials.
Katy, R. T., Prinos, S. T., and Paillet, F.L., 1994. Geohydrology and ground-water quality in the vicinity of a ground-water-contamination site in Rockford, Illinois. USGS Water Resources Investigations Report 93-4187.	VOCs were found is a fractured bedrock aquifer in concentrations greater than 2,000 micrograms/liter in several samples.
14. Any biological or chemical testing, analysis or research which involves the use, storage or disposal of hazardous material.	
North Country Gazette. “State Settles in Cleanup of Hexagon Laboratories”. February 23, 2006. <http://www.northcountrygazette.org/articles/022306HexagonCleanup.html>. (accessed: 1/9/2007)	News article regarding Hexagon Laboratories, a manufacturer of pharmaceuticals and organic chemicals, located in the Bronx, New York City. Numerous spills of chemicals contaminated the soil and groundwater. Remediation included the removal of a large amounts of soil and a project for treating the affected groundwater. Clean up costs exceeded well above $6 million dollars.
Vroblesky, D.A., Lorah, M.M., and Oliveros, J.P., 1989. Ground-water, Surface-Water, and Bottom-Sediment Contamination in the O-Field Area, Aberdeen Proving Ground, Maryland, and the Possible Effects of Selected Remedial Actions on Ground Water. USGS Open File Report 89-399.	Arsenic and chlorinated-organic solvents have been detected at the proving ground where munitions and chemical-warfare agents were disposed.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
15. Pest control services which involve storage, mixing or loading of pesticides or other hazardous materials.	
Acquay, H., Biltonen M., D'Amore, M., Giordano, S., Horowitz, A., Lipner, S., Nelson, J., Pimental, D., Rice, P., Silva, M. "Environmental and Economic Costs of Pesticide Use." *Bioscience*.(1992); Vol. 42 (10), pp. 750-760.	Survey of indirect costs of all pesticide use including, but not limited to, groundwater contamination, exposure, ecological toxicity, species non-differention. In regards to groundwater, study cites a projection of $1.3 billion (1992) as necessary annual expenditure for groundwater monitoring.
16. Salvage operations of metal or vehicle parts.	
National Cancer Ins't. "Public Health Assessment for Byron Salvage Yard (a/k/a Byron Johnson) Byron, Ogle, County, Illinois, Region 5. CERCLIS No. ILD010236230. *Gov't Reports Announcements & Index (GRA&I)*, Issue 18, 2099	Case study for the Bryan Salvage Yard, IL. Significant soil, sediment, and groundwater contamination included volatile organic compounds, cyanide, and heavy metals. Water posed public health hazard to all private well use. Residents living outside of public supply service area at greatest risk.
17. Photographic finishing which involves the use, storage, or disposal of hazardous materials.	
Phillips, NM. "Process Waste Assessment for the Photography Laboratory." Gov't Reports Announcements & Index (GRA&I), Issue 10, 2093. 1992.	Study conducted by the Department of Energy, to test for and mitigate pollution hazards at government's photography laboratory.
18. Printing, plate making, lithography, photoengraving or gravure, which involves the use, storage or disposal of hazardous materials.	
Carpenter, BH. Hilliard, GK Jr. "Environmental Aspects of Chemical Use in Printing Operations." Office of Toxic Substances, U.S. Environmental Protection Agency, Washington D.C. Contract No. 68-01-2928, 48 pages, 20 references0000 1990.	Study of all aspects of printing process, from air pollution to water and groundwater contamination. Water contamination is particularly problematic during binding and composition stages. EPA study recommends industrial review of pollution mitigation standards due to increased chemical use by the printing industry.
19. Pulp production, which involves the use, storage or disposal of any hazardous materials.	
Solecki, WD. "Paternalism, pollution, and protest in a company town." *Political Geography:* Jan. 1996; Vol.15 (1) pp. 5-20.	Proctor & Gamble wood pulp mill in Perry, FL. P&G had been using groundwater to adulterate processing effluent before discharge into the Fenhalloway River. Effluent included ammonia, zinc, platinum, mercury, and suspended particles. Reports of well-water issues became particularly acute during a drought year, 1989. Draw-down in ground-water levels caused intrusion of river water and increased contamination levels.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
20. Accumulation or storage of waste oil, anti-freeze or spent lead-acid batteries.	
Reinhart, Debra." A Review of Recent Studies On the Sources of Hazardous Compounds Emitted From Solid Waste Landfills: a U.S. Experience." *Waste Management & Research. (*1993*);*Vol. 11, No. 3, pp. 257-268.	Citing statistics and analysis results for Virginia and Washington, article lists common leachate found through monitoring of disposal sites. Study concentrates on sources of these hazardous contaminants in municipal solid waste landfills that may include small quantity generators of hazardous wastes, household hazardous wastes, and wastes disposed prior to the 1980 enactment of U.S. hazardous waste disposal legislation, and biological and chemical transformation products of buried refuse.
Lewis, J.C., and Hochreiter, J., 1990. History of Ground-Water Contamination and Summary of Ground-Water Investigations Through 1985 at Four Industrial Sites, Logan Township, New Jersey. USGS Open File Report 90-102.	A waste-oil processing and storage business, a chemical-transportation business, a manufacturer of organic compounds, and a disposal facility for hazardous wastes all contaminated the area's groundwater resources.
21. Production or processing of rubber, resin cements, elastomers or plastic, which involves the use, storage or disposal of hazardous materials.	
"Profile of the rubber and plastics industry. EPA Office of Compliance Sector Notebook Project." EPA: Office of Enforcement and Compliance Assurance." *GRA&I*, Issue 08, 2099, 1995.	EPA report on monitoring of plastics products industry including those plants that produce resins, natural and synthetic rubber, reclaimed rubber, fuuta percha, balata, and gutta sica. Project presents accident, leak, and production waste analysis.
Vroblesky, D.A., and Casey, C.C., 2007. Investigation of Ground-Water Contamination at a Drainage Ditch, Installation Restoration Site 4, Naval Air Station Corpus Christi, Corpus Christi, Texas, 2005-06. USGS Scientific Investigations Report 2007-5155.	Chlorobenzene was found ground water samples beneath the drainage ditch at concentrations up to 160 micrograms per liter.
22. Any activity listed in this column that is conducted at a residence for compensation.	
Eid EP, Lahtinen MJ, Maloney JS, Trojan MD, Stockinger, JM. "Effects of land use on ground water quality in the Anoka Sand Plain Aquifer of Minnesota." *Ground Water.* 2003 Jul-Aug;41(4):482-492.	Study compared ground water quality under irrigated and non-irrigated agriculture, sewered and non-sewered residential developments, industrial, and nondeveloped land uses. Twenty-three monitoring wells were completed in the upper meter of an unconfined sand aquifer. Significant differences were observed in water chemistry beneath different land uses. Concentrations of several trace inorganic chemicals were greatest under sewered urban areas. Between 1997 and 2000, sampling occurred quarterly for major ions, trace inorganic chemicals, volatile organic compounds (VOCs), herbicides, and herbicide degradates. On single occasions, we collected samples for polynuclear aromatic hydrocarbons (PAHs), perchlorate, and coliform bacteria.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
Moran, M, Squillance, PJ, Zogorski, JS, 2007. "Chlorinated Solvents in Groundwater of the United States." *Environmental Science & Technology*; 1/1/2007, Vol. 41 Issue 1, pp 74-81.	Four chlorinated solvents, including methylene chloride that is commonly found in furniture stripping/refurbishment products --were analyzed in samples of groundwater taken throughout the conterminous United States by the U.S. Geological Survey. Of 55 volatile organic compounds (VOCs) analyzed in groundwater samples, solvents were among the most frequently detected. The probability of occurrence of solvents in groundwater was associated with dissolved oxygen content of groundwater, sources such as urban land use and population density.
23. Storage of pavement de-icing chemicals unless storage takes place within a weather-tight waterproof structure.	
Howard, Ken W.F., Herb Maier. "Road de-icing salt as a potential constraint on urban growth in the Greater Toronto Area, Canada." *Journal of Contaminant Hydrology*; Apr. 2007, Vol. 91 (1/2), pp 146-170.	Effects of continued urban growth studies, focusing on long-term impacts on ground and surface water and use of Na Cl de-icing salt. Inorganic chloride salts have been designated "toxic" under the Canadian Environmental Protection Act. Studies results showed groundwater quality deterioration in shallow aquifers, chloride concentrations approaching Canadian water quality standard of 250 mg/l.
Meyer, M.M., 1999. Fate and Transport of Deicing Materials in an Unconfined Roadside Aquifer. PhD Dissertation. University of Massachusetts Amherst.	The groundwater beneath a closed drainage system and shoulder drainage system both exceeded drinking water standards for chloride.
24. The accumulation, storage, handling, recycling, disposal, reduction, processing, burning, transfer or composting of solid waste except for a potable water treatment sludge disposal area.	
Drake, V.M. and Zimmer, R.. "Temporal Change in Groundwater Nitrate Concentrations Parts 1 and 2 (Abridged)". June 2001, Vol. 21, No. 6 and July/August 2001, Vol. 21, No. 7. <http://www.profsurv.com>. (accessed: January 1, 2007).	Densely populated septic systems, improperly constructed or not maintained, can lead to high concentrations of nitrates in groundwater. This study looks at nitrate concentrations outside of Helena, MT near Lake Helena. The study concluded that area with a higher density of septic systems contained elevated levels of nitrates in the groundwater supplies.
Lewis, J.C., and Hochreiter, J., 1990. History of Ground-Water Contamination and Summary of Ground-Water Investigations Through 1985 at Four Industrial Sites, Logan Township, New Jersey. USGS Open File Report 90-102.	A waste-oil processing and storage business, a chemical-transportation business, a manufacturer of organic compounds, and a disposal facility for hazardous wastes all contaminated the area's groundwater resources.
25. Finishing or etching of stone, clay, concrete or glass products, or painting of clay products which involves the use, storage, or disposal of hazardous materials.	
Katy, R. T., Prinos, S. T., and Paillet, F.L., 1994. Geohydrology and ground-water quality in the vicinity of a ground-water-contamination site in Rockford, Illinois. USGS Water Resources Investigations Report 93-4187.	VOCs were found is a fractured bedrock aquifer in concentrations greater than 2,000 micrograms/liter in several samples.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
26. Dying, coating or printing of textiles, or tanning or finishing of leather, which involves the use, storage, or disposal of hazardous materials.	
Khwaja, A.R., Singh, R., Tandon, S.N. "Monitoring of Ganga Water and Sediments Vis-à-Vis Tannery Pollution at Kanpur (India): A Case Study." *Environmental Monitoring and Assessment. (*Apr. 2001); Vol. 68 (1) pp. 19-35.	A study of the leather industry and its effluent. Two sampling sites have been chosen at Kanpur, the first before and the second after the point where tanneries are located. The results reveal that most parameters increase as the river traverses between these two points. Monitoring found the following contaminates: BOD, COD, Cl-, total solids, phenols, sulfides.
Desimone, L.A., Barlow, P.M., 1995. Water-Quality and Hydrologic Conditions at a Site of Ground-Water Contamination by Volatile Organic Compounds, South Grafton< Massachusetts, September and October 1994. USGS Open File Report 95-425.	An abandoned textile mill has a plume of volatile organic compounds (VOCs) under the site. The main VOC is tricholroethylene and VOC concentrations range from 1 to more than 40,000 micrograms per liter.
27. Repair or maintenance of automotive or marine vehicles or internal combustion engines of vehicles, involving the use, storage or disposal of hazardous materials, including solvents, lubricants, paints, brake or transmission fluids or the generation of hazardous wastes.	
Robbins, G., and Gilbert E., 2000. MTBE: a conservative tracer for estimating biodegradation and hydrodynamic dispersion at underground storage tank sites. In: Tracers and Modeling in Hydrogeology (Proceedings of the TraM '2000 Conference held at Liege, Belgium, May 2000).	MTBE contamination plume was analyzed using multilevel sampling probes. The MTBE data was used to estimate mass dissipation of the gasoline plume.
Alexander, A. G., Zettwoch, D.D., Unthank, M.D., and Burns, R. B., 1992. Contamination of Soil, Soil Gas, and Ground Water by Hydrocarbon Compounds Near Greear, Morgan County, Kentucky. USGS Water Resources Investigations Report 92-4138.	Hydrocarbons concentrations greater than 1,000 times the maximum contaminant levels were found in the groundwater at and near an active gasoline station.
28. On-site storage of hazardous materials for the purpose of wholesale or retail sale.	
Michigan Department of Environmental Quality. " Case Study Abstract: Crystal Refinery, Carson City, MI.". <http://64.233.167.104/search?q=cache:PRJL4vc1YcMJ:costperformance.org/monitoring/pdf/5_crystal.pdf+case+studies+of+groundwater+contamination+from+above+ground+storage+tanks&hl=en&ct=clnk&cd=13&gl=us&client=firefox-a>. (accessed: January 10, 2007).	This case study discusses the impacts to groundwater from the leaking above ground storage tank. The two major sources of contamination are: hydrocarbons and residual oil. The leaking occurred fr storage tanks from an oil refinery. Article discusses the nature of the groundwater contamination and costs associated with the site investigation.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
Public Health Assessment for Leonard Chemical Company, Inc., Catawba, York County, South Carolina, Region 4. CERCLIS No. SCD991279324.e, *Govt Reports Announcements & Index (GRA&I).* (1994)*;* Issue 11, 2004	The Leonard Chemical Company (LCC) site of Rock Hill, South Carolina. LCC provided waste solvent treatment, storage, and disposal services. The waste solvents were generated by cleaning processes and contained alcohols, ketones, and chlorinated hydrocarbons. Contaminants were identified in on-site soils and groundwater and in off-site groundwater, surface water, and sediments. Contaminants of concern at the LCC site include: acetone, arsenic, bis(2-ethylhexyl)phthalate, cadmium, chromium, copper, 4,4'-DDT, 1,2-dichlroethane, dimethyl phthalate, iron, isophorone, lead, methylene chloride, methy-ethyl-ketone, polychlorinated biphenyls (PCBs), tetrachloroethene, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, and vinyl chloride.
29. Production or treatment of wood, veneer, plywood, or reconstituted wood, which involves the use, storage or disposal of any hazardous material.	
AIG Environmental. “Lumber and Wood Products Industry”. September 14, 2004. <http://www.aigenvironmental.com/environmental/public/envindustries/0,1340,63-11-325,00.html>. (Accessed: January 10, 2008).	Article discusses the environmental impacts from lumber and wood products that could potentially impact groundwater quality. Includes an inventory of chemicals used in the various phases of lumber and secondary wood products. Improper techniques and practices leading to environmental hazards are discussed.
Franks, B. J., ed., 1987. Chapter A: Movement and Fate of Creosote Waste in Ground Water Near and Abandoned Wood-Preserving Plant Near Pensacola, Florida. In: U.S. Geological Survey Program on Toxic Waste-Ground-Water Contamination: Proceedings of the Third Technical Meeting, Pensacola, Florida, March 23-27, 1987. USGS Open File Report 87-109.	Waste effluent which contained diesel fuel, creosote, and PCP was discharged into impoundments in direct hydraulic connection with the aquifer. The groundwater was contaminated 30 m below the ground surface and extended 600 m beyond the impoundments.
30. All Underground Injection Control (UIC) wells except Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, and 5B7, as defined in WDEQ Chapter 16.	
Environmental Protection Agency. “Preliminary Close Out Report-Frontier Hard Chrome, Vancouver, WA”. Yosemite EPA, October 2003, pp. 1-14.	An EPA super fund site in Vancouver, WA that contains a site study in groundwater contamination caused by chromium plating wastes discharged in wastewater via a subsurface injection well. Report contains a complete background of cause and effect, including the estimated cost of remediation.
Slack, L. J., O'Hara, C. G., and Oakley, W. T., 1996. Brine Contamination of Ground Water in the Vicinity of the Brookhaven Oil Field, Lincoln County, Mississippi. USGS Water Resources Investigations Report 96-4023.	The injection of brine from oil production has contaminated groundwater with concentrations of brine up to 9,400 mg/L.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
31. Water wells which are not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface, or in accordance with the state engineer's requirements or recommendations, whichever is stricter.	
Stein, R.B. "Proceedings and Recommendations of the Workshop on Groundwater Problems in the Ohio River Basin". Cincinnati April 28-29, 1981. Purdue University, Water Resources Research Center, West Lafayette, IN. p 32-33.	Article discusses Ohio's groundwater reserves and issues leading to groundwater contamination. Contamination has most often been the direct result of poor well construction and maintenance, or improper well abandonment.
Environmental Protection Agency. "Preliminary Close Out Report-Frontier Hard Chrome, Vancouver, WA". Yosemite EPA, October 2003, pp. 1-14.	An EPA super fund site in Vancouver, WA that contains a site study in groundwater contamination caused by chromium plating wastes discharged in wastewater via a subsurface injection well. Report contains a complete background of cause and effect, including the estimated cost of remediation.
32. Application of pesticides and herbicides which do not become non-hazardous within 48 hours of application or which are not applied according to the manufacturer's instructions.	
USGS, 2001. Selected Findings and Current Perspectives on Urban and Agricultural Water Quality by the National Water-Quality Assessment Program. FS-047-01.	A brief discussion of the water-quality problems found in both agricultural and urban watersheds and groundwater. Nitrates, pesticides, and herbicides are found in the groundwater in both types of land use.
USGS, 1996. Vulnerability of Public Drinking Water Supplies in New Jersey to Pesticides. FS-165-96.	The USGS analyzed 1,955 public-supply wells for vulnerability to pesticides. This investigation looked at detection of pesticides and hydrogeology to determine vulnerability. Pesticides were detected most often in agricultural areas and five different pesticides were detected in New Jersey.
33. Application of fertilizer at greater than the agronomic uptake rate of the vegetation fertilized.	
Cesareo Giraldez, Glenn Fox (1995). "An Economic Analysis of Groundwater Contamination from Agricultural Nitrate Emissions in Southern Ontario" *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomi*e 43 (3), 387–402.	This paper analyzes the costs and benefits of controlling groundwater pollution from agricultural use of nitrogen fertilizer in southwestern Ontario. The village of Hensall, where nitrate concentrations have been observed above 10 mg/L in recent years, is selected as the study site. Study concluded that the estimated annual benefits of improved ground-water quality range from less than $1,000 to more than $30,000 for Hensall.
USGS, 2001. Selected Findings and Current Perspectives on Urban and Agricultural Water Quality by the National Water-Quality Assessment Program. FS-047-01.	A brief discussion of the water-quality problems found in both agricultural and urban watersheds and groundwater. Nitrates, pesticides, and herbicides are found in the groundwater in both types of land use.
Ator, S.W., and Ferrari, M. J., 1997. Nitrate and Selected Pesticides in Ground Water of the Mid-Atlantic Region. USGS: WRIR 97-4139.	Nitrates and pesticides were detected throughout the region. Elevated nitrate levels were generally associated with agricultural areas. Pesticides were detected in urban and agricultural areas. Pesticide and nitrate concentrations were typically lowest in forested areas.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
34. Quarrying and sand and gravel mining to the extent that such prohibition is not violative of state law. The operations must be conducted pursuant to valid permits issued by the Wyoming Department of Environmental Quality, Bureau of Land Management, or other federal or state regulatory agencies.	
Loyd, JW. "Implications of Gravel Extraction on Groundwater Conditions." *Water in Mining and Underground Works,* Vol. I & II 1984. SIAMOS 78. Pp 1249-1264.	Study monitored gravel mining for the UK construction industry. Study found the gravel operations affected the groundwater flow on a short-term basis, especially during dry working phases. Long-term effects on flow occurred when back-filling of poor permeability used. Gravel operations also caused derogation of wells, pollution, and water-logging.
Van Metre, P.C., Wirt, L., Lopes, T.J., and Ferguson, S.A., 1997. Effects of Uranium-Mining Releases on Ground-Water Quality in the Puerco River Basin, Arizona and New Mexico. USGS Water-Supply Paper 2476.	Large concentrations of dissolved uranium were found 65 kilometers downstream from where mine effluent entered the river. Sediments near the river adsorbed some of the uranium
35. Above ground storage of any hazardous material, including oil and petroleum, unless enclosed in secondary containment as described in Section 7.D of this ordinance.	
Michigan Department of Environmental Quality. “ Case Study Abstract: Crystal Refinery, Carson City, MI.”. <http://64.233.167.104/search?q=cache:PRJL4vc1YcMJ:costperformance.org/monitoring/pdf/5_crystal.pdf+case+studies+of+groundwater+contamination+from+above+ground+storage+tanks&hl=en&ct=clnk&cd=13&gl=us&client=firefox-a>. (accessed: January 10, 2007).	This case study discusses the impacts to groundwater from the leaking above ground storage tank. The two major sources of contamination are: hydrocarbons and residual oil. The leaking occurred from storage tanks at an oil refinery. Article discusses the nature of the groundwater contamination and costs associated with the site investigation.
Wright, W. G., and Powell, J. D., 1990. Preliminary Investigation of Soil and Ground-Water Contamination at a U.S. Army Petroleum Training Facility, Fort Lee, Virgina, September-October 1989. USGS Open File Report 90-387.	Leaking tanks, leaking transfer lines, and accidental spills contributed to hydrocarbon contamination of the groundwater at the Fort Lee facility. Free-floating fuel oil was observed in some monitoring wells and concentrations of hydrocarbons ranged from below detection limit to 130 micrograms per liter.
Lewis, J.C., and Hochreiter, J., 1990. History of Ground-Water Contamination and Summary of Ground-Water Investigations Through 1985 at Four Industrial Sites, Logan Township, New Jersey. USGS Open File Report 90-102.	A waste-oil processing and storage business, a chemical-transportation business, a manufacturer of organic compounds, and a disposal facility for hazardous wastes all contaminated the area's groundwater resources.

Prohibitive Activities with the Casper Aquifer Protection Area	
Reference	**Description**
36. Installation and use of on-site wastewater treatment systems or septic-systems in densities higher than 1 system per 35 acres.	
Drake, V.M.and Zimmer, R.. “Temporal Change in Groundwater Nitrate Concentrations Parts 1 and 2 (Abridged)”. June 2001, Vol. 21, No. 6 and July/August 2001, Vol. 21, No. 7. <http://www.profsurv.com>. (accessed: January 1, 2007).	Densely populated septic systems, improperly constructed or not maintained, can lead to high concentrations of nitrates in groundwater. This study looks at nitrate concentrations outside of Helena, MT near Lake Helena. The study concluded that area with a higher density of septic systems contained elevated levels of nitrates in the groundwater supplies.
Seiler, R.L., 1996. Methods for Identifying Sources of Nitrogen Contamination of Ground Water in Valleys in Washoe County, Nevada. USGS Open File Report 96-461.	Concentration of nitrogen exceeded drinking-water standards for several wells. The most likely source of the contamination comes from septic systems and animal corrals.
37. Animal feeding operations where a) animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and b) crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.	
Goldberg, VM. "Groundwater pollution by nitrates from livestock wastes." *Environmental Health Perspectives.* 1989, Nov; 83:25-9	Concentrated breeding areas generate large amounts of animal wastes. One solution has been to apply a diluted form of the waste for irrigation purposes. Using this form of application increases the risk of groundwater contamination.
USGS, 2001. Selected Findings and Current Perspectives on Urban and Agricultural Water Quality by the National Water-Quality Assessment Program. FS-047-01.	A brief discussion of the water-quality problems found in both agricultural and urban watersheds and groundwater. Nitrates, pesticides, and herbicides are found in the groundwater in both types of land use.
Seiler, R.L., 1996. Methods for Identifying Sources of Nitrogen Contamination of Ground Water in Valleys in Washoe County, Nevada. USGS Open File Report 96-461.	Concentration of nitrogen exceeded drinking-water standards for several wells. The most likely source of the contamination comes from septic systems and animal corrals.
38. Golf course.	
Schueler, T.R., and Holland, H. K., eds. 2000. Groundwater Impacts of Golf Course Development in Cape Cod. In: The Practice of Watershed Protection. Center for Watershed Protection.	Nitrogen and pesticides were detected in 19 test wells and were generally associated with the greens and tee areas. The mobility of and persistence of selected pesticides in th soil was also reviewed.
USGS, 1998. Pesticides Used On and Detected in Ground Water Beneath Golf Course. http://ca.water.usgs.gov/pnsp/golf.html. (accessed on November 11, 2007).	A review of pesticides, location of golf course where the chemical is used, location where the chemical was detected in groundwater, and the reference source.

APPENDIX K

NITRATE LOADING STUDY IN THE LARAMIE PLAINS SUBDIVISION

NITRATE LOADING EXERCISE

CASS BAKER FOR EAC SPRING 2001

*Note: WDEQ does not consider the application of simplistic nitrate loading models (Wehrmann and double dilution methods) developed for porous media as appropriate tools for evaluating potential impacts to aquifers in fractured or faulted environments, nor to determine subdivision lot size. With regard to on site wastewater systems in particular, WDEQ recommends either the use of contaminant fate and transport modeling to determine minimum acceptable setbacks, or the use of 'enhanced' wastewater treatment systems. The following nitrate loading exercise is presented as an example and for background information only. Actual or future conditions may vary significantly from the model results presented below.

INTRODUCTION

In February of 2001, the EAC suggested that a nitrate loading study be done for the Laramie Plains Subdivision located in Township 15 N, Range 73 W, Section 1, SW 1/4. Both on-site and down-gradient nitrate discharge from subdivision septic systems are examined. As adopted by the Wyoming DEQ, a Double Dilution Well Model was used for the on-site portion of the study and the Wehrmann Nitrate Model was used for the down-gradient portion. The models were obtained from the WDEQ Water Quality Division Subdivision Application Requirements Web Page at:

http://deq.state.wy.us/wqd/subdiv.htm.

Throughout the study, averages for leach field length, well depth, lot size and lot width (taken from existing septic and well permits and applications) are used.

PROCEDURE

DOUBLE DILUTION WELL MODEL

For on-site nitrate loading, a calculated fixed radius was used under the assumption that any individual lot's septic system plume would be captured by that lot's well. The calculated fixed radius describes a circular area around the well defined by a two-year time of travel. It is assumed that any one well is fully penetrating the aquifer thickness used in the equation and that cones of depression do not intersect between lots. The zone of contribution, a diameter measure, is twice the calculated fixed radius.

Equation 1: Calculated Fixed Radius or CFR (ft)

CFR= F.S .* SqRt(Q*T/7.48*Por.*W.S.* π)

F.S= factor of safety

Q= well discharge from average home (gallons/yr)

T= time of travel (yrs)

Por.= Porosity of Aquifer (gallons/ft3) W.S= well screen (ft)

Next, the leach field flux, or cross-sectional flow, is calculated by Eq. 2.

Equation 2: Leach field flux or Qleach (gallons/day)

Qleach= K*i*L*b

K= Aquifer hydraulic conductivity (ft/day)

i= Aquifer hydraulic gradient (ft/ft)

L= length of average leach field (ft)

b=aquifer thickness (ft)

The leach field dilution occurs directly beneath the leach field when the leachate encounters the upper thickness (used in leach field flux calculation) of the saturated aquifer.

Equation 3: Leach field dilution or Cr (mg/L)

Cr=(Qseptic*Cseptic+ Qleach*Cleach)/(Qseptic+ Qleach)

Qseptic= septic tank discharge (gallons/day)

Cseptic= septic tank leachate nitrate concentration (mg/L)

Qleach= leach field flux from Eq. 2 (gallons/day)

Cleach= Ambient nitrate concentration in groundwater samples from area (mg/L)

Next, the diluted nitrates are captured within the domestic well's zone of contribution and then further diluted within this zone by Eq. 4.

Equation 4: Dilution in saturated well screen cylinder or Cp (mg/L)

Cp=(Qleach*Cr+Qwell*Cwell)/ (Qleach+ Qwell)

Qleach= already calculated

Cr= already calculated

Qwell=porosity * π * wellscreen*CFR^2/T*365*7.48 (gallons/day)

Cwell=ambient nitrate concentration in groundwater samples from area (mg/L)

The concentration of diluted nitrates within the well's zone of contribution is then, Cp. This number is then compared to the EPA designated maximum level of contamination, 10 mg/L. The Cp is then used in the Wehrmann Nitrate Model for down-gradient accumulation of nitrate across the entire subdivision.

WEHRMANN NITRATE MODEL

This model takes into account the rollover of nitrate effluent moving in a down-gradient fashion across the subdivision. Cones of depression outside the subdivision study area do not intersect the exterior boundaries of the subdivision. The first calculation to be made is for the volume of precipitation collected on an average lot using precipitation infiltration.

Equation 5: Finding the volume of precipitation or Vi (gallons/day)

Vi=L*W*I*7.48

L= SqRt(mean gross acres*43,560) (ft)

W= same as above

I= precipitation infiltration (ft/day)

The second step is to calculate the volume of septic effluent introduced beneath the subdivision.

Equation 6: Volume beneath subdivision or Vs (gallons/day)

Vs= lots*Qseptic

Lots= number of lots aligned in down-gradient flow

Qseptic=effluent from average lot (gallons/day)

The third step is to calculate the volume of ground water entering the subdivision from the upgradient area.

Equation 7: Volume entering subdivision or Vb (gallons/day)

Vb=K*i*A*7.48

All taken from previous equations.

The fourth step is to calculate any ground water pumped from wells located within the same aquifer, or Vp for the purpose of irrigation. This can be done through the model or by thoughtful approximation of water usage for this purpose in the lots aligned with ground water flow.

Finally, the total concentration of nitrate-nitrogen at the down-gradient boundary is calculated by Eq. 8.

Equation 8: Total nitrate at down-gradient boundary or Co (mg/L)

Co=(Vi*Ci+Vb*Cb-Vp*Cp)/(Vi+Vs+Vb-Vp)

Cp=obtained from Double Well Dilution Model (mg/L)

Ci= concentration of nitrate in precipitation (mg/L)

Cs=concentration of nitrate in septic effluent (mg/L)

Cb=ambient concentration of nitrate in upgradient water

LARAMIE PLAINS SUBDIVISION STUDY

The Laramie Plains Subdivision was chosen as a study site due to its high population density and its proximity to the outcropping of the Casper Aquifer. In this area, overlying Satanka Shale thickness and well depths can be approximated with ease and ambient ground water nitrate concentrations have recently been tested.

Laramie Plains is composed of 76 lots over about 96 acres east of Vista Drive and west of Grand Avenue in Laramie, WY. Ground water flow direction in this area is in an east northeast to west southwest fashion, making the eastern border of the subdivision (Grand Avenue) the up-gradient boundary and Vista Drive the down-gradient boundary. The mean length of all lots along this gradient was 210 ft, numbering 10 lots aligned with ground water flow. All information used to obtain results is as follows in Table 1.

TABLE 1. PARAMETERS AND SOURCES FOR EQUATIONS 1-8.

Factor of Safety (F.S.): 1.5 (DEQ)

Well Discharge (Q): 162,780 gal/year (109,500 (DEQ)+ 3 mos. Irrigation-53280 gal)

Time of Travel (T): 2 years (DEQ)

Porosity (Por): 0.2 (Ben Jordan-referencing Lundy's 1978 pre-thesis)

Average Well Screen (W.S.): 59 ft (Average well depth in area-average Satanka depth in area)

Hydraulic Conductivity (K):** .1-1 ft/day (Western Water LaPrele Study, Table 4-2)

Hydraulic Gradient (i): 0.01 ft/ft (Potentiometric elevation change/topographical change per Western Water's Plate 6-2, 1997)

Average Length of Leach Field (L): 167ft (Average of 7 random samples taken in subdivision-trench drain fields-Septic Permits)

Aquifer Thickness (b):** 160-350 ft (Ben Jordan and Joel Farber)

Household Septic Discharge (Qseptic): 300 gal/day (DEQ)

Leachate Nitrate Concentration (Cseptic): 40 mg/L (DEQ)

Ambient Nitrate Concentration (Cleach): 1.91 mg/L (Average of 2001 samples from local resident, Ron Olsen)

Precipitation Infiltration (I): 0.000183 ft/day (7% precipitation for Laramie @11.5 in/yr)

Average Size per Lot: 1.3 acres (Average from well data)

Maximum Lots Aligned with Flow: 10 (County Assessor's Map)

Mean Lot Width: A=210.1, s=163, L=269 (County Assessor's Map-NOTE: at s, the number of lots down flow is 8, not 10)

Note: **The final concentration of nitrates has been calculated using both numbers to achieve both conservative and non-conservative solutions.

RESULTS

Using 150 gal/day as an estimation of water pumped for irrigation in the 10 lots aligned with ground water flow, and the variance in hydraulic conductivity and aquifer thickness, the following results were achieved:

Hydraulic Conductivity (K) Aquifer Thickness (b) On-Site Nitrate Loading (Cp) Nitrate Loading at Down Gradient Subdivision Boundary (Co)

0.1 ft/day 160 ft 4.0 mg/L29.7 mg/L

0.1 ft/day 350 ft 4.7 mg/L27.8 mg/L

1 ft/day 160 ft 4.4 mg/L19.8 mg/L

1 ft/day 350 ft 3.6 mg/L14.0 mg/L

DISCUSSION

The EPA MCL is 10 mg/L. The on-site nitrate loading for the subdivision is below the maximum. However, according to this model, even in the best-case scenario with respect to possible hydraulic conductivity and aquifer thickness in Laramie Plains yields 14.0 mg/L - almost 150% the maximum nitrate levels dictated by the EPA.

The Double Dilution and Wehrmann Nitrate Models are box models which yield a worst-case scenario, one in which denitrification through soil process is non-existent and all nitrate loaded leachate seeps into the same aquifer from which the ground water is drawn. The EAC believes that this conservative model is appropriate for Laramie Plains for two reasons. First, the soils in the subdivision provide little to no denitrification. Therefore, an assumption can be made that a large percentage of the original leachate is reaching groundwater. Secondly, there are many fractures and faults mapped and known to exist in and near the Laramie Plains Subdivision where conduit flow may lead to the rapid introduction of nitrate to the aquifer below. In areas where this is true, the worst-case scenario described by this model may be accurate.

RECOMMENDATION

After reviewing the results of this study, the EAC feels it is necessary to recommend that Laramie Plains receive City Water and Sewer services. The EAC also recommends that further studies of surrounding subdivisions be pursued.

APPENDIX L

DELEGATION AGREEMENT

DELEGATION AGREEMENT

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

AND ALBANY COUNTY

ARTICLE I. AUTHORITY

Pursuant to the authority of W.S. § 35-11-304, the State of Wyoming, acting through the administrator of the Water Quality Division and the director of the Department of Environmental Quality referenced to herein as "Department", and Albany County, a local governmental County, referred to herein as "County", enter into the following delegation agreement.

ARTICLE II. INTRODUCTION AND PURPOSE

This agreement is authorized by W.S. § 35-11-304, which provides that, to the extent requested by a county, the administrator of the Water Quality Division, with the approval of the director of the Department of Environmental Quality, shall delegate the authority to enforce and administer the provisions of W.S. § 35-11-301(a)(iii). This delegation includes the authority to develop necessary rules, regulations, standards and permit systems and to review and approve construction plans, conduct inspections and issue permits. This agreement provides for local assumption of such authority, and for promulgation of local regulations consistent with the standards and provisions of the Wyoming Environmental Quality Act and applicable standards and regulations promulgated pursuant to the Act.

The purpose of this agreement is to enhance and foster state-local cooperation in the regulation of small wastewater facilities, and to provide uniform and effective application of the provisions of Wyoming Environmental Quality Act relating to the construction and operation of these facilities. The County agrees to assume, and the Department agrees to delegate authority for the County to regulate small wastewater facilities within Albany County.

ARTICLE III. DEFINITIONS

SMALL WASTEWATER SYSTEM - any sewage system, disposal system or treatment works having simple hydrological and engineering needs which are intended for wastes originating from a single residential unit serving no more than four (4) families or which distributes 2,000 gallons or less of domestic sewage per day.

"DOMESTIC SEWAGE" - For purposes of this agreement, means the organic waste and wastewater of the type generally associated with a residence, whether generated by a residential, commercial or industrial use, but does not include wastes that are likely to contain significant quantities of chemicals, grease or oil,, or other materials that may require separation or special treatment, including but not limited to car washes, laundromats and restaurants.

ARTICLE IV. EFFECTIVE DATE

This agreement is effective upon execution by the authorized representatives of the Department and the County designated to assume the authority described in W.S. § 35-11-304. This agreement shall remain in effect until terminated as provided in Article XI.

ARTICLE V. SCOPE

Under this agreement, the authority to administer and enforce a permit program for small wastewater facilities, within Albany County is delegated to the County which has complied with the requirements of W.S. § 35-11-304, applicable Wyoming Water Quality Rules and Regulations and the terms of the Wyoming Administrative Procedure Act, W.S. § 16-3-101, et. seq..

ARTICLE VI. REQUIREMENTS FOR THE AGREEMENT

The Department, by the administrator of the Water Quality Division, and the County by the Chairman of the Albany County Commissioners, affirm that they will comply with all of the provisions of this agreement, all applicable standards and Wyoming Water Quality Rules and Regulations and any applicable regulations promulgated by the County and that they will continue to meet all the conditions and requirements specified in this agreement.

The administrator of the Department of Environmental Quality, Water Quality Division shall be responsible for administering this agreement on behalf of the State of Wyoming. The Albany County Commissioners shall administer this agreement on behalf of the County in accordance with W.S. § 35-11-304(a)(ii).

The Department of Environmental Quality, Water Quality Division, has had and shall continue to have authority to carry out this agreement, and shall expend sufficient funds to effectively implement the delegation and oversight activities contemplated in W.S. § 35-11-304.

ARTICLE VII. TERMS OF THE AGREEMENT

By execution of this agreement, the Department of Environmental Quality, Water Quality Division delegates and Albany County accepts authority and responsibility to enforce and administer the provisions of W.S. § 35-11-301(a)(iii) for small wastewater facilities. The delegation includes the authority to develop necessary rules, regulations, standards and permit systems, to review and approve construction plans, conduct inspections, issue permits, to enforce compliance and to develop rules governing the review and appeal of any decision made by the County.

The County agrees to enforce and administer the permit program for small wastewater facilities within its boundaries, namely the unincorporated areas of Albany County, Wyoming. The boundaries are identified on the maps included in Exhibits 1, 1A and 1B, and incorporated herein by reference.

The County designates the Albany County Planning Director as the “delegated local official” who has been authorized to enforce and administer the permitting program delegated herein. The resolution designating the “delegated local official” is included in Exhibit 2 and incorporated by reference.

The County will be responsible for review and approval, based on compliance with the Design and Construction Standards, of all applications for installation, replacement, and/or repair of small wastewater facilities, and for the on-site inspections of all approved systems. The review and inspection process of applications may be conducted by qualified employees that are employed by the County, or the County may enter into a contract for professional services with a qualified consultant to the extent authorized by the administrator. The County has established rules, regulations and standards for the issuance of permits required under W.S. §§ 35-11-301(a)(iii), which are at least as stringent as those promulgated by the state under W.S. § 35-11-302(a)(iii). Such standards and rules, as promulgated, are found in Exhibit 3 and incorporated herein by reference.

The County has developed and adopted permitting procedures consistent with those established in Chapter III, Wyoming Water Quality Rules and Regulations. The procedures as adopted by the County are included in Exhibit 4 and incorporated by reference.

The delegated local official shall establish and maintain an adequate system of records and information for each project. The records and information system to be used by the County is described in Exhibit 5 incorporated herein by references.

The County agrees to submit status reports to the administrator annually. The administrator will review the status report and may conduct an on-site evaluation of the local program to assess the County’s compliance with the terms of this agreement. Upon request and reasonable notice, the administrator may during business hours inspect and copy the records and procedures of the County with regard to the review, issuance, inspection and enforcement of the permit program.

ARTICLE VIII. OTHER CONDITIONS OF DELEGATION

A permit may not be issued for any facility which would result in non-compliance with an approved Water Quality Management Plan prepared under Sections 208 or 201 of the Federal Clean Water Act.

The Department of Environmental Quality, Water Quality Division will provide technical and other assistance as requested in order to provide support to Albany County in administering the Delegation Agreement.

The County will commence performing the functions delegated by this agreement upon the date of execution and continue until such time as delegation is suspended or revoked or until the County provides 90 days' notice of intent to terminate the agreement.

This agreement may be amended at any time by written agreement of the parties.

ARTICLE IX. CHANGES IN STATE OR COUNTY STANDARDS

The Department may from time to time revise and promulgate new or revised construction and/or operation standards and administrative procedures. If necessary in order to meet the requirements of W.S. § 35-11-304(a)(iii) and (iv), the County shall make such changes as may be accomplished by rule-making within six months of notice by the state. Such changes shall be made in conformity with the requirements of W.S. §§ 16-3-101, et. seq.

The state and the County shall provide each other with copies of any changes to their respective laws, rules, regulations and standards which pertain to the administration and enforcement of this agreement.

ARTICLE X. INSPECTION

The delegated local official, or his designee, shall provide for inspection of all facilities during construction to ensure the facilities have been constructed according to approved plans and specification. The delegated local official, or his designee, may also conduct periodic operation inspections of facilities permitted under the authority of this agreement, and may implement procedures for inspection and reporting of inspection in conformity with W.S. § 35-11-303(a)(i). The delegated local official will be the primary point of contact and inspection authority for activities covered by this agreement.

The Department may designate authorized representatives to enter and inspect the construction and/or operation of the facilities described in this agreement. The inspections shall be conducted in conformity with W.S. § 35-11-303(a)(i). The County shall receive reasonable notice and may participate in such inspection.

ARTICLE XI. ENFORCEMENT

The County shall be the primary enforcement authority concerning compliance with the requirements of the construction and permitting management activities delegated by this agreement. A legal opinion indicating that the County has necessary authority to enforce compliance at the local level is included in Exhibit 8 and incorporated herein by reference.

The Department and/or County may take action necessary to comply with the terms of the Wyoming Environmental Quality Act, and applicable standards and regulations. The agreement does not limit the state's authority to enforce other violations of state law.

Through monthly reports, the local governmental County shall notify the Department of all violations of applicable laws, regulations or orders and all actions taken with respect to such violations and copies of all approved permits to construct.

ARTICLE XII. REVOCATION, SUSPENSION OR TERMINATION

This agreement may be voluntarily terminated by the County upon 90 days notice. Additionally, the administrator with the approval of the director may revoke or temporarily suspend the delegation agreement if the County fails to perform its delegated duties or has otherwise violated the terms of this agreement. The administrator shall immediately notify the delegated local official in writing of any revocation or suspension of the permitting authority. Such administrative action is subject to review by the Environmental Quality Council if the County so requests within 20 days after the receipt of such notice. Unless a revocation or suspension is appealed to the Council, it becomes effective 20 days after the receipt of such notice.

The County may not assign any of its functions or authority delegated by this agreement without prior consent of the administrator.

The parties to this agreement have read and understand all of its provisions. This agreement is effective upon execution this ___________ day of __________, 2002.

DEPARTMENT OF ENVIRONMENTAL QUALITY

_______________________________________ _________________________

Dennis Hemmer, Director Date

WATER QUALITY DIVISION

____

____

Gary Beach, Administrator   Date

ALBANY COUNTY

____

____

Chairman, Albany County Commissioners   Date

APPENDIX M

GLOSSARY OF WELLHEAD PROTECTION AND HYDROGEOLOGIC TERMS AND ACRONYMS

PURPOSE

The purpose of this Glossary is to provide a list of terms and acronyms used in this document, commonly used by hydrogeologists, as well as some specific terms used in groundwater contamination assessments and Wellhead Protection. These definitions are adapted from EPA Guidance Documents on Wellhead Protection and textbooks on groundwater hydrology.

DEFINITIONS

Alluvium: A general term for clay, silt, sand, gravel or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water.

Analytical model: A model that provides approximate or exact solutions to simplified mathematical forms of the differential equations for water movement and solute transport. Analytical models can generally be solved using calculators or computers.

Anisotropy: The condition of having different properties in different directions. The direction of flow.

Anticline: A fold in rock strata that is convex upward.

Aquiclude: A subsurface rock, soil or sediment unit that does not yield useful quantities of water.

Aquifer test: A test to determine hydrologic properties of an aquifer, involving the withdrawal of measured quantities of water from, or addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition. Same as pump test.

Aquifer/Aquifer System: A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells, springs, and drain tunnels.

Aquitard: The less-permeable beds in a stratigraphic sequence that tend to restrict or impede groundwater flow relative to the more permeable beds that serve as aquifers.

Area of influence: Area surrounding a pumping or recharging well within which the water table or potentiometric surface has been changed due to the well's pumping or recharge.

Artesian Conditions: In a confined aquifer, when the water level in a well rises above the top of the aquifer.

Attenuation: The process of diminishing contaminant concentrations in groundwater, due to filtration, biodegradation, dilution, sorption, volatilization, and other processes.

Collection area: The area surrounding a groundwater source which is underlain by collection pipes, tile, tunnels, infiltration boxes, or other groundwater collection devices.

Colluvium: Loose, heterogeneous, incoherent mass of soil material and/or rock fragments deposited chiefly by mass-wasting.

Cone of depression (COD): A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a well from which water is being withdrawn. Its trace (perimeter) on the land surface defines the zone of influence of a well. Also called pumping cone and cone of drawdown.

Confined aquifer: The following criteria are met in order to verify and maintain an upward hydraulic gradient in the producing aquifer: an effective confining layer must exist between the ground surface and the producing aquifer.

Contact: The surface where two different kinds of rock come together.

Contaminant: An undesirable substance not normally present, or an unusually high concentration of a naturally occurring substance, in water, soil, or other environmental medium.

Contamination: The degradation of natural water quality as a result of man's activities.

Controls: The codes, ordinances, rules, and regulations currently in effect to regulate a potential contamination source.

Criteria: The conceptual standards that form the basis for WHPA area delineation to include distance, groundwater time of travel, aquifer boundaries, and groundwater divides.

Criteria threshold: A value or set of values selected to represent the limits above or below which a given criterion will cease to provide the desired degree of protection.

DEQ: Wyoming Department of Environmental Quality.

Designated person: The person appointed by a PWS to ensure that the requirements of State-wide wellhead protection program are met.

Dip: The angle at which a stratum or planar feature is inclined from the horizontal.

Dispersion: The spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

Drawdown: The vertical distance groundwater elevation is lowered, or the amount head is reduced, due to the removal of groundwater. Also the decline in potentiometric surface caused by the withdrawal of water from a hydrogeologic unit. The distance between the static water level and the surface of the cone of depression. A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of groundwater from wells.

Existing groundwater source of drinking water: A public supply groundwater source for which plans and specifications are submitted to DEQ.

Fissure: A fracture or crack in a rock along which there is a distinct separation.

Flow line: The general path that a particle of water follows under laminar flow conditions. Line indicating the direction followed by groundwater toward points of discharge. Flow lines generally are considered perpendicular to equipotential lines.

Flow model: A computer model that calculates a hydraulic head field for the study area using numerical methods to arrive at an approximate solution to the differential equation of groundwater flow.

Flow path: The path a water molecule or solute follows in the subsurface.

Flow System/Hydraulic Boundary: A hydrologic feature that prevents the flow of groundwater. Examples include groundwater divides or low permeability material that impedes groundwater flow.

Flowing Artesian: When the water level in a well rises above and flows at the ground surface.

FOOTWALL: The lower side of a horizontal or inclined rock body or fault. If the fault has dip-slip translational movement along a normal fault, the footwall block is upthrown; the footwall block is downthrown along a reverse fault.

FRACTURE: A general term for any break in a rock, which includes cracks, joints, and faults.

GROUNDWATER BARRIER: Rock or artificial material with a relatively low permeability that occurs (or is placed) below ground surface, where it impedes the movement of groundwater and thus may cause a pronounced difference in the heads on opposite sides of the barrier.

GROUNDWATER BASIN: General term used to define a groundwater flow system that has defined boundaries and may include more than one aquifer. The basin includes both the surface area and the permeable materials beneath it. A rather vague designation pertaining to a groundwater reservoir that is more or less separate from neighboring groundwater reservoirs. A groundwater basin could be separated from adjacent basins by geologic boundaries or by hydrologic boundaries.

GROUNDWATER DIVIDE: Ridge in the water table, or potentiometric surface, from which groundwater moves away at right angles in both directions. Line of highest hydraulic head in the water table or potentiometric surface.

GROUNDWATER MOUND: Raised area in a water table or other potentiometric surface, generated by groundwater recharge.

GROUNDWATER SOURCE: Any well, spring, tunnel, adit, or other underground opening from or through which groundwater flows or is pumped from subsurface water bearing formations.

HANGING WALL: The upper side of a horizontal or inclined rock body or fault . The hanging wall is downthrown along a normal fault with dip-slip movement; the hanging wall is upthrown along a reverse-slip fault.

HEAD, TOTAL: Height of the column of water at a given point in a groundwater system above a datum plane such as mean sea level. The sum of the elevation head (distance of a point above datum), the pressure head (the height of a column of liquid that can be supported by static pressure at the point), and the velocity head (the height to which the liquid can be raised by its kinetic energy).

HETEROGENEITY: Characteristic of a medium in which material properties vary from point to point.

HOMOGENEITY: Characteristic of a medium in which material properties are identical throughout.

HYDRAULIC CONDUCTIVITY (K): A coefficient of proportionality describing the rate at which water can move through a permeable medium. It is a function of the porous medium and the fluid.

HYDRAULIC GRADIENT (I): Slope of a water table or potentiometric surface. More specifically, change in head per unit of distance in a given direction, generally the direction of the maximum rate of decrease in head. The difference in hydraulic head divided by the distance along the flowpath.

HYDROGEOLOGIC METHODS: The techniques used to translate selected criteria and criteria thresholds into mappable delineation boundaries. These methods include, but are not limited to, arbitrary fixed radii, analytical calculations and models, hydrogeologic mapping, and numerical flow models.

HYDROGEOLOGIC UNIT: Any soil or rock unit or zone that because of its hydraulic properties has a distinct influence on the storage or movement of groundwater.

IMPERMEABLE: Characteristic of geologic materials that limit their ability to transmit significant quantities of water under the head differences normally found in the subsurface environment.

INTERFERENCE: The result of two or more pumping wells, the drawdown cones of which intercept. At a given location, the total well interference is the sum of the drawdowns due to each individual well. The condition occurring when the area of influence of a water well comes into contact with or overlaps that of a neighboring well, as when two wells are pumping from the same aquifer or are located near each other.

ISOTROPY: The condition in which the properties of interest (generally hydraulic properties of the aquifer) are the same in all directions.

LAND MANAGEMENT STRATEGIES: Zoning and non-zoning controls which include, but are not limited to, the following: zoning and subdivision ordinances, site plan reviews, design and operating standards, source prohibitions, purchase of property and development rights, public education programs, groundwater monitoring, household hazardous waste collection programs, water conservation programs, memoranda of understanding, written contracts and agreements, and so forth.

LEAKAGE: The vertical flow of groundwater; commonly used in the context of vertical groundwater flow through confining strata.

LIMESTONE: A bedded sedimentary deposit consisting chiefly of calcium carbonate.

MAXIMUM CONTAMINANT LEVEL (MCL): Maximum permissible level of a contaminant in water that is delivered to the users of a public water system.

Maximum containment level is defined more explicitly in Safe Drinking Water Act (SDWA) regulations (40 CFR Section 141.2).

New groundwater source of drinking water: A public supply groundwater source of drinking water for which plans and specifications are submitted to DEQ.

Nonpoint source: Any conveyance not meeting the definition of point source.

Normal fault: A fault, with an angle usually between 45-90 degrees, at which the hanging wall (upper block) has moved downward relative to the footwall (lower block) .

Observation well: A well drilled in a selected location for the purpose of observing parameters such as water levels or water chemistry changes.

Permeability: Capacity of a rock or soil material to transmit a fluid.

Piezometric surface: See potentiometric surface.

Point source: Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, animal feeding operation with more than ten animal units, landfill, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture.

Pollution source: Point source discharges of contaminants to ground water or potential discharges of the liquid forms of "extremely hazardous substances" which are stored in containers in excess of "applicable threshold planning quantities" as specified in SARA Title III. Examples of possible pollution sources include, but are not limited to, the following: storage facilities that store the liquid forms of extremely hazardous substances, septic tanks, drain fields, Class V underground injection wells, landfills, open dumps, landfilling of sludge and septage, manure piles, salt piles, pit privies, drain lines, sewer lines, and animal feeding operations.

Porosity: The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

Potable water: Suitable for human consumption as drinking water.

Potential contamination source: Any facility or site which employs an activity or procedure which may potentially contaminate groundwater. A pollution source is also a potential contamination source.

Potentiometric Surface: A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.

Pump Test: A test to determine hydrologic properties of an aquifer, involving the withdrawal of measured quantities of water from, or additional of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition.

PWS: Public water system.

Radial flow: The flow of water in an aquifer toward a well.

Recharge area: Area in which water reaches the groundwater reservoir by surface infiltration. An area in which there is a downward component of hydraulic head in the aquifer.

Residual soil: Unconsolidated or partly weathered material, presumed to have developed in place (by weathering) from the consolidated rock on which it lies.

Reverse fault: Fault with a dip greater than 45 degrees at which the hanging wall (upper block) appears to have moved upward relative to the footwall (lower block).

Sandstone: A cemented or otherwise compacted detrital sediment composed predominantly of quartz sand grains.

Shale: A laminated sediment in which the constituent particles are composed of clay. Same as mudstone, except mudstone may be composed of a percentage of silt and may or may not be laminated.

Stagnation point: A place in a groundwater flow field at which the groundwater is not moving.

Storage Coefficient: The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

Thrust fault: Fault with a dip of 45 degrees or less in which the hanging wall (upper block) appears to have moved upward relative to the footwall (lower block) .

Time of travel (TOT): The time required for a particle of water to move in the saturated zone from a specific point to a groundwater source of drinking water.

Transmissivity: The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media.

Unconfined Aquifer: Any aquifer that does not meet the definition of a confined aquifer. An aquifer over which there is no confining strata and the water table forms the upper boundary.

Wellfield: An area containing two or more wells supplying a public water supply system.

Wellhead Protection Program (WHP): The program to protect drinking water source protection zones and management areas from contaminants that may have an adverse effect on the health of persons.

Wellhead: The physical structure, facility, or device at the land surface from or through which groundwater flows or is pumped from subsurface, water-bearing formations.

Wellhead Protection Area (WHPA): The surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field.

Zone of Contribution (ZOC): The area surrounding a pumping well, spring, or tunnel that encompasses all areas and features that supply groundwater recharge to the well spring, or tunnel.

Zone of Influence (ZOI): The distance from the well where changes in the groundwater surface (water levels) can be measured or inferred as a result of pumping.

ACRONYMS

AG: Agriculture
AST: Aboveground Storage Tank
ASTM: American Society for Testing and Materials
AUM: Animal Unit Month
AWWA: American Water Works Association
BMP's: Best Management Practices
Bti: Bacillus Thuringiensis Israelensis
CAPA: Casper Aquifer Protection Area
CAPP: Casper Aquifer Protection Plan
CERCLIS: CERCLA Information System
CFR: Code of Federal Regulations
CMP: Contaminant Management Plan
CP: Contingency Plan
CSIS: Contaminant Source Identification Subcommittee
COD: Cone of Depression
DEQ: Department of Environmental Quality

EAC: Environmental Advisory Committee
EIA: Environmental Impact Assessment
EMA: Emergency Medical Association
EOC: Emergency Operations Center
EPA: Environmental Protection Agency
FEMA: Federal Emergency Management Agency
FRDS: Federal Reporting Data System
GIA: Groundwater Impact Assessment
GIS: Geographic Information System
Gpd/ft: Gallons per day per foot
GPM: Gallons Per Minute
GPS: Global Position Systems
HHWC: Household Hazardous Waste Collection
HWDMS: Hazardous Waste Data Management System
LARC: Laramie Albany Records and Communications
LRRC: Laramie Rifle Range Corporation
LRDWPP: Laramie Regional Drinking Water Protection Program
LUST: Leaking Underground Storage Tank
MCL: Maximum Contaminant Level
Mgd: Million Gallons per Day
Mg/L: Milligrams per Liter
MOA/MOU: Memorandum of Agreement or Understanding
NPDES: National Pollution Discharge Elimination System
NRCS: Natural Resources Conservation Service
PIO: Public Information Officer
PPIC: Pollution Prevention Information Clearinghouse
PUD: Cluster/Planned Unit Development
PWS: Public Water System
RCRA: Resource Conservation and Recovery Act
RCRIS: RCRA Information System
SARA: Superfund Amendments and Reauthorization Act
SDWA: Safe Drinking Water Act
SEO: State Engineer's Office
SPCC: Spill Prevention Control and Countermeasure
SWAP: Source Water Protection
SWD: Solid Waste Division
TDS: Total Dissolved Solids
TOT: Time of Travel
TRI: Toxic Chemical Release Inventory
UIC: Underground Injection Control
UPRR: Union Pacific Railroad
UST: Underground Storage Tanks
UW: University of Wyoming
WDEQ: Wyoming Department of Environmental Quality

WEMA: Wyoming Emergency Management Agency
WHP: Wellhead Protection
WHPA: Wittman Hydro Planning Associates
WOC: Water Outreach Coordinator
WQD: Water Quality Division
WRI: Wyoming Research Institute
WWC: Western Water Consultants, Inc.
WYDOT: Wyoming Department of Transportation
ZOC: Zone of Contribution
ZOI: Zone of Influence