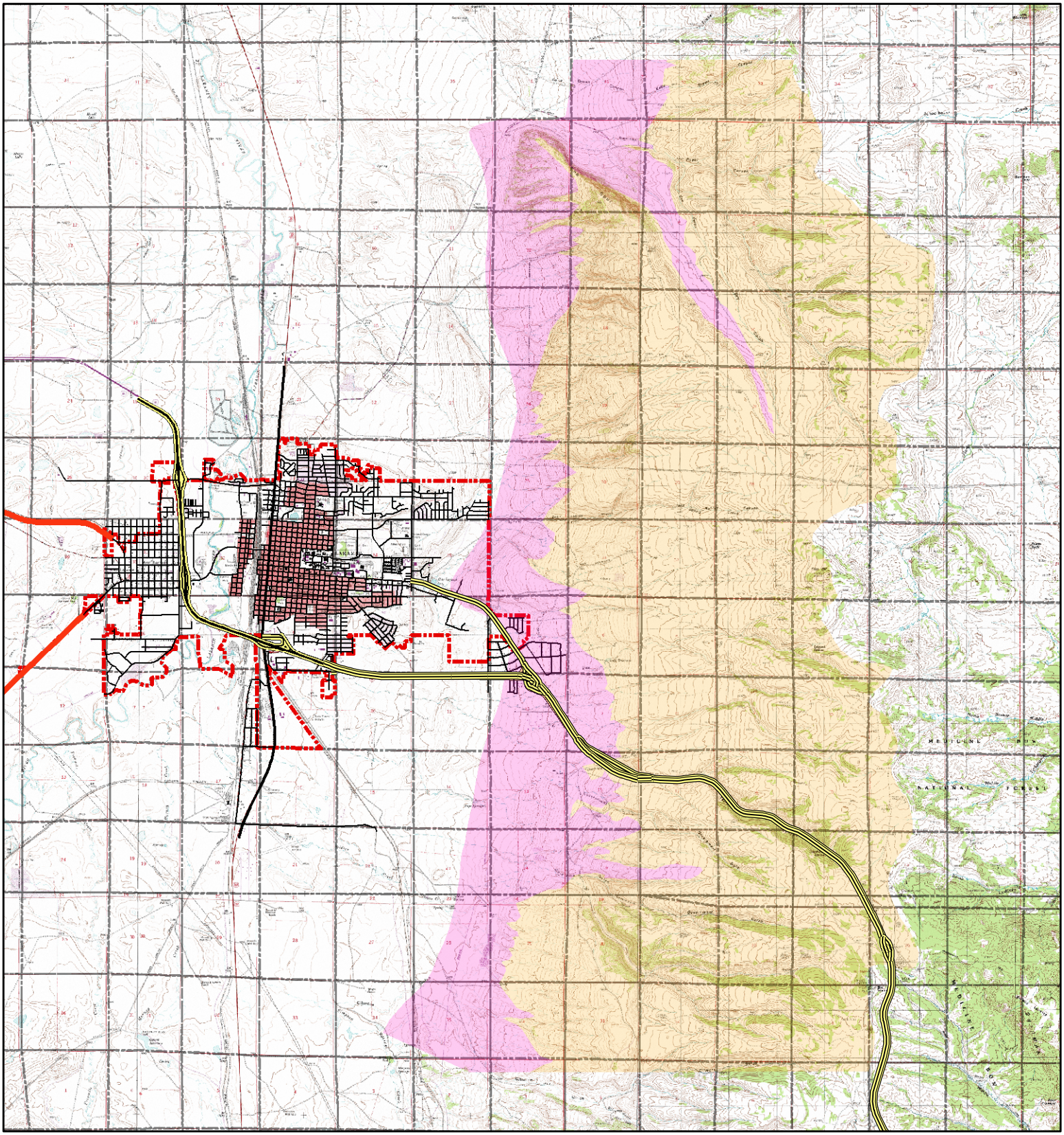
The Casper Aquifer Protection Plan



City of Laramie/Albany County
Environmental Advisory Committee
November, 2006

TABLE OF CONTENTS

LIST OF FIGURES, TABLES, PLATES

ACKNOWLEDGEMENT

EXECUTIVE SUMMARY

1
INTRODUCTION 1-1
Purpose 1-1
Wellhead Protection (WHP) Plan Overview 1-1
Background 1-2
Ground water Protection and Use 1-2
Wellhead Protection Versus Aquifer Protection 1-3

2
COMMUNITY PLANNING TEAM 2-1
General Intent 2-1
Laramie-Albany County Environmental Advisory Committee 2-1
Groundwater Guardian Program 2-2
Community Outreach and Educational Activities 2-2
Index of Press Releases 2-3
1998 2-3
1999 2-3
2000 2-3
2001 2-4
2002 2-4
EAC Goals 2-5

3
DELINEATION REPORT 3-1
Introduction 3-1
Drinking Water Protection Programs 3-1
History of Laramie Regional Drinking Water Protection Program 3-2
Geology and Hydrogeology of the Laramie Area 3-3
Structural Setting 3-3
Stratigraphy 3-5
Hydrostratigraphy 3-6
Well Data 3-3
Pump Data 3-3
Delineation Methods 3-3
Delineation Process 3-14
Written Description of Aquifer Protection Areas 3-22
Available Data Limitations and Future Recommendations 3-22
Site Specific Modifications to the Plan 3-22
Recommended Investigations 3-23
Revising and Updating the Plan 3-23

4
CONTAMINANT SOURCE INVENTORY 4-1
Introduction 4-1
Approach 4-2
Potential Sources of Contamination 4-3
Potential Sources of Contamination 4-4
Residential Contaminant Sources 4-5
Updating and Refining the Contaminant Source Inventory 4-5

5
CONTAMINANT MANAGEMENT PLAN 5-1
Introduction 5-1
Priority Management Strategies and Implementation Schedule 5-1
Year 2004 Management Goals 5-1
Year 2006 Management Goals 5-2
Year 2009 Management Goals 5-2
Management Strategies Presently Being Implemented 5-2
Overview of Potential Management Strategies and Approaches 5-3
Non-Regulatory Management Strategies 5-3
Regulatory Management Strategies 5-5

Recommended Management Strategies for Potential Contaminant Sources Identified within the Casper Aquifer Protection Area 5-7
Zone 1 5-7
Groundwater Monitoring 5-7
Septic Systems 5-8
Hazardous Material Spills along Interstate 80 5-11
Road Salt Application 5-12
Springs 5-12
Wells 5-13
Abandoned Wells 5-13
Underground Injection Control (UIC) Wells 5-14
Hazardous Materials Spills along Union Pacific Railroad 5-14
Limestone Quarries 5-14
Local Landfills and Dumps 5-15
Laramie Rifle Range 5-16
Sewer Lines 5-17
Natural Gas Pipelines 5-17
Urban Runoff 5-17
Underground Storage Tanks 5-18
Aboveground Storage Tanks 5-18
Pesticide Spraying and Fertilizer Application 5-19
Existing Land-Uses that are Potentially Nonconforming 5-19
Future Types of Land Use within the Protection Area 5-20

Disclaimer 5-20

6
CONTINGENCY PLAN 6-1
Introduction 6-1
Organization of Plan 6-1
Plan Development 6-1
Plan Distribution 6-1
Procedures for Review and Update 6-2
Emergency Probability and Severity Chart 6-2
City of Laramie Water Demands and Source Inventory 6-2
Alternative Potable Water Supplies or Emergency Coordinating Agencies 6-3
Water Distribution System and Storage Facilities 6-3
Emergency Response 6-4
Water Shortage Contingency Plans and Scenarios 6-4
Potential Scenarios 6-6
Scenario #1 Contamination of the Laramie River upstream of the Water Treatment Plant 6-6
Scenario #2 Spill occurs on I-80 in Telephone Canyon 6-6
Scenario #3 Spill occurs south of town on the UPRR 6-7
Contaminant Spill Scenarios and Contingency Plan 6-8
Plan 6-9
Sources of Funds and Disaster Relief 6-9
Press Release Template 6-10
Emergency Notification Roster 6-11

BIBLIOGRAPHY

APPENDIX A Resolutions of Support
APPENDIX B Delineation Report Version 1.0
APPENDIX C Contaminant Source Identification Forms, Source Inventory List, Form IV
APPENDIX D Best Management Practices for Single-Family Residences
APPENDIX E Delegation Agreement
APPENDIX F Nitrate Loading Study in the Laramie Plains Subdivision
APPENDIX G Underground Storage Tank Ordinance – Ch. 8.60
APPENDIX H Commercial and Industrial Land Uses that Generate Hazardous Waste
APPENDIX I Susceptibility Assessment
APPENDIX J Aquifer Protection Ordinances
APPENDIX K Glossary of Wellhead Protection and Hydrogeologic Terms

LIST OF FIGURES

Figure 1-1: Casper Aquifer Protection Area
Figure 1-2: The Difference between a Wellhead Protection Area and an Aquifer Protection Area

Figure 3-1: Stratigraphic Column in the Vicinity of Laramie
Figure 3-2: General Outcrop Area of the Casper Aquifer
Figure 3-3: Hydrogeologic Role of Formation
Figure 3-4: General Schematic Cross-sections
Figure 3-5: Casper Aquifer Protection Area Zones
Figure 3-6. Casper Aquifer Protection Area Zone 1 Delineation (Accident Prevention Zone)
Figure 3-7: Determination of Offset Distances as a Function of Dip of the Satanka Shale

Figure 4-1a: Casper Aquifer Protection Area
Figure 4-1b: Imagery
Figure 4-2: County Land Use and City Zoning
Figure 4-3a: Potential Contamination Sources
Figure 4-3b: Potential Contamination Sources
Figure 4-4a: Subdivisions & Parcels
Figure 4-4b: Subdivisions by Year
Figure 4-5a: Potential Septic Systems & Wells
Figure 4-5b: Potential Septic Systems & Wells

LIST OF TABLES

Table 2-1: 2001-2002 Environmental Advisory Committee
Table 2-2: Environmental Advisory Subcommittee Members

Table 3-1: City of Laramie Municipal Well Data
Table 3-2: Pump Data

Table 4-1: Subdivision Information for the Casper Aquifer Protection Area

Table 6-1: Emergency Probability and Severity Chart for Laramie Regional Drinking Water Protection Program
Table 6-2: Water Demand Projection (mgd)
Table 6-3: Water Source Inventory (mgd)
Table 6-4: Water Availability (mg/d)
Table 6-5: Water Deficiency Compared to Average and Peak Demand (mg/d)

LIST OF PLATES

Plate 1: Aquifer Protection Area Map of the Laramie Area, Albany County, Wyoming

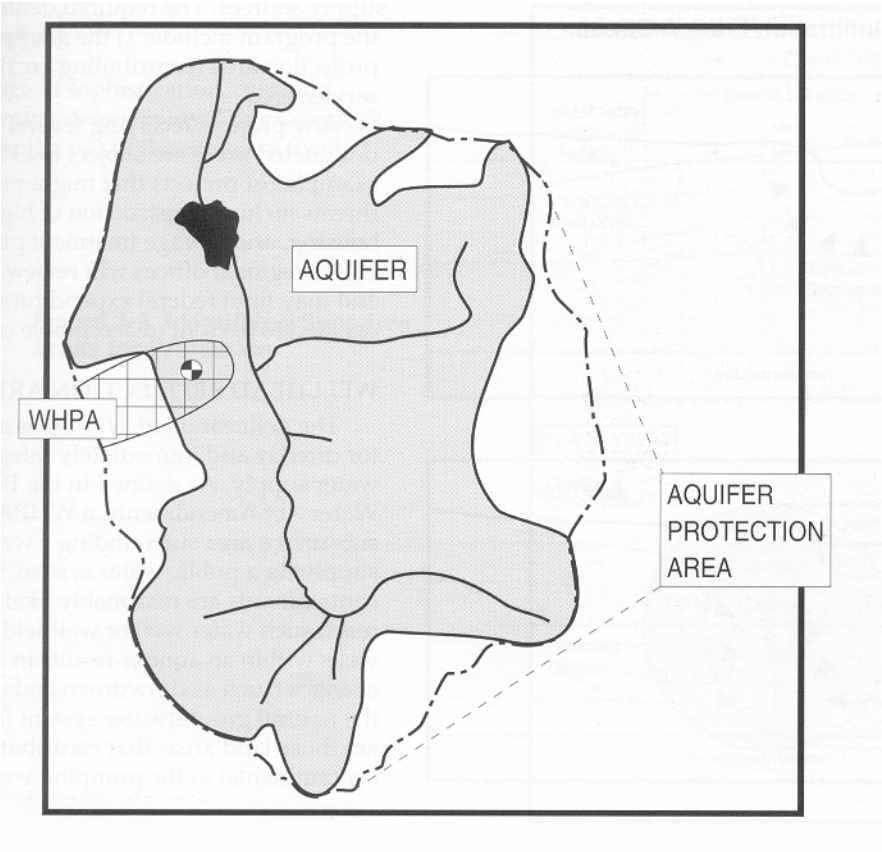


Figure 1-2 THE DIFFERENCE BETWEEN A WELLHEAD PROTECTION AREA AND AN AQUIFER PROTECTION AREA

Casper Aquifer Protection Program
Adapted From: Witten and Horsley (1995)

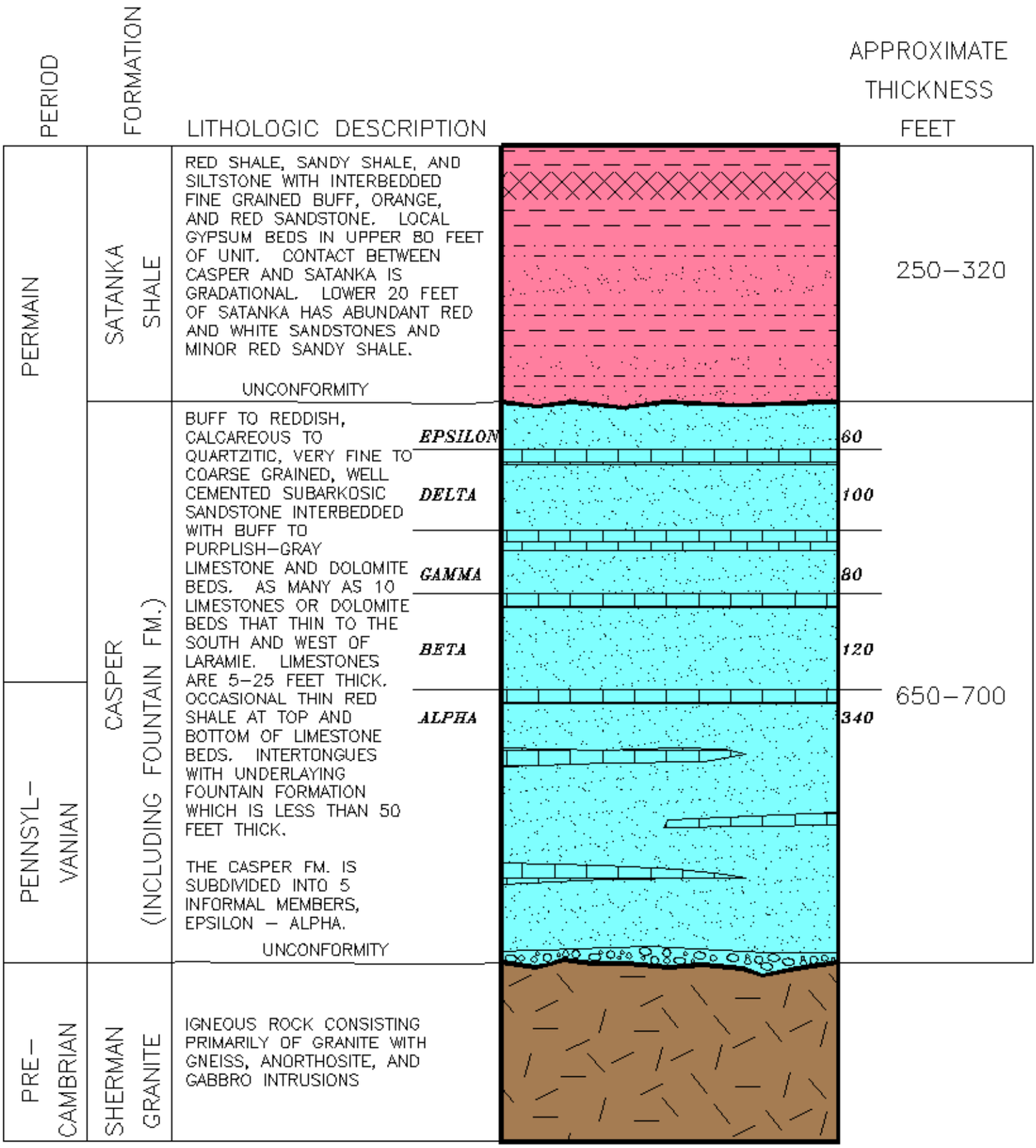


Figure 3-1 Stratigraphic Column in the Vicinity of Laramie

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

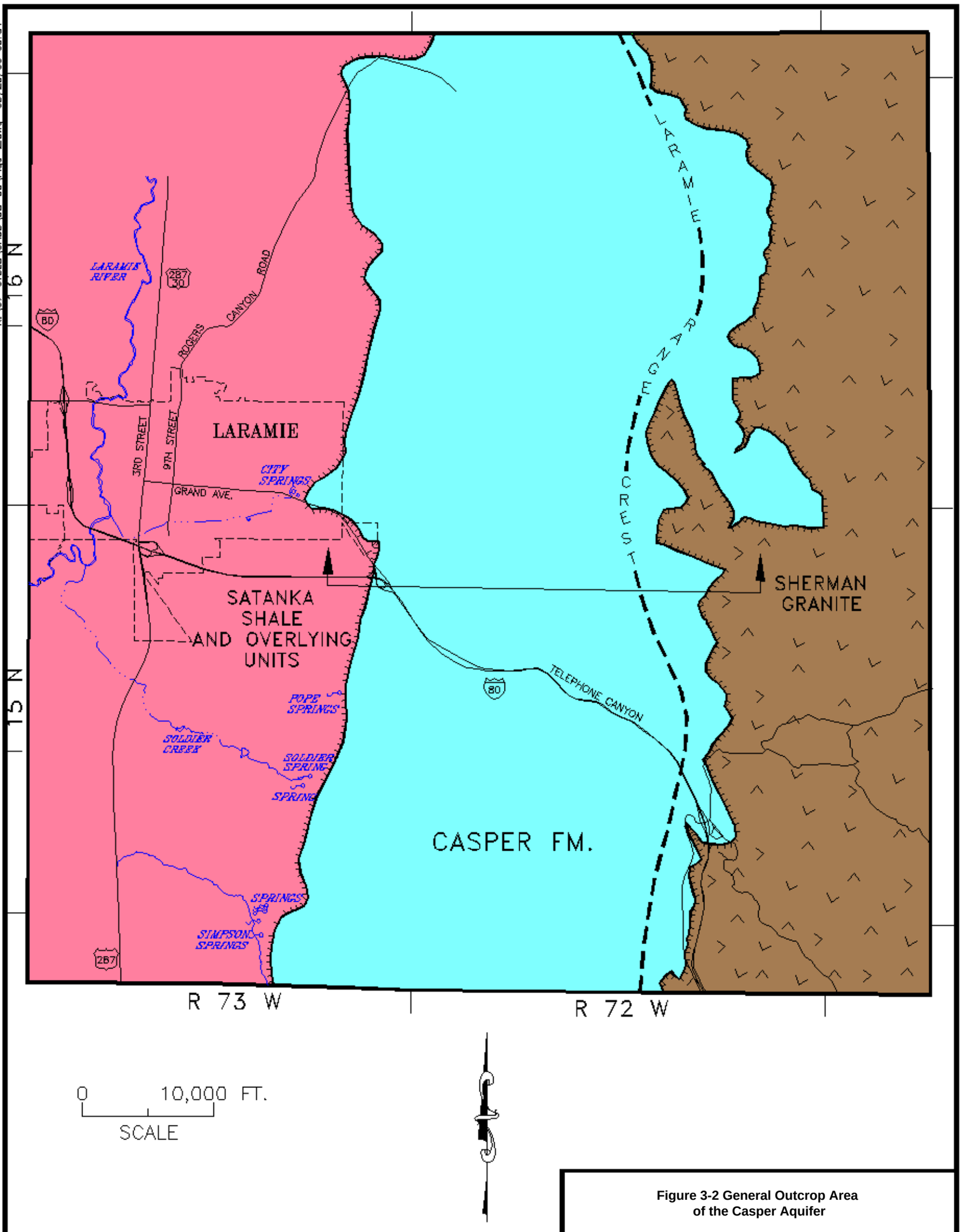
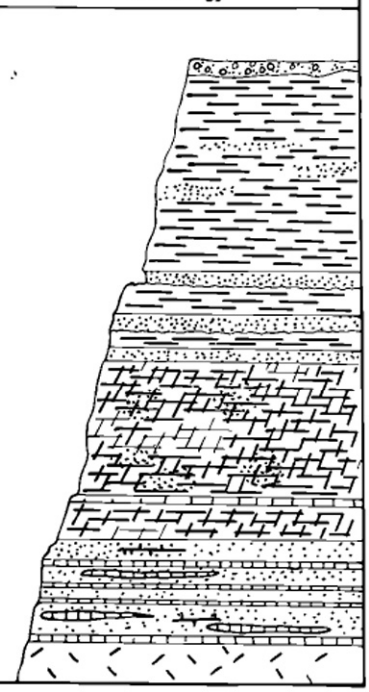


Figure 3-2 General Outcrop Area of the Casper Aquifer

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

Age	Formation	Thickness (feet)	Water Supply
QUARTERNARY	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 Mesoverde 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.

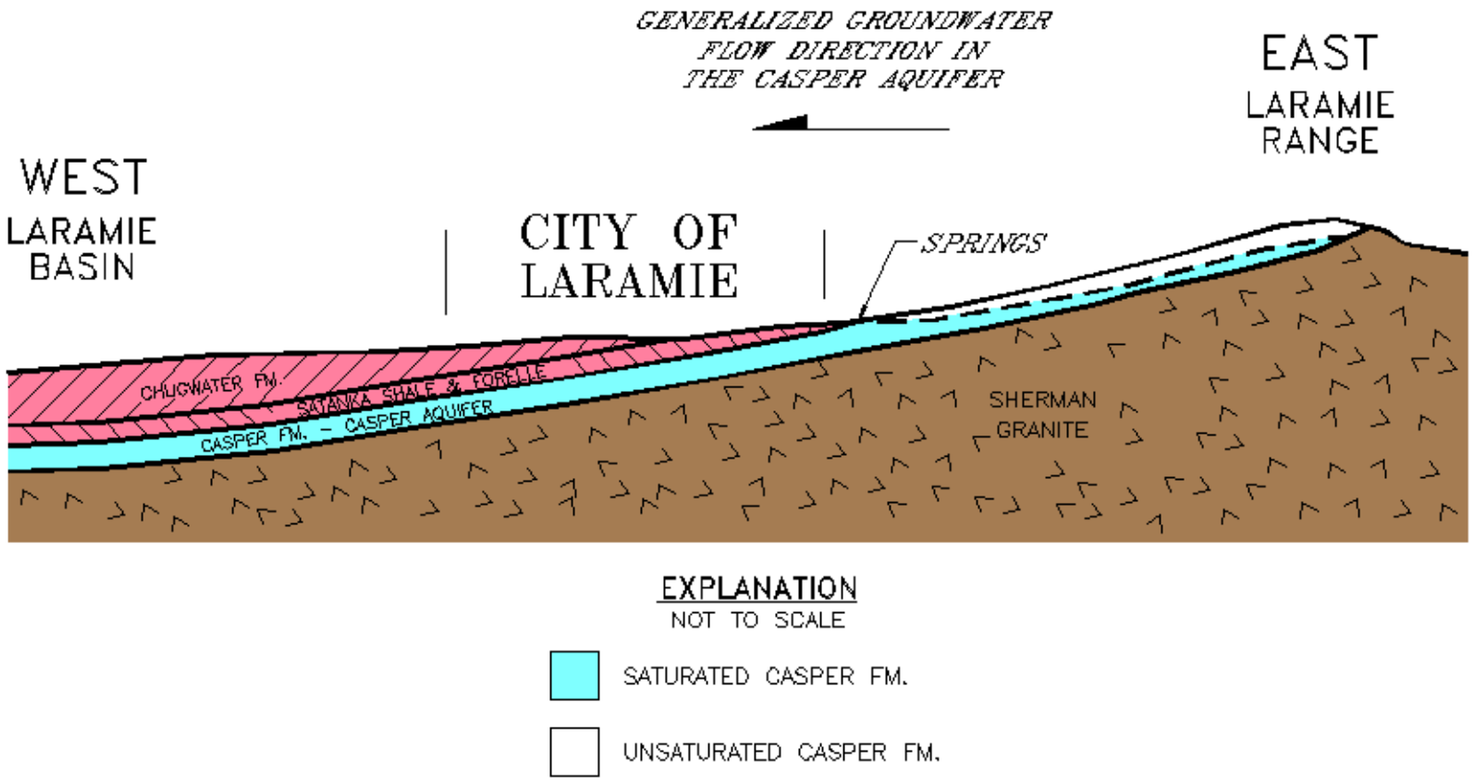
Lithology



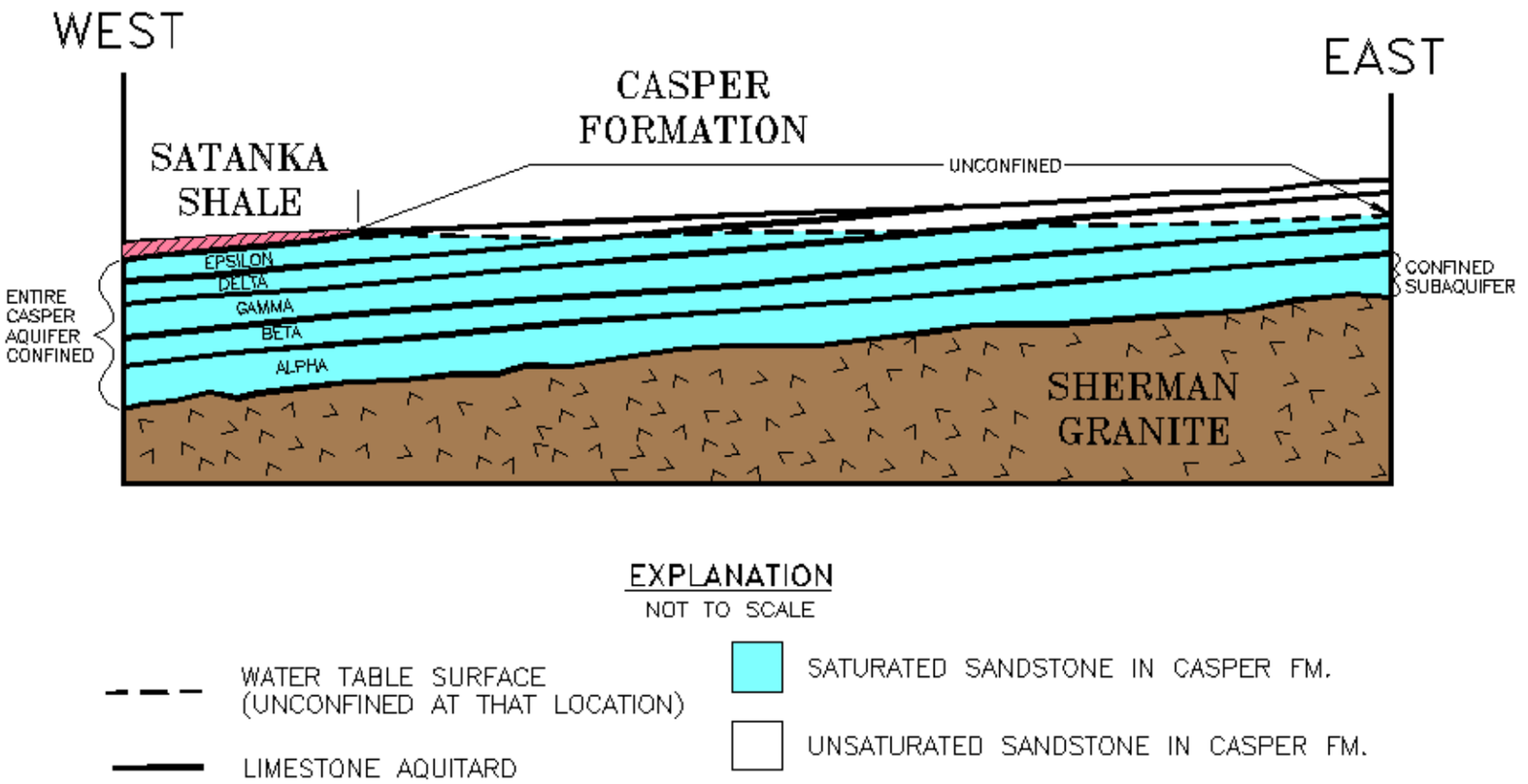
Sandstone - Siltstone
Shale
Limestone
Dolomite
Gypsum
Igneous - Metamorphic
Gravel

Figure 3-3 Hydrogeologic Role Of Formation

Casper Aquifer Protection Program
Thompson (1979)



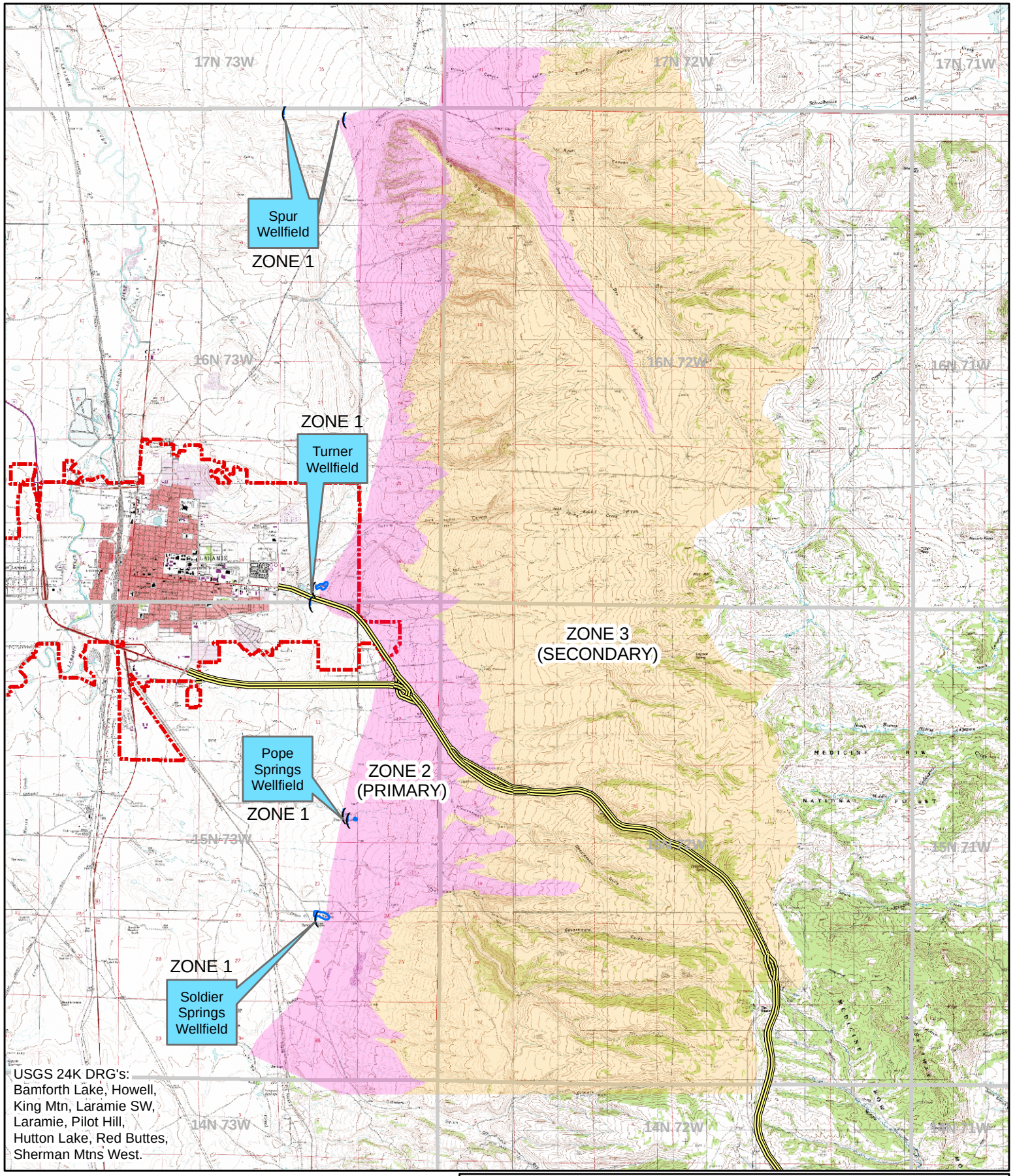
GENERALIZED CROSS–SECTION THROUGH THE VICINITY OF LARAMIE, WYOMING.



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)



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Zones Figure 3-5

CASPER AQUIFER PROTECTION AREA ZONES

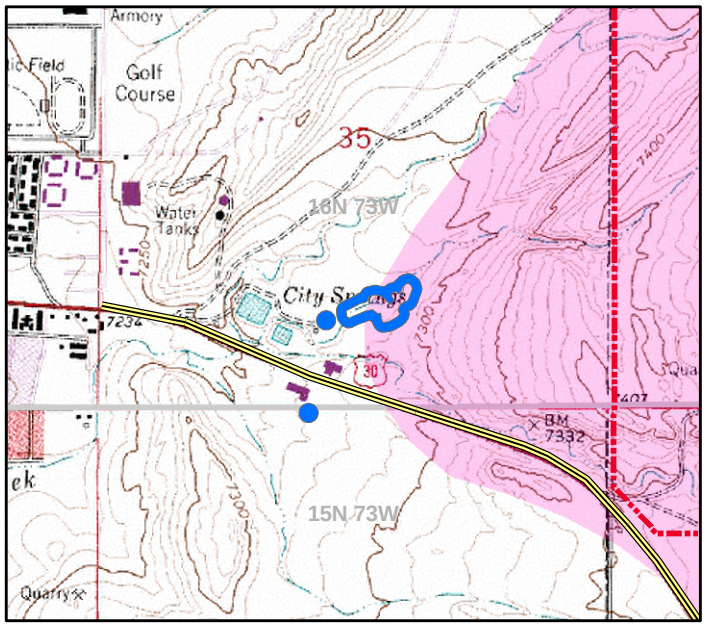
- ZONE 1
- ZONE 1
- ZONE 2 PRIMARY
- ZONE 3 SECONDARY
- CITY OF LARAMIE

1

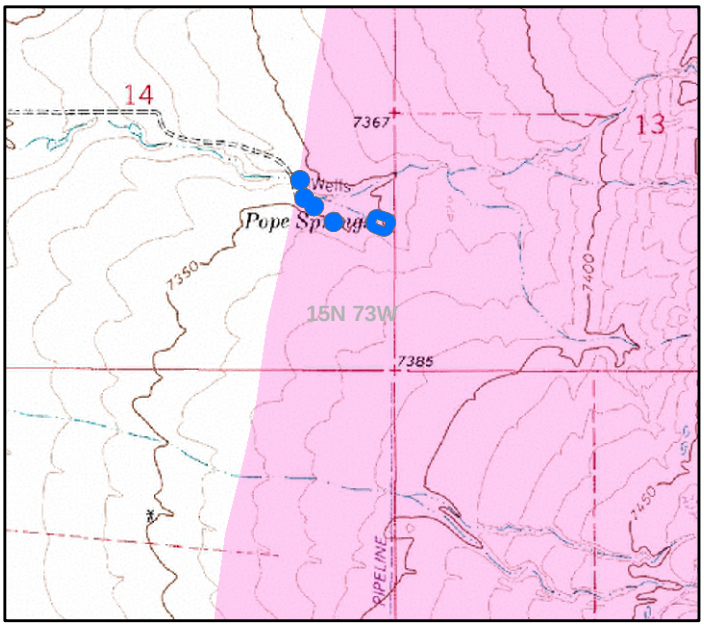
1:100,000

0 2,500 5,000 10,000
Feet

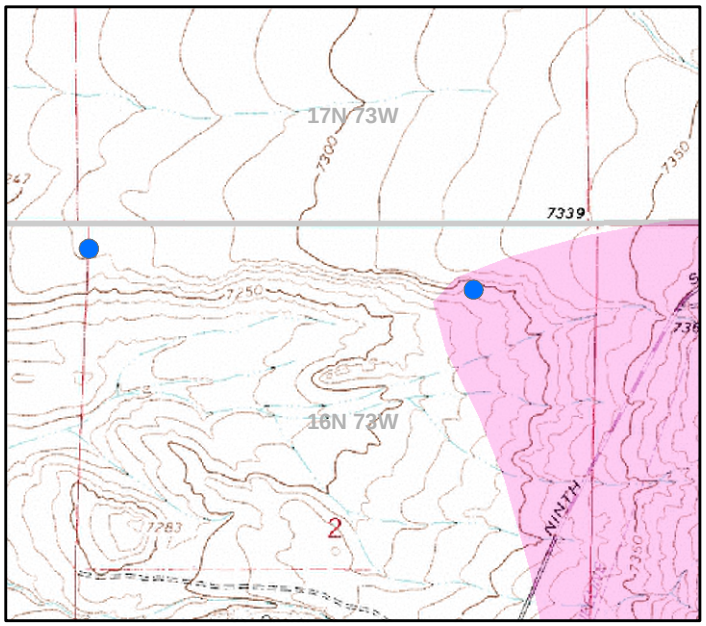
TURNER WELLFIELD



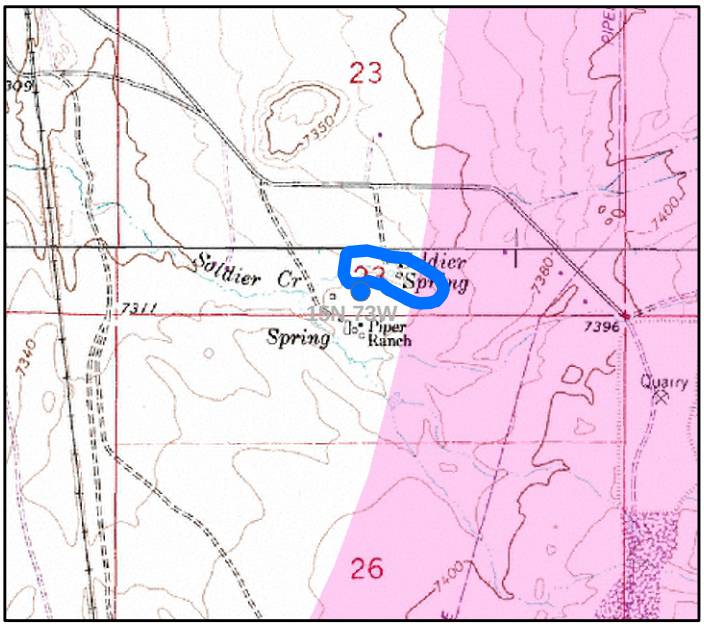
POPE SPRINGS WELLFIELD



SPUR WELLFIELD



SOLDIER SPRINGS WELLFIELD



LARAMIE

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Zone 1 Delineation (Accident Prevention Zone) Figure 3-6

CITY OF LARAMIE

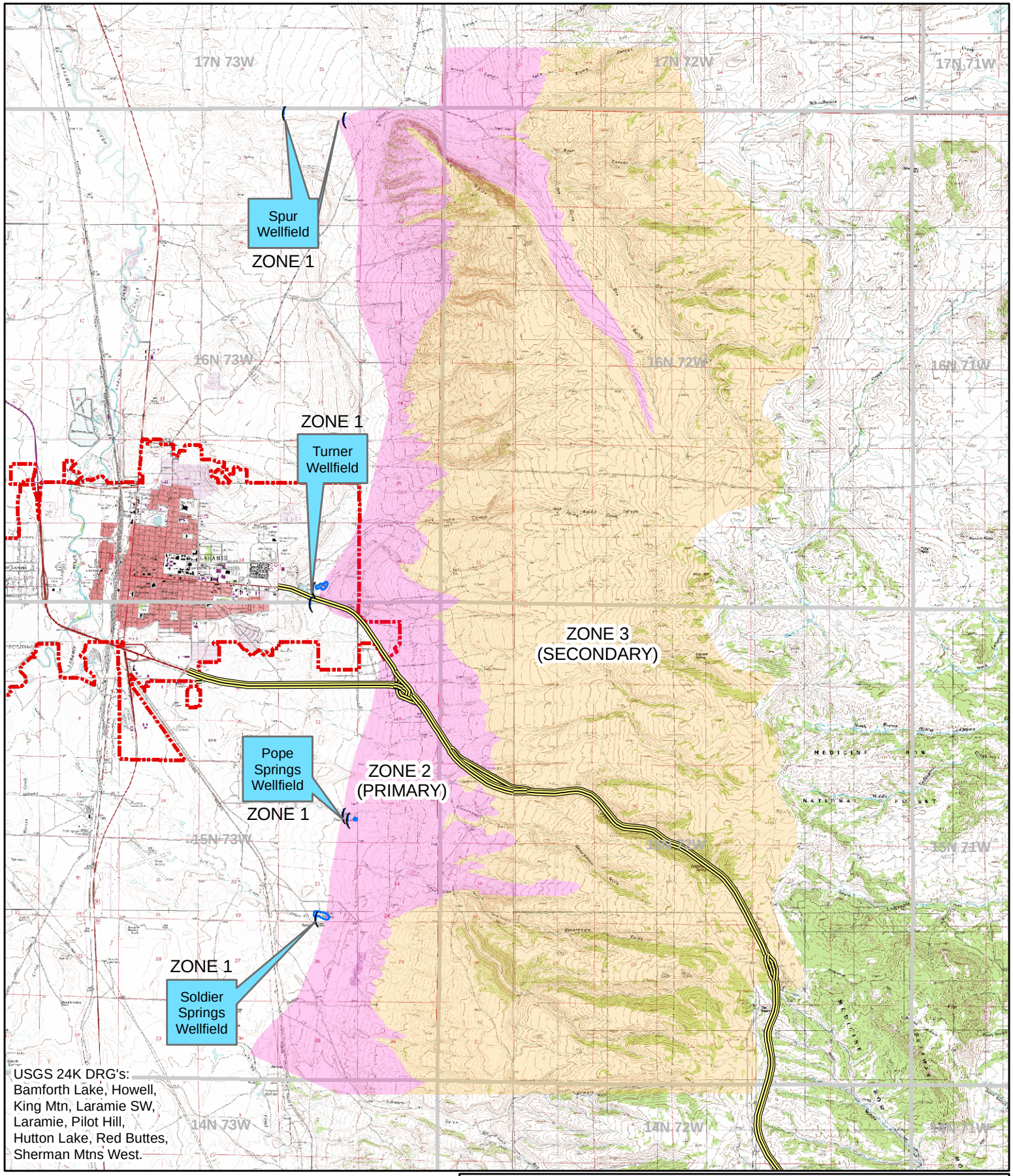
CASPER AQUIFER PROTECTION AREA ZONES

- ZONE 1
- ZONE 1
- ZONE 2 PRIMARY
- ZONE 3 SECONDARY

1

1:24,000

0 500 1,000 2,000 Feet



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Figure 4-1a

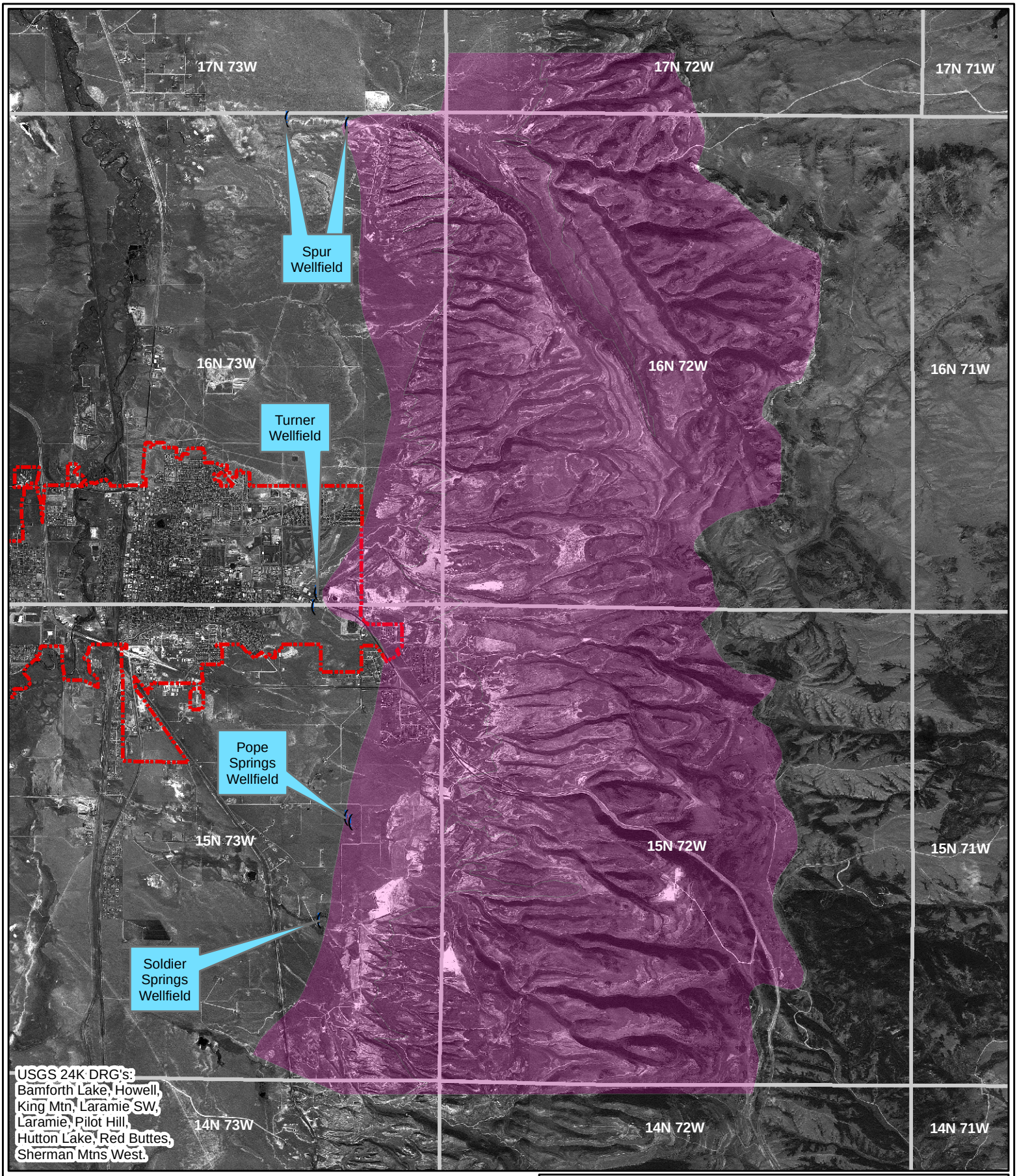
CASPER AQUIFER PROTECTION AREA ZONES

- ZONE 1
- ZONE 1
- ZONE 2 PRIMARY
- ZONE 3 SECONDARY
- CITY OF LARAMIE

1

1:100,000

0 2,500 5,000 10,000
Feet



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Imagery Figure 4-1b

CITY OF LARAMIE

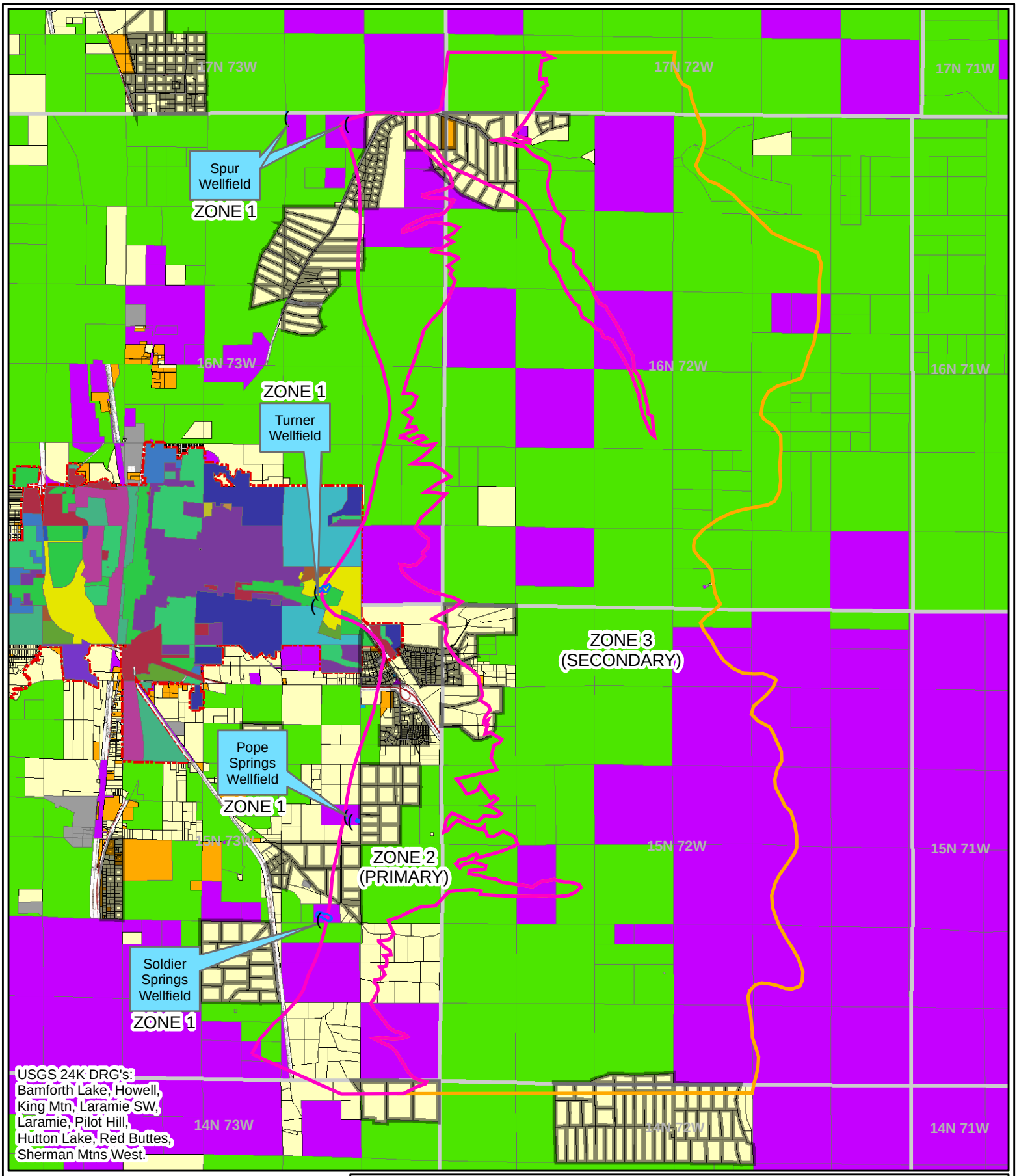
CASPER AQUIFER PROTECTION AREA

1

SATELLITE IMAGERY
SEPTEMBER, 2000

1:100,000

0 2,500 5,000 10,000
Feet



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

County Land Use & City Zoning Figure 4-2

CITY ZONING

- AE Airport Enterprise
- AG Agriculture
- AV Aviation District
- B1 Limited Business
- B2 General Business
- C2 Commercial Wholesale
- I1 Light Industrial
- I2 Industrial
- IP Industrial Park
- LM Light Manufacturing
- LR Low Density Residential
- NB Neighborhood Business
- O Open Zone
- R1 Low Density Residential
- R2 Medium Density Residential
- R2M Med. Density Resid. w/Independent Mobile Home
- R3 Multifamily
- R3-PUD Planned Unit Development

COUNTY LANDUSE

- APARTMENT
- COMMERCIAL
- EXEMPT
- FARMLAND
- INDUSTRIAL
- RESIDENTIAL
- CITY OF LARAMIE

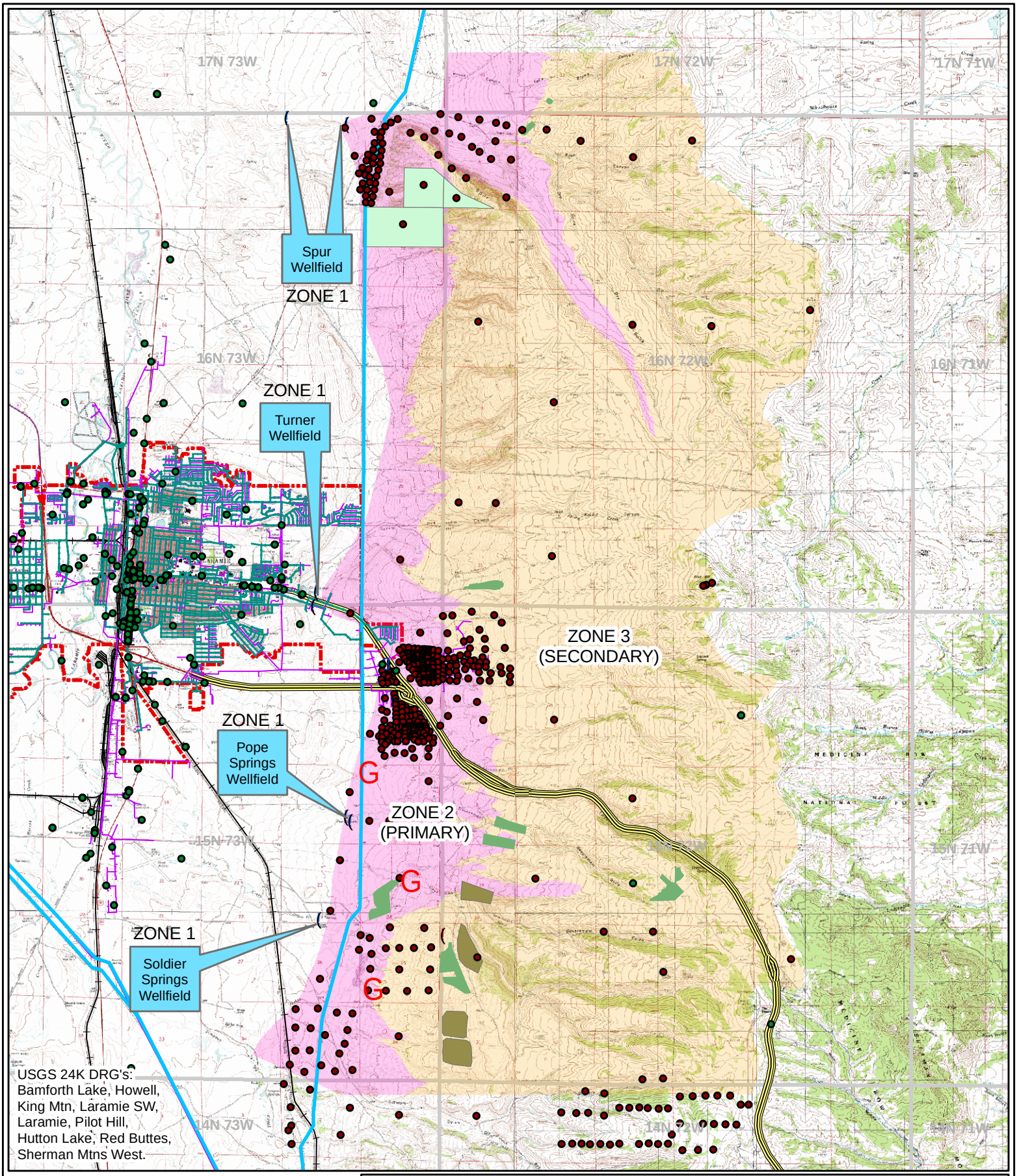
CASPER AQUIFER PROTECTION AREA ZONES

- ZONE 1
- ZONE 1
- ZONE 2 PRIMARY
- ZONE 2 PRIMARY

1

1:100,000

0 2,500 5,000 10,000
Feet



LARAMIE

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Potential Contamination Sources Figure 4-3a

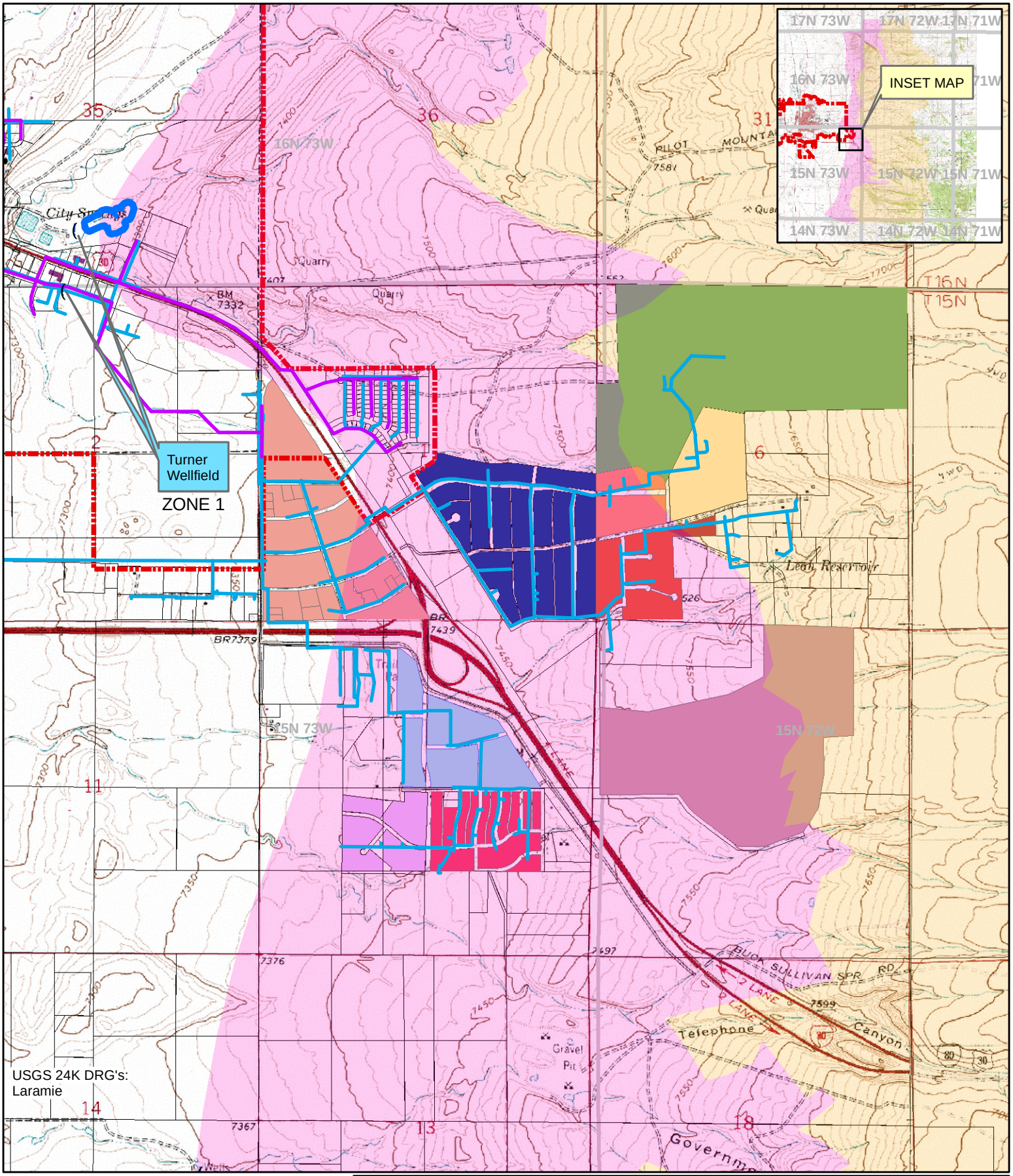
RIFLE RANGE
CITY OF LARAMIE
GAS STATION
ABOVEGROUND STORAGE TANK
LARAMIE PSOC's
SEPTIC SYSTEM
ABANDONED WELL

QUARRY
EXISTING
FUTURE
MAJOR GAS PIPELINE
RAILROAD
RESIDENTIAL GAS
RESIDENTIAL SEWER

CASPER AQUIFER PROTECTION AREA ZONES
ZONE 1
ZONE 1
ZONE 2 PRIMARY
ZONE 3 SECONDARY

1

1:100,000
0 2,500 5,000 10,000
Feet



LARAMIE

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Potential Contamination Sources Figure 4-3b

CITY OF LARAMIE
RESIDENTIAL GAS
RESIDENTIAL SEWER
PARCELS

BERNER MILL TR
FORK, THE
LARAMIE PLAINS
MTN VALLEY EST
PILOT PEAK EST
SHERMAN HILLS EST

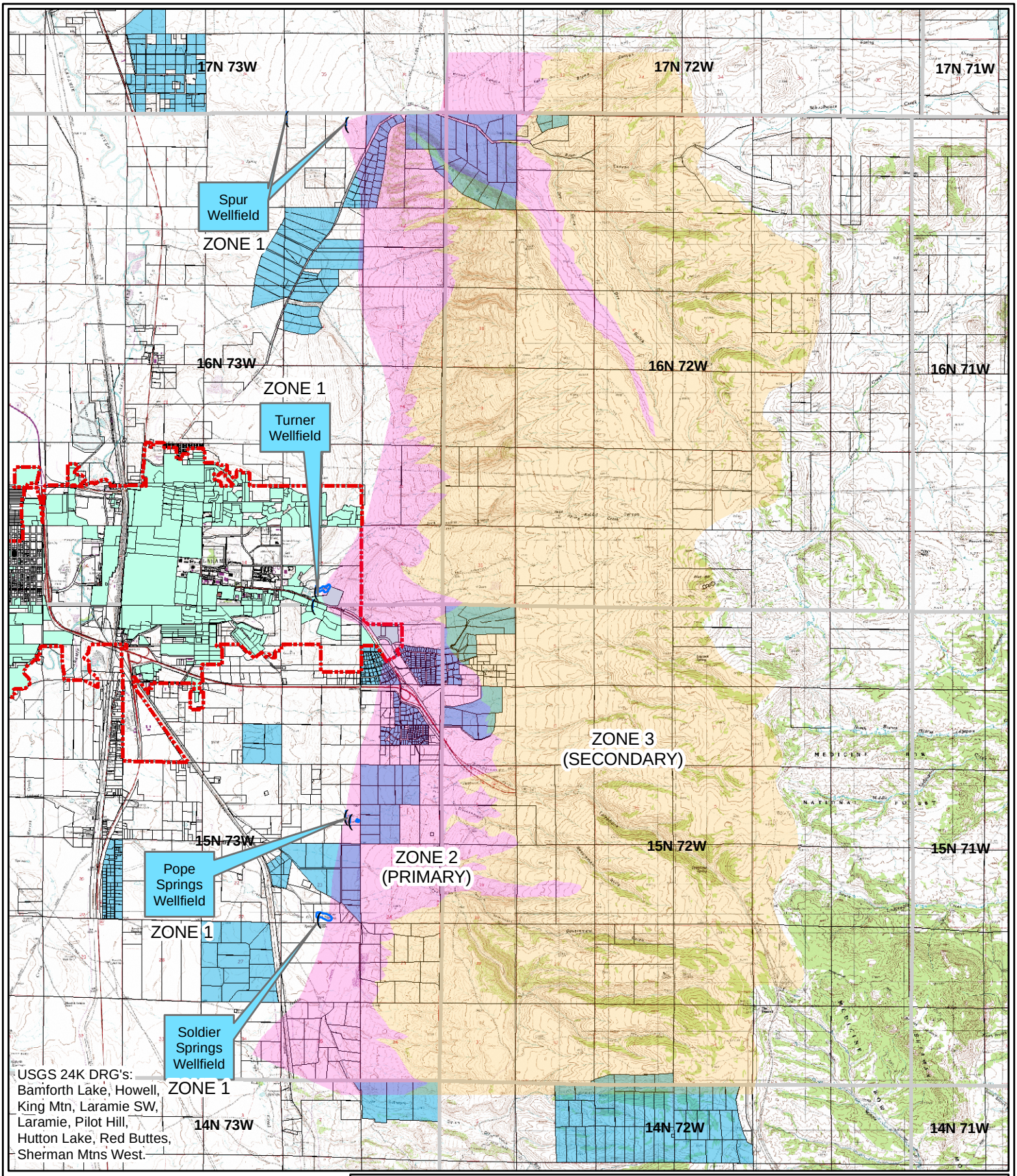
SNOWY VIEW ACRES
SUNDIAL ACRES
VALLEY VIEW AC
WARREN TRACTS
WYATT FOSTER
Buffer_of_Springs

CASPER AQUIFER PROTECTION AREA ZONES
ZONE 1
ZONE 1
ZONE 2 PRIMARY
ZONE 3 SECONDARY

1

1:24,000

0 600 1,200 2,400
Feet



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Subdivisions & Parcels Figure 4-4a

PARCELS 2003
ALBANY COUNTY SUBDIVISION
CITY OF LARAMIE SUBDIVISIONS
CITY OF LARAMIE

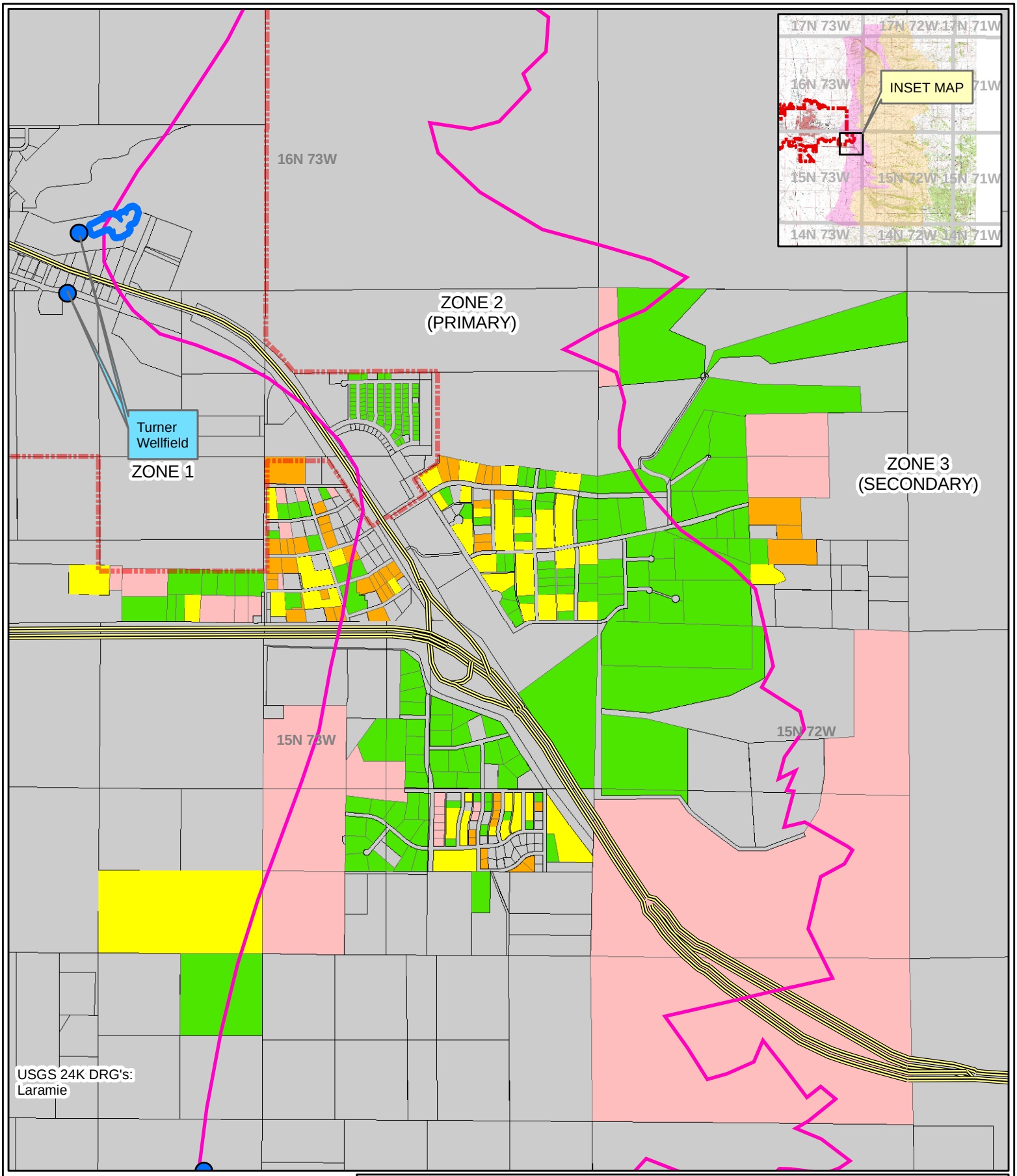
CASPER AQUIFER PROTECTION AREA ZONES

ZONE 1
ZONE 1
ZONE 2 PRIMARY
ZONE 3 SECONDARY

1

1:100,000

0 2,300 4,600 9,200
Feet



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Subdivisions by Year Figure 4-4b

YEAR BUILT

- NON RESIDENTIAL
- 1900-1959
- 1960-1969
- 1970-1979
- 1980-2005
- CITY OF LARAMIE

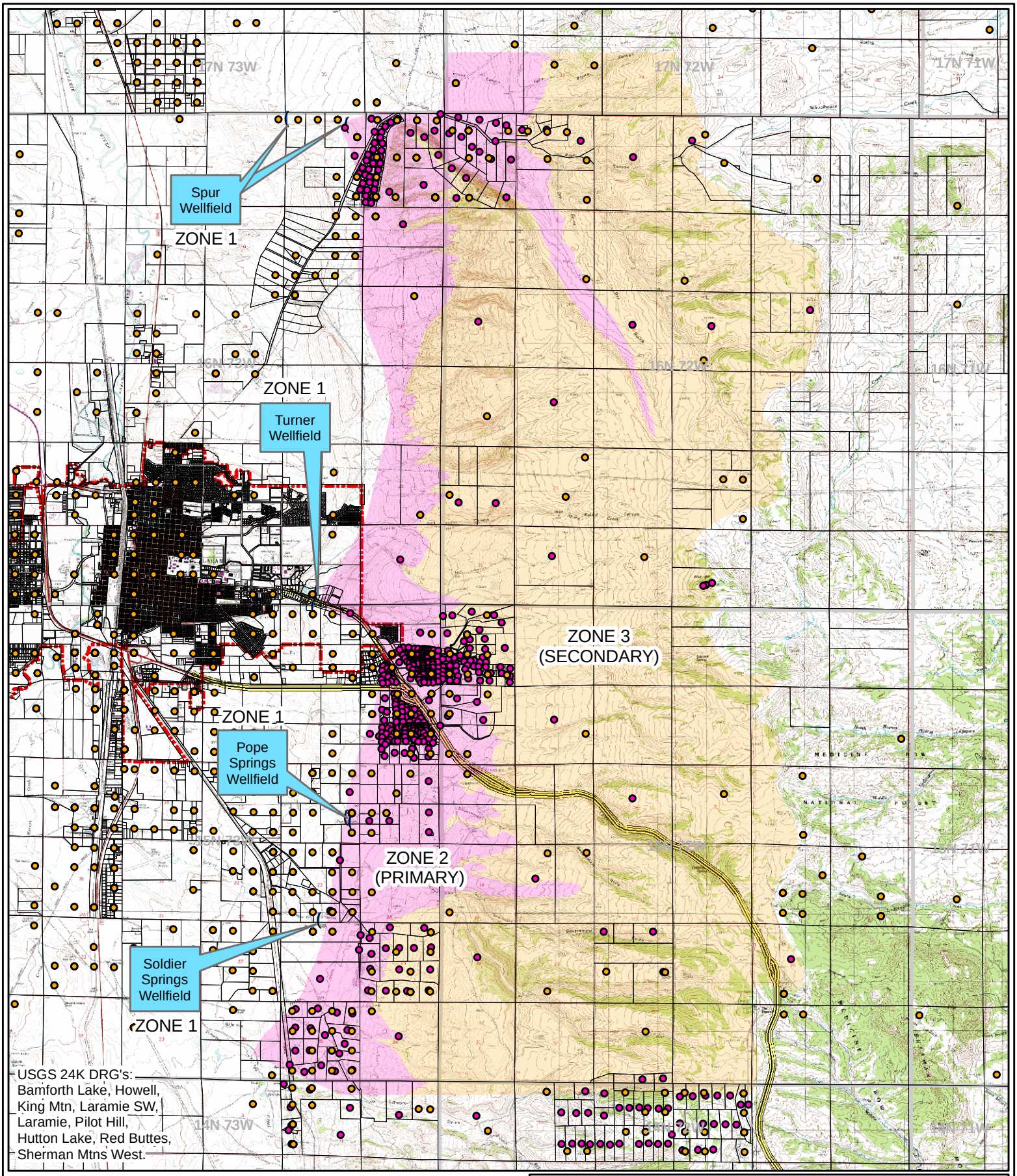
CASPER AQUIFER PROTECTION AREA ZONES

- ZONE 1
- ZONE 1
- ZONE 2 PRIMARY
- ZONE 3 SECONDARY

1

1:24,000

0 600 1,200 2,400
Feet



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Wells & Potential Septic Systems Figure 4-5a

CITY OF LARAMIE
SEPTIC SYSTEM
WATER WELL

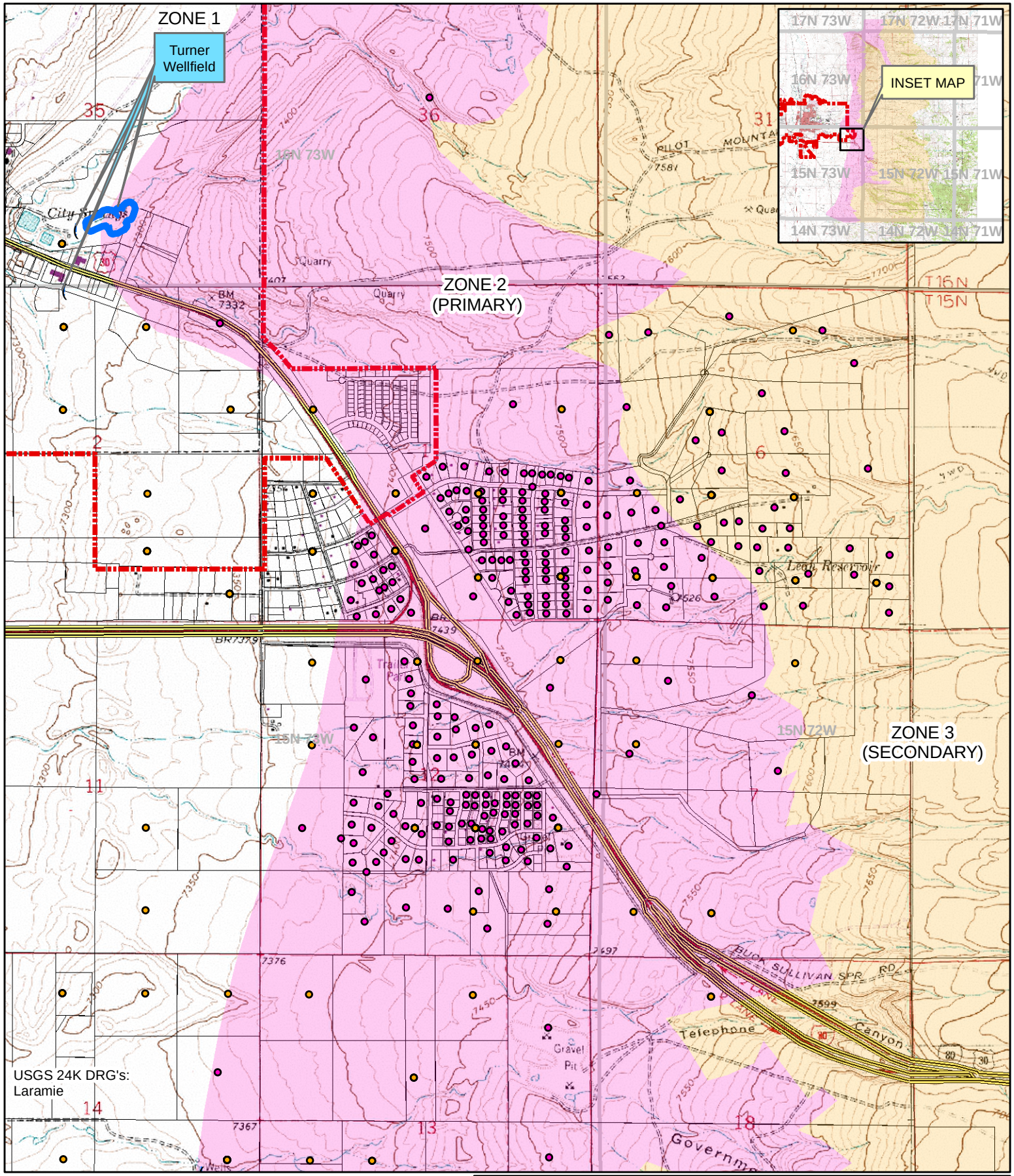
CASPER AQUIFER PROTECTION AREA ZONES

ZONE 1
ZONE 1
ZONE 2 PRIMARY
ZONE 3 SECONDARY

1

1:100,000

0 1,500 3,000 6,000
Feet



LARAMIE 1868

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Wells & Potential Septic Systems Figure 4-5b

CITY OF LARAMIE
SEPTIC SYSTEM
WATER WELL

CASPER AQUIFER PROTECTION AREA ZONES

ZONE 1
ZONE 1
ZONE 2 PRIMARY
ZONE 3 SECONDARY

1

1:24,000

0 600 1,200 2,400
Feet

Table 2-1: 2001-2002 Environmental Advisory Committee

Environmental Advisory Committee

NAME	PHONE NUMBER	EMAIL ADDRESS	REPRESENTATION
Bill Brizuela (chairman)	742-6341 (w)	Gabruz@aol.com	Local Business Owner
Ben Jordan (vice chairman)	745-6118 (w)	Weston@vcn.com	Hydrogeologist
Joel Farber	755-5898 (w)	Jjfarbr@trib.com	Engineer/Geologist
Stan Huff	745-5726 (h)	Srhuff@lariat.org	Retired Citizen
Paul Etchepare	742-0080 (w)	Paule700w@msn.com	Concerned Citizen
Norm Rhodine	745-4254 (h)	Rhodine@lariat.com	Retired UW Faculty
Jerrry Schmidt	721-9226 (h)	Jschm33525@aol.com	Retired USFS Employee

Table 2-2: Environmental Advisory Subcommittee Members

Public Information Subcommittee

NAME	PHONE NUMBER	EMAIL ADDRESS
Mary Bower	742-2022 (w)	Lincoln@wyoming.com
Carol Frost	766-6254 (w)	Frost@uwyo.edu
Kathy Rittle	745-7474 (w)	Kathyrittle@trihydro.com
Bill Brizuela	742-6341 (w)	Gabruz@aol.com
Norm Rhodine	745-4254 (h)	Rhodine@lariat.com

Aquifer Area Management Subcommittee

NAME	PHONE NUMBER	EMAIL ADDRESS
Paul Etchepare	742-0080 (w)	Paule700w@msn.com
Ron Olsen	742-9144 (h)	Rolsen@cyberhighway.net
Richard Allen	745-6118 (w)	Rallen@trihydro.com
Stan Huff	745-5726 (h)	Srhuff@lariat.org
Kristi Radosevich	721-0205 (h)	Kmrad@uwyo.edu
Ben Jordan	745-6118 (w)	Weston@vcn.com
Charlie DeWolf	742-5939 (h)	Cdewolf@trihydro.com
Karl Taboga	721-5344 (w)	Ktaboga@ci.laramie.wy.us
Bill Sansing	745-4879 Ext 121 (w)	
Valentine Sworts	742-5964 (h)	Vsworts@uwyo.edu
Joel Farber	755-5898 (w)	Jjfarbr@trib.com

Technical Review Subcommittee

NAME	PHONE NUMBER	EMAIL ADDRESS
Alan VerPloeg	766-2286 (w)	Averpl@wsgs.uwyo.edu
Ben Jordan	745-6118 (w)	Weston@vcn.com
Chris Moody	742-0031 (w)	Cmoody@wwcengineering.com
Demian Saffer	766-2981 (w)	Dsaffer@uwyo.edu
Jim Case	766-2286 (w)	Jcase@wsgs.uwyo.edu
Joel Farber	755-5898 (w)	Jfarbr@trib.com
Keith Clarey	745-7474 (w)	Kclarey@trihydro.com
Paul Etchepare	742-0080 (w)	Paule700w@msn.com
Stan Huff	745-5726 (h)	Srhuff@lariat.org
Tom Edgar	766-6220 (w)	Tvedgar@uwyo.edu

Table 3-1 City of Laramie Municipal Well Data

Well Name	UW Permit #	Location	Year Drilled	Elevation	Lithologic Log Location	Well Radius	Total Depth	Screen Length	Screened Intervals	Screen Type	Pumping Rates	SEO Adjud pump rate
Soldier Wellfield												
Soldier #1	105576	T15N R73W Sec23 SE, SW	1997	7322.9'	WSEO	24"	289'	20.3"	44.1-64.4	Slot	1450gpm	1800gpm
Turner Wellfield												
Turner #1	55507	T15N R73W Sec14 NE,SE	1982	7273'	WSEO	16"	240'	NA	NA	NA	1750gpm	1400gpm
1st ENL Turner #1	61724	T15N R73W Sec14 NE,SE	1982	7273'	WSEO	16"	240'	NA	NA	NA	1750gpm	800gpm
2nd ENL Turner #1	72689	T15N R73W Sec14 NE,SE	1982	7273'	WSEO	16"	240'	NA	NA	NA	1750gpm	300 gpm
		*Under UW permit numbers 55507, 61724, and 72689, the City of Laramie is adjuducated a total of 2500gpm from Turner #1										
Turner #2	55508	T16N R73W Sec35 SE,SW	1982	7266'	WSEO	16"	350'	NA	NA	NA	1250gpm	1400gpm*
1st ENL Turner #2	59131	T16N R73W Sec35 SE,SW	1982	7266'	WSEO	16"	350'	NA	NA	NA	1250gpm	200gpm*
		*Under permit numbers 55508 and 59131, the City of Laramie is adjudicated a total of 1600gpm from Turner #2										
Pope Wellfield												
Pope #1	153	T15N R73W Sec14 NE,SE	1937	7335.5'	WSEO	8"	156'	NA	NA	NA	220gpm	600gpm
Pope #2	154	T15N R73W Sec14 NE,SE	1938	7338.8'	WSEO	8"	162'	NA	NA	NA	520gpm	600gpm*
1st ENL Pope#2	72690	T15N R73W Sec14 NE,SE	1938	7338.8'	WSEO	8"	162'	NA	NA	NA	675gpm	75gpm*
Pope #3	155	T15N R73W Sec14 NE,SE	1939	7338.8'	WSEO	15"	158'	NA	NA	NA	600gpm	600gpm^^
1st ENL Pope#3	55505	T15N R73W Sec14 NE,SE	1939	7338.8'	WSEO	15"	158'	NA	NA	NA	600gpm	250gpm^^
2nd ENL Pope#3	72691	T15N R73W Sec14 NE,SE	1939	7338.8'	WSEO	15"	158'	NA	NA	NA	600gpm	50gpm^^
Pope #4	55506	T15N R73W Sec14 NE,SE	1982	7351'	WSEO	16"	350'	NA	NA	NA	1500gpm	1750gpm>>
1st Enl Pope#4	72692	T15N R73W Sec14 NE,SE	1982	7351'	WSEO	16"	350'	NA	NA	NA	1500gpm	50gpm>>
			*Under UW permit numbers 154 and 72690, the City of Laramie s adjudicated a total of 675gpm from Pope #2									
			^^Under UW permit numbers 155,55505, and 72691, the City of Laramie if adjudicated a total of 900gpm from Pope #3									
			>>Under UW permit numbers 55506 and 72692, the City of Laramie is adjudicated a total of 1800gpm from Pope#4									
Spur Wellfield												
Spur #1	106547	T16N R73W Sec2 NE,NE	1997	7290.65'	WSEO	16"	305'	NA	NA	NA	1400gpm	1400gpm
Spur #2	107279	T16N R73W Sec2 NW,NW	1997	7270'	WSEO	16"	323'	NA	NA	NA	1400gpm	1400gpm

Table 3-2 Pump Data

Well Name	Pump Type	Pump Make	Pump Model	Pump Setting (Feet)	Pump Capacity (GPM)	Motor Make	Motor Model	Motor Rating (HP)	Year Installed
Spur #1	Line-Shaft Turbine	Floway	12JKH	86	1400	G.E.	VHS	100	1997
Spur #2	Line-Shaft Turbine	Floway	12JKH	76	1400	G.E.	VHS	100	1997
Turner #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70503	80	2500	G.E.	JTJ930342	40	1981
Turner #2	Line-Shaft Turbine	Aurora Verti-Line	V82-70502	88	1600	G.E.	JTJ930341	40	1981
Pope #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70504	55	550	G.E.	BV83131	7.5	1982
Pope #2	Line-Shaft Turbine	Peerless	193178	42	675	G.E.	N/A	15	1967
Pope #3	Line-Shaft Turbine	Aurora Verti-Line	V82-70500	62	900	G.E.	AVJ120301	40	1982
Pope #4	Line-Shaft Turbine	Aurora Verti-Line	V32-70501	80	1800	G.E.	GTJ729339	75	1982
Soldier #1	Line-Shaft Turbine	Floway	14DKH	46	1970	U.S. Motors	VHS	75	1997

All information collected from pump and motor sales sheets, SEO Completion Reports, Operation and Maintenance Manuals, and the 1998 EPA Sanitary Survey for Albany County.

TABLE 4-1. Subdivision information for the Casper Aquifer Protection Area.

Subdivision Name	Number of Lots	Average Acre Size	Number of Developed Lots	Number of Undeveloped Lots
The Berner Mill	7	28	21	7
The Fork	1	4	1	--
Laramie Plains	92	1	60	32
Mountain Valley Estates	11	3	9	2
Pilot Peak Estates	9	4	9	--
Rockaway Ranch	49	32	12	37
Rocky Top Ranches	9	35	4	5
Sherman Hills	107	1	98	9
Snowy View Acres	4	6	3	1
Spur Ridge Ranches	14	31	9	5
Sundial Acres	26	2	23	3
Sunset Acres	48	5	27	21
Valley View	77	1	56	21
Warren Tracts	14	17	5	9
Wyatt Foster	19	2	18	1

TABLE 6-1: EMERGENCY PROBABILITY AND SEVERITY CHART FOR LARAMIE REGIONAL DRINKING WATER PROTECTION PROGRAM

TYPE OF EMERGENCY	PROBABILITY (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 as to impact
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 (e.g., fences)

TABLE 6-2: WATER DEMAND PROJECTION (mgd)

Year 2000	Average	Peak 7-Day
Winter	5.5	7.4
Summer	12.6	16.8

TABLE 6-3: WATER SOURCE INVENTORY (mgd)

SOURCE	WINTER CAPACITY		SUMMER CAPACITY	
	Average	**Peak^^**	**Average**	**Peak^^**
Laramie River	2.5	6.8	6.8	7.5
Turner Wellfield	1.7	4.0	1.7	4.0
Pope Wellfield*	1.3	4.2	1.3	4.2
Soldier Springs*	1.2	1.2	1.2	1.2
Spur Wellfield**	2.0	4.0	2.0	4.0
Totals (mgd)	**8.7**	**20.2**	**13.0**	**20.9**

*These two wellfields must be considered together for a contamination event due to connectivity.

**See the Spur wellfield condition of use agreement at the City of Laramie Public Works Departmentt/Utilities Division.

^^Peaks were acquired from maximum production levels.

TABLE 6-4: WATER AVAILABILITY (mg/d)

SCENARIO	AVERAGE SUPPLY TOTAL		7-DAY PEAK SUPPLY TOTAL	
	Winter	Summer	Winter	Summer
1	6.2	6.2	13.4	13.4
2	7.0	11.3	16.2	16.9
3	6.2	10.5	14.8	15.5

Supply totals were tabulated by adding the existing water sources average and peak capacity from Table 6-3 and excluded the contaminated water source. For example, scenario #3-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 7-day peak supply total numbers from Table 6-4 are then subtracted from Laramie's average and 7-day peak demands from Table 6-2. Deficiencies were calculated and are shown in Table 6-5.

TABLE 6-5: WATER DEFICIENCY COMPARED TO AVERAGE AND PEAK DEMAND (mg/d)

SCENARIO	AVERAGE		7-DAY PEAK	
	Winter	Summer	Winter	Summer
1	--	6.4	--	3.4
2	--	1.3	--	--
3	--	2.1	--	1.3

Under the scenarios listed above there would be two cases (highlighted figures in Table 6-5) when mandatory action would be imposed with possible implementation of other contingency plan elements due to shortfalls greater than 25 percent:

- Scenario 1 - summer average and summer 7-day peak

Acknowledgement

The Laramie Regional Drinking Water Protection Plan for the Casper aquifer has been generated after more than seven years of hard work and dedication from various groups and City and County staff members. The Environmental Advisory Committee and Subcommittee members have spent endless volunteer hours devoted to completing this plan. The County Assessor's and Planning Offices have been supportive, gave technical advice, and generated the contaminant source inventory maps. The Laramie City Council and City Manager, Albany County Board of Commissioner's and the Albany County Planning and Zoning Commission always reinforced the importance of completing the plan and funded the efforts of the EAC.

Executive Summary

The Laramie Regional Drinking Water Protection Plan (LRDWPP) is an aquifer protection program for the City of Laramie and Albany County. The purpose of the plan is to protect the recharge area for the Casper aquifer. The Casper aquifer supplies half of the city's water supply and 100% of the water to approximately 450 rural residences in Albany County. The plan follows the requirements defined in the Wyoming Wellhead Protection Guidance Document from the Wyoming Department of Environmental Quality - Water Quality Division (June, 1998).

The delineated recharge area encompasses approximately 80 square miles that lie east of the city and extends to the crest of the Laramie Range. The northern boundary is 2 miles north and the southern boundary is approximately 6 miles south of the city limits. Laramie's four 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.

The plan includes: the role of the County-City Environmental Advisory Committee in developing the plan and their outreach and education efforts; the delineation of three aquifer protection zones; identified potential and known contaminant sources within the protection area; recommended management strategies for the identified potential contaminant sources; and a contingency plan which will help provide potable water to the public during a water supply emergency.

Chapter
1

Introduction

Purpose

The primary purpose of the Laramie Regional Drinking Water Protection Program (LRDWPP) and the Casper Aquifer Protection Plan (CAPP) is to prevent the contamination of groundwater resources that supply the City of Laramie with drinking water.

Wellhead Protection (WHP) Plan Overview

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

On September 18, 1997, Wyoming became the 46th state to have an EPA-approved Wellhead Protection Program. Wyoming's WHP plan adopts the systematic and logical proactive approach to protecting drinking water supplies that has been established under the Safe Drinking Water Act Amendments of 1986. 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 wishing 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 performance of the following five steps.

- Step 1: The 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 (WHPAs). WHPAs 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: Identification of the locations of potential sources of contamination.
- Step 4: Development and implementation of a Contaminant Source Management Plan.
- Step 5: Development of a Contingency Plan to ensure an alternative public water supply if contamination occurs.

Because WHP plans are dynamic and evolving, it is understood that the LRDWPP may also be subject to periodic change to make it more useful to the community. This plan will be updated and revised at least every two years as specified in Wyoming's WHP guidance document.

Background

Groundwater Protection and Use

About half of the U.S. population and about 75 percent of Wyoming residents depend on groundwater for their primary source of fresh water. Groundwater is derived from rain and snow infiltrating through the soil, and from water in streams and rivers that recharge underground aquifers. An aquifer is a saturated, permeable geologic unit that can transmit significant quantities of groundwater. Aquifers may be localized or lie below several towns or counties.

In the Laramie area, the Casper aquifer supplies approximately 50% of the city's fresh drinking water and 100% to the rural homeowners that fall within the Casper aquifer recharge area. The city also uses treated water from the Laramie River to supply drinking water to the community. Groundwater is obtained through 4 different wellfields (see Figure 1-1). These wellfield facilities are used year-round and along with the water supplied from the water treatment plant the city's base water demands are met.

The Casper aquifer is a sandstone-limestone geologic rock formation that is over 600 feet thick. The uppermost occurrence of groundwater is typically between 0-100 feet below ground surface in the wellfields. Due to the highly faulted, fractured, and folded nature of the Casper aquifer recharge area, a contaminant introduced at the surface might easily enter the aquifer system and move rapidly away from the entry point.

Once contaminated, aquifers are difficult and expensive to clean up. For example, localities or responsible parties may have to pay for site studies, remediation and property damage. The most cost-effective approach is to prevent contamination before it occurs, rather than attempting to remedy existing contamination.

Figure 1-1 presents the layout of the City's wellfields and their relative location to the city limits and to the Casper aquifer recharge area. All the wellfields are on fenced property owned and controlled by the City of Laramie. The wellfields from north to south are called: Spur , Turner, Pope Springs, and Soldier Springs.

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

- Chapter 2 describes the formation and function of the City/County Environmental Advisory Committee which is the volunteer community planning team that developed the Plan.
- Chapter 3 describes the Aquifer Protection Area Delineation Report for the City of Laramie's wellfields.
- Chapter 4 presents the Inventory of Known and Potential Contaminant Sources within the Aquifer Protection Area.
- Chapter 5 presents the LRDWPP Contaminant Source Management Plan.
- Chapter 6 presents the LRDWPP Contingency Plan.

The technical information for all the City's 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, water quality data, and other miscellaneous information. This information is summarized throughout this plan, as appropriate.

Wellhead Protection Versus Aquifer Protection

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 1-2).

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 1-2). 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.

In 1997 the Laramie City Council and Albany County Commissioners instructed the 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 the City of Laramie's public water supply because it includes the entire aquifer resource in the vicinity of the city, rather than focusing solely on the municipal wellfields.

Chapter
2

Community Planning Team

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

General Intent

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 their local aquifer protection plan.

Wyoming's WHP guidance document presents a list of entities and individuals who should be considered when developing a WHP plan 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
- Technical, legal, and regulatory advisors

Laramie-Albany County Environmental Advisory Committee (EAC)

The Environmental Advisory Committee (EAC) is an appointed group of Albany County citizens concerned and interested in environmental issues pertinent to the County (see Table 2-1). **The City Council and County Commissioners have charged the EAC with developing an aquifer protection program, a voluntary, nonregulatory approach to protecting the Casper aquifer, in the vicinity of the City of Laramie, from contamination.** Therefore, the EAC is our designated community planning team for the Casper aquifer.

The EAC created five subcommittees to address the steps required in the 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 (see Table 2-2).

The EAC meetings are held once a month at various times and locations in Laramie. Subcommittee meetings are held as needed at the direction of the EAC. Meeting agendas and

informational packets are organized by the EAC chairperson. All minutes from EAC and committee meetings are on file at the City Public Works Department. A city council liaison, city public works department staff, and county commissioner are invited to attend all EAC meetings. All meetings are open to the public.

The City of Laramie Utility Division Manager (UDM) is the primary contact for all Casper Aquifer Protection Plan administrative duties such as educational outreach, public/agency inquiries, implementation, and periodic plan updates. In the event that the UDM is unavailable, the secondary contact is the City Water Treatment Supervisor.

Groundwater Guardian Program

The EAC is 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. Obviously, contaminated groundwater is extremely expensive and difficult to clean, therefore prevention is the logical alternative. The City of Laramie was designated a Groundwater Guardian community for 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.

Community Outreach and Educational Activities

Outreach and educational activities that the UDM and the EAC have been involved in to promote the importance of protecting and conserving our groundwater resources include the following:

- 6 different brochures relating to the LRDWPP, water conservation, septic system maintenance and the household hazardous waste collection (HHWC) program have been distributed through out the community.
- A LRDWPP logo was designed and used on all outreach material.
- T-shirts and hats have been printed to promote the HHWC program.
- Bookmarks with a list of 10 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 has been displayed in City Hall, the Albany County Courthouse, the Albany County Public Library and at various venues throughout the community over the past two years.
- 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 has promoted the LRDWPP during National Drinking Water Week, Earth Day celebrations at the University of Wyoming, 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.

- Over 30 presentations have been 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).

Index of EAC Press Releases

1998:

January 15, 1998. Roten, R. Aquifer protection committees appointed, budget requested. The Laramie Daily Boomerang, pp.18.

May 14, 1998. Roten, R. Environmental committee to attack noise. The Laramie Daily Boomerang.

1999:

April 4, 11, 18, 25, 1999. Welker, M. Laramie Regional Drinking Water Protection Program. The Laramie Daily Boomerang.

2000:

July 5, 2000. Hale, S. Freedom Has a Birthday comes off without a hitch. The Laramie Daily Boomerang, pp.1.

July 19, 2000. Gilliland, B. Albany County Commissioners have a busy day. The Laramie Daily Boomerang, pp.1.

August 8, 2000. Welker, M. Sunrise Rotary learns about Laramie water. The Laramie Daily Boomerang.

September 25, 2000. Welker, M. Don't pour it down the drain! The Laramie Daily Boomerang.

September 26, 2000. Dynes, M. EAC continues work with water protection. The Laramie Daily Boomerang, pp.1.

October 12, 18, 24, 2000. Welker, M. What are the potential threats to the Laramie regional drinking water supply? The Laramie Daily Boomerang.

2001:

January 9, 2001. Welker, M. Rural water quality information workshop planned for next weekend. The Laramie Daily Boomerang.

January 10, 14, 17, 2001. Welker, M. Tapping into Rural Water Quality: Water Quality and Septic Systems for Rural Homeowners. The Laramie Daily Boomerang.

January 21, 2001. Green, N. Septic system upkeep protects water supply. The Laramie Daily Boomerang, pp.1.

February 2, 2001. Mayer, P. Laramie takes voluntary steps to protect its groundwater. The Laramie Daily Boomerang, pp.1.

February 7, 10, 11, 2001. Welker, M. Tapping into Rural Water Quality: Water Quality and Septic Systems for Rural Homeowners. The Laramie Daily Boomerang.

February 17, 2001. Mayer, P. Children's books, women's magazines available at library thanks to Soroptomist. The Laramie Daily Boomerang.

March 10, 2001. Welker, M. How failing septic systems can harm household health. The Laramie Daily Boomerang.

September, 2001. Welker, M. Laramie celebrates National Pollution Prevention Week. The Laramie Daily Boomerang, pp.1.

September 18, 2001. Tonak, B. Pollution prevention week underway. The Branding Iron, pp. 9.

October 12, 2001. Dynes, M. Laramie designated Groundwater Guardian. The Laramie Daily Boomerang, pp. 1.

November 28, 2001. Wright, E. R. EAC to move forward on aquifer protection plan. The Laramie Daily Boomerang, pp.1.

2002:

January 10, 2002. Wright, E.R. County reviews water protection proposals. The Laramie Daily Boomerang, pp.1.

April 10, 2002. Dynes, Michelle. Protection plan of Casper Aquifer presented. The Laramie Daily Boomerang.

May 14, 2002. Boomerang Staff, Molly. Council, Commissioners to discuss Casper Aquifer Protection Plan. The Laramie Daily Boomerang, pp.1.

June 19, 2002, Messimer, Felicia J. Commissioners hear of fire moving into Albany County. Casper Aquifer Protection Plan also approved. The Laramie Daily Boomerang, pp. 1.

June 19, 2002, Brooks, Angela. City Council backs Casper Aquifer plan. The Laramie Daily Boomerang, pp. 3.

EAC Goals

The EAC goals for the next three years include:

- Expand and intensify the public education and outreach efforts.
- Design and implement a groundwater monitoring network.
- Expand our understanding of how the Casper aquifer is recharged through more fieldwork and research projects in collaboration with the University of Wyoming, the Wyoming Geological Survey, and the Wyoming Department of Environmental Quality.

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:

- Forming a local Drinking Water Protection Committee;
- Identifying land areas that contribute water to public water supplies;
- Inventorying existing and future potential sources of contamination;
- Developing a management program to deal with identified existing and future contaminant sources; and
- 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:

- 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;
- 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
- 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= 8.23×10^4 to 1.95×10^5 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 1.4×10^5 to 6.4×10^5 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 10^4 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:

- 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 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 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 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:

- 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 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.

- The base of the Satanka Shale is composed of interbedded fractured shale and sandstone;
- 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 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 4.32×10^5 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:

- The intergranular permeability of the delta and epsilon sandstone members is greater than the intergranular permeability of the underlying alpha, beta and gamma members;
- The shallower depth to groundwater near the western edge of the Casper outcrop;
- 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 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:

- Hydrologic characteristics of the Casper aquifer;
- Changes in water supply, or pumping volumes; and/or
- 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.

Chapter
4

Contaminant Source Inventory

Introduction

This chapter presents the Contaminant Source Inventory as specified in Section III of Wyoming's WHP Program Guidance Document (June 1998).

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, or threaten to cause groundwater contamination. Potential sources are those that may or may not have caused groundwater contamination, but have the potential to do so.

In general, groundwater contamination stems from the misuse and improper disposal of liquid and solid wastes; the illegal dumping or abandonment of household, commercial, or industrial chemicals; the accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; or the improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities. Contaminants also can stem 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 percolate through the soil.

The State encourages a flexible 'do-it-yourself' approach for completing the contaminant source inventory. The inventory process includes:

1. Obtaining a base map on which to plot existing and potential sources.
2. Obtaining available information on existing and potential sources:
    a. Access and record existing data
    b. Target likely sources for further study
    c. Access unknown sources
    d. Verify accuracy and reliability of the information gathered
3. Describing sources within the WHPA:
    a. Complete Source Identification forms for each existing and potential source of contamination identified within the WHPA.
4. Developing the Source Inventory list from completed Source Identification forms.
5. Prioritizing sources within the WHPA for management purposes.

6. Transferring source location and information to WHPA delineation maps.

7. Updating, refining and expanding Source Inventory Information.

The EAC Contaminant Source Identification Subcommittee (CSIS) began its inventory in 1998. The mission of this subcommittee is to identify existing and potential sources of contamination to the groundwater supply of the City of Laramie. The CSIS is 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 (Plate 1, UW Master Thesis, 1978) for the base map of this inventory. It is a topographic base map with detailed geologic mapping. The Zone 2 and 3 of the Casper Aquifer Protection Area were overlaid onto this map.

Potential contaminant source, planning and zoning, subdivision and parcel maps have been generated by the Albany County Assessor's Office for use in this document (see Figures 4-2 through 4-5b). Figure 4-1a and Figure 4-1b denotes the Casper Aquifer Protection Area - Zones 2 and 3, as delineated by the methods described in Chapter 3. The Accident Prevention Zone (Zone 1) around each of the wellheads is shown in Chapter 3 on Figure 3-6.

The source inventory was completed using several methods of study. Databases and published information were used by the University of Wyoming Geography and Recreation Department's Planning Program to survey subdivisions in 16 sections due east of the City of Laramie (1998). Two graduate students within the UW Planning Program completed an inventory of over 50 sections within the protection area for a master thesis and an EAC intern project (Powell, 2000 & Hallgarth, 2001). 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 Planning Program from the UW Geography and Recreation (G&R) Department 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 their land-ownership files, one and five-meter resolution satellite imagery and GIS applications.

An independent inventory of contaminant sources in the Casper Aquifer Protection Area 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).

Approach

The CSIS researched existing data sources and identified potential contaminant sources located within the protection area. Existing sources were verified or, more often, ruled out by mail and 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

Although all of the preceding references were thoroughly examined, those that did not reveal any existing or potential contaminant sources will not be listed in the contaminant source inventory or detailed on the figures.

The UW Planning Program class project (G&R, Planning Impact Analysis, Spring 1999) examined land use activities in an area east of the City of Laramie by a windshield survey. The land-uses include residential areas, commercial sites, industrial facilities, transportation networks, forestry activities, mining operations, and agricultural practices. This information is reported in an unpublished document (Casper Aquifer Protection and Future Land Use, Albany County Wyoming, July 1999). Figure 4-2 provides county and city land use and zoning designations in the Casper Aquifer Protection Area.

Potential Sources of Contamination

After completing the source inventory in September 2000 and mapping the Accident Prevention Zone (Zone 1) around each of the City's wellheads the potential contaminant sources could be mapped as well. The potential contaminant sources within the delineated Zone 1 are naturally occurring springs at Pope, Soldier and Turner (City Springs) wellfields, a car dealership parking lot near Turner No. 1 well and a domestic well near Soldier Springs wellfield.

All of the inventoried contaminant sources are labeled "potential" as they have not, to date, caused recorded drinking water contamination. Source Identification Forms, Form IV and the Source Inventory List for these contaminant sources can be found in Appendix C. Due to the complexity of our aquifer protection area delineation, the contaminant sources for all wellheads in Zone 2 (Primary Protection Area) and Zone 3 (Secondary Protection Area) have been listed together on the Source ID and Inventory List.

Potential Sources of Contamination

Potential sources of contamination to the City of Laramie wellfields are listed below and shown in Figures 4-3a and 4-3b and described in the next section.

- Transportation Corridors: Interstate–80 and Union Pacific Railroad-Hermosa spur line
- Domestic wells
- Small wastewater systems (septic systems)
- Present and future limestone quarries
- Abandoned wells
- Unregulated local landfills or dumps
- Rifle range
- Underground and aboveground storage tanks
- Stormwater and urban runoff (not shown on maps)
- Gas Station
- Gas pipelines and residential gas and sewer lines

Three commercial facilities exist on the western border of the Primary Protection Area. An orthopedic medical center and Super Wal-Mart are both on city water and sewer lines. Both facilities have large parking areas with automobile residues that accumulate until washed off by rainfall and runoff. There are three underground storage tanks located at the Tumbleweed Gas Station off East Grand Ave (4700 Bluebird Lane). These UST gasoline and diesel inventories are statistically monitored as a leak detection method, and the pipes are cathodically protected. The diesel tank has overfill protection and the pipes are fitted with automatic leak detectors.

The Source Water Assessment for Laramie completed in 2004 (Trihydro, 2004) identified the following potential sources of contamination in the Aquifer Protection Area:

- Etchepare Quarry
- Pilot Hill Repeater (underground storage tank)
- Tumbleweed Express (underground storage tank)
- Burman Motors (solid/hazardous waste)
- Transportation Corridors (pipelines, railroad, interstate highway)

The underground storage tank at the Pilot Hill Repeater and the solid/hazardous waste generated at the Burman Motors car dealership (near Turner No. 1 well) represent additional sources of potential contamination. All other potential sources identified in the SWAP were identified in the contaminant inventory presented in this chapter.

Residential Contaminant Sources

Residential housing includes low and high-density subdivisions within the Casper Aquifer Protection Area. Approximately 455 developed and undeveloped lots have been identified to have, or potentially have, a septic system and domestic well within the aquifer protection area. The various subdivisions located in the Laramie area are shown in Figure 4-3b and Figure 4-4a. Information regarding these subdivisions is given in Table 4-1 and the age of the subdivision lots near Laramie is shown in Figure 4-4b. The age of the lots is important due to the fact that most septic systems typically need to be replaced after 20-30 years after they are initially installed.

Domestic wells and septic systems serve the residents throughout the Zone 2 and Zone 3 of the aquifer protection area. Figures 4-5a and 4-5b show an estimate of septic systems and domestic wells located within the Casper Aquifer Protection Area as of 2003. Also shown in these figures are the lots that are currently undeveloped and could potentially house a septic system and well in the future.

As further residential development is expected within Zones 2 and 3, septic system leachate becomes a potential contaminant source of concern. As shown in Figures 4-5a and 4-5b, many lots remain undeveloped at present. However, a majority of both developed and undeveloped lots lie within Zone 2 and are considered to be higher potential hazards than those within Zone 3, for reasons given in the Delineation Report (Chapter 3).

Other residential activities that may influence the groundwater include household hazardous waste such as: paints, solvents, petroleum products, pesticides and herbicides that are carelessly handled and improperly disposed.

Updating and Refining the Contaminant Source Inventory

To ensure that the Contaminant Source Inventory continues to be updated, the City Utility Division Manager will reconvene a meeting of the CSIS as development dictates. The EAC is notified during the development and permitting of most new industrial, residential and commercial buildings within the aquifer protection area and will identify any new contaminant sources to the CSIS.

Chapter
5

Contaminant Management Plan

Introduction

The purpose of the Laramie Regional Drinking Water Protection Program (LRDWPP) is to identify and minimize the existing and potential contaminant threats to our community's drinking water 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 perceived threat to the supply and public reception of the strategies.

This Contaminant Management Plan presents the EAC's recommendations for managing potential contaminant sources identified within the Casper aquifer protection area. The Plan is organized into sections, as follows:

- The EAC's prioritized management strategies with an implementation schedule;
- An overview of potential management strategies and approaches considered by the EAC; and
- Detailed discussion of suggested management strategies for each type of contaminant source.

Priority Management Strategies and Implementation Schedule

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

Year 2004 Management Goals (within 2 years)

The EAC recommends the following management programs and policies be implemented no later than 2004:

1. Establish a systematic groundwater-monitoring program for the Casper aquifer.
2. Create a permanent staff position to develop and oversee an on-site wastewater management program within the aquifer protection area, including:
    a. Consistently and thoroughly inspect new on-site wastewater treatment facilities, and
    b. Inspections of on-site wastewater treatment facilities upon property transfers.

3. Establish an overlay zone within the City and County which defines:

    a. Design standards for on-site wastewater treatment systems;

    b. Setbacks from recharge features; and

    c. Prohibition of inappropriate land-uses.

4. Institute mitigation investigations to address I-80 hazardous materials transport.

5. Establish Memoranda of Understanding or other agreements with the UPRR, WYDOT and Mountain Cement regarding spill prevention and response protocols.

Year 2006 Management Goals (within 4 years)

The EAC recommends the following management programs and policies be implemented no later than 2006. Note that the timeframe for these programs is based not on lesser importance, but by the logistical constraint that a staff position needs to be created to oversee and implement these programs.

6. License contractors who install and pump small wastewater treatment systems and drill water supply wells. Also, institute procedures for augmenting and evaluating information provided as part of our community's existing program requiring manifests for hauling septic waste.

7. Establish requirements for two compartment septic tanks for new or replacement construction of onsite wastewater treatment systems and requirements for improved well construction standards.

As of October 2006, the Laramie City Council and Albany County Board of Commissioners have implemented items 1, 2, 3, and 7 (with respect to two compartment septic tanks). Items 4, 5, and 6 will be integrated into the Year 2009 Management Goals described below.

Year 2009 Management Goals (within 7 years)

The EAC recommends the City and County initiate planning for the following management policy to be implemented no later than 2009:

8. Extend City sewer services to existing high-density development areas that are documented, based upon monitoring data, to be adversely impacting groundwater quality in the Casper aquifer. Existing developments along the East Grand Avenue corridor are of greatest concern in this regard.

Management Strategies Presently Being Implemented

- Public Education and Outreach Programs
- Household Hazardous Waste Collection Program

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 current 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, including 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 specified protection area. 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 the contaminant sources identified in the delineated protection areas. Regulations should also include enforcement procedures and penalties, and may 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. EPA, include both regulatory and non-regulatory strategies (EPA, 1995).

The following is an overview of the regulatory and non-regulatory strategies that the EAC discussed in developing the recommendations presented in this plan.

Non-Regulatory Management Strategies

Public Education and Involvement

To build support for regulatory efforts or to implement 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 is frequently the most effective and economic means of altering activities that pose a threat to the aquifer. Often when people are aware that their activities can pollute groundwater they are more cautious.

Groundwater Monitoring

To assess the quality of the aquifer by sampling public and private wells for selected contaminants through a long-term monitoring effort. Monitoring can be used to measure the effectiveness of the aquifer protection program or as an early warning of threats. Trained volunteers may serve as effective observers of resource quality.

Best Management Practices (BMPs)

Best Management Practices are ways to conduct everyday projects in the protection area in ways that will minimize the threat of contaminating the ground- water. A list of BMPs for single-family residences is included in Appendix D. The list should be continuously updated and provided to people who live, develop and conduct projects in the aquifer protection area.

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 of, these products may contaminate the soil, surface water and groundwater. Laramie and Albany County residents must take significant precautions to protect their limited community water supply from household wastes and other potential contaminants. Therefore, a residential hazardous waste management program should continue to be made available to the community in order to reduce the quantity of household hazardous waste being disposed of improperly.

Land Acquisition Programs

The local government can acquire land that is designated to be within the aquifer protection area to protect it from land uses that may adversely affect the groundwater. Five ways to acquire property within the protection area 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, which 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 this plan, 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 aquifer. The exchange may involve the surface, 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.

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 usually have the same goals as MOA/MOU but are susceptible to public resistance. Ordinances may elicit public resistance and therefore can take long periods of time to pass. Additionally, once an ordinance is passed resources must be devoted to enforcement of violations.

The City-County Environmental Advisory Committee can help define ordinances to protect the community's groundwater supply. Inasmuch as most of the aquifer protection area is located outside of the City limits, the City and County will need to act cooperatively to regulate activities of concern. Potential regulatory management strategies include:

Zoning Ordinances

Zoning regulations segregate different and possible conflicting activities into different areas of a community and are a good mechanism for controlling future development and may include a number of techniques. However, one limitation is that state statutes may provide broad "grandfather" protection for some uses.

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, a groundwater protection overlay district has been applied to the basic zoning within the City and County that restricts the use of on-site wastewater treatment systems (see Appendix J).

Prohibition of Various Land Uses

Such as gas stations, landfills and storage or disposal of toxic or hazardous materials. The City and County have identified prohibited land uses in the aquifer protection area in a current ordinance (see Appendix J).

Special Permitting

To regulate uses and structures which may potentially negatively impact water and land quality, such as underground storage tanks within vulnerable aquifer protection areas.

Large Lot Zoning

Would limit the potential for degrading groundwater quality by reducing the density of buildings and, therefore on-site wastewater treatment systems, within the aquifer protection area.

Cluster/Planned Unit Development (PUD) Design

Allow for an area of small lot development in association with a conservation easement in a way that limits the overall development density to a level consistent with the goal of protecting the aquifer.

Growth Controls/Timing

Limitations on the number of building permits issued annually or outright development moratoria based on a community's physical and financial capabilities.

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 and ordinances, and focus primarily on engineering concerns rather than land use. Subdivision regulations may include the following techniques:

Performance Standards

To limit the impact of development on water quality.

Environmental Impact Assessment (EIA)

Proposed subdivisions exceeding a minimum size would be required to do an EIA. An EIA describes the existing condition of the resources and provides a list of potential effects of the proposed development on the aquifer protection area.

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.

Inspectors at Septic System Construction and Water Well Sites

When construction of an individual sewage disposal system has been completed, except for backfilling, an inspection should be performed. The final inspection will verify that the system is installed in accordance with the regulations and the permit.

Licensing

Licensing regulations require design and construction activities within an area of special concern be conducted by qualified firms. A licensing authority such as the state, county or the city establishes qualifications.

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 aquifer protection area. 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 this plan. This section describes suggested management strategies for each type of 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 to be established around each municipal well and spring area as described in Chapter 3. These zones will be managed to prevent the accidental introduction of contaminants into the aquifer in the immediate vicinity of the wells. The City should control and maintain the security of these areas by restricting development and access from unauthorized personnel. Development restrictions should include, but are not necessarily limited to, prohibition of underground storage tanks or above ground storage tanks in Zone 1. In addition to these Zone 1 specific management strategies, all management strategies for potential sources of contamination for Zone 2 and Zone 3 apply to Zone 1.

Groundwater Monitoring

To date, there has not been a systematic groundwater monitoring program to assess impacts to water quality in the Casper aquifer. The depth to water beneath the subdivisions located east of Laramie that rely on conventional on-site wastewater treatment (septic systems) is between 70 and 400 feet. Wastewater effluent from these subdivisions may have measurable impacts to the community's groundwater supply. A systematic groundwater quality monitoring program to assess impacts to groundwater quality down-gradient of subdivisions located near the City's municipal well fields should be instituted to determine the real threat of septic systems to water quality. As a result this document focuses on potential threats.

Recommendations

It is recommended that the City and County develop a program to routinely collect groundwater samples to evaluate changes in groundwater quality over time. This method differs from other management strategies because it would establish baseline data and provide feedback on the effectiveness of management strategies in protecting groundwater quality. A systematic monitoring program has a secondary benefit of increasing our understanding of the aquifer properties.

A good monitoring program can provide an 'early warning' prior to the arrival of contaminated groundwater at a municipal supply well. The monitoring wells should be located such that an early warning would provide enough lead time to either mitigate the in-coming contamination before it can reach the well or arrange for an alternate drinking water supply or treatment. The groundwater-monitoring program should include periodic monitoring of groundwater for suspected or known contaminants that may find their way toward a municipal supply well (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 participating residents within the aquifer protection area, who allow testing, might evoke more interest in such a program.

It is recommended the City conduct an investigation to design a plan for a long-term groundwater monitoring network and sampling program. As outlined previously this is the highest priority. The EAC recommends that funding be acquired or set aside as quickly as possible to allow for establishing a monitoring program within two years.

Septic Systems

Albany County is working to execute a delegation agreement with the Wyoming Department of Environmental Quality, Water Quality Division (WDEQ-WQD) to regulate small wastewater systems within the County. This delegation agreement can be found in Appendix E. To accomplish this goal, 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.

EAC recommends the City and County revise the delegation agreement with DEQ when City/County pass ordinances or overlays requiring enhanced systems (or fate/transport alternative systems). While the county does not currently have the expertise to inspect and permit enhanced septic systems and to date has not handled an enhanced septic system permit, if presented with such a permit application, the county will contact DEQ and receive training (usually one to two days) to give the county staff the knowledge to inspect and permit enhanced septic systems. The county could enter into a cost collection agreement with the city to provide the expertise and knowledge for inspection on an as-needed basis.

The majority of the aquifer protection area falls outside of city limits, so all rural homeowners in this area need an on-site small wastewater system and private well. Management of septic systems is a high priority because there are subdivisions within the Zone 2 that have systems that are over 30 years old and have begun to fail and new subdivisions are located up gradient from the City's wellfields. Elevated nitrate values (4-10.6 mg/l) from drinking water samples within Zone 2 were identified 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 (see Appendix F).

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 through their roots 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 neglectful operation.

To avoid contamination of an important drinking water source for our community, the leachfield must be situated at prescribed distances from wells, surface waters and springs, property boundaries and building foundations, and from potentially vulnerable features identified within the Casper aquifer protection area.

Recognition that small on-site wastewater systems are an integral and necessary part of the infrastructure within the aquifer protection area is important. The City and County should work to see that these systems are managed to protect the public health and the environment.

Recommendations

Licensing

It is recommended that the City and County require, by regulation, design and/or repair of septic systems located within the aquifer protection area be certified by a professional engineer registered to practice in the State of Wyoming.

It is recommended that the City and County establish licensing authority for contractors responsible for constructing and repairing septic systems and leachfields located within Zones 2 and 3 of the aquifer protection area. This authority will establish standards for installation of septic systems within the aquifer protection area. The licensing authority will be responsible for permitting, licensing, contracting, reporting, and record keeping.

Inspections

It is recommended that the County Planning Office maintain authority to inspect new or replaced septic systems and leach fields, prior to backfilling, to verify proper installation and confirm design information stated in the permit application. Upon establishment of licensing of contractors, inspections can be performed in conjunction with routine pumping of the septic tank.

- Inspections within the aquifer protection area should be required every three years to confirm that baffles are operating correctly, that no leaks are occurring, and to check the levels of sludge and scum in the tank. The tank should be pumped out if the sludge layer thickness exceeds 25 percent of the working liquid capacity of the tank, or if the bottom of the scum layer is within three inches of the bottom of the outlet baffle.

- Inspections of septic systems should be required at the time of property transfer.

Education

Approximately 455 conventional septic systems currently exist within the aquifer protection area (Figures 4-6 and 4-7b). New construction of rural residences is expected to continue in the future within the protection area. Education is recommended to promote proper maintenance and inspections of septic systems in the aquifer protection area. A homeowner's guide to septic systems is available at the Albany County Planning Office. It contains the following information:

- Description of a typical septic system;

- How to care for a septic system;

- Tips to avoid trouble; and

- When service or pumping is needed.

Sewer Extension

As growth continues and the associated threats to the aquifer increase, it may become cost effective for the City to extend sanitary sewer service to subdivisions in the aquifer protection area that are near the city limits. The City should update its Sewer Master Plan to address increasing sewer capacity east of town as needed to serve existing and anticipated high-density subdivisions in this area. City and county residents will have to bear much of the costs for sewer line extension and maintenance. A Wastewater Service Area could be created between the City and the County to address this concern. A 'sunset date' would be established as part of the comprehensive plan whereby the City and County would place property owners in high density subdivisions near the City on notice that the City intends to establish sewer service to specific areas in 7 years and affected property owners should plan for a defined economic impact to their property in terms of that schedule.

Design and Location Standards

The following design and location standards are recommended:

- Features observed within the outcrop of the Casper Formation in the aquifer protection area have been identified as potentially providing routes of contamination to the aquifer from the ground surface. These features are discussed in detail in Chapter 3.

- We recommend a site-specific investigation be conducted as part of design of on-site wastewater treatment systems proposed within Zones 2 and 3, or whenever any conventional septic system is being repaired, replaced, or installed within Zone 2 or 3. The investigation should be certified by a Wyoming registered engineer and/or Wyoming licensed geologist qualified to perform the investigation. Site investigations should address the requirements of site-specific delineations provided in Chapter 3.

- If the certified site investigation determines that leachate from the on-site wastewater disposal system may infiltrate through faults, fractures, or karst features and into an aquifer being used, or suitable for use as a drinking water supply, we recommend that an enhanced wastewater treatment system be used to meet effluent and disposal standards established in WDEQ/WQD Chapter 23, Section 7 (viii)(C)(I-II), unless a contaminant fate and transport analysis is completed and demonstrates that leachate will not impair the quality or use of groundwater or surface water.

- If the certified site investigation determines that leachate from the on-site wastewater disposal system will not infiltrate through faults, fractures, or karst features and into an aquifer being used, or suitable for use as a drinking water supply, we recommend that the standards established in WDEQ/WQD Chapter 23, Section 7 (viii)(A)(I-III) be applied for conventional septic systems.

- Two-tank or two-piece compartment systems should be required. They are the ASTM standard and will improve effluent quality.

- EAC encourages the City/County to develop a low maintenance prototype enhanced treatment system permit that meets Chapter 23, Section 7 (viii) (C) (I-II) requirements. WDEQ has a low maintenance prototype example for review.

- At the least, the existing minimum 5 acre-lot size should be enforced within Zones 2 and 3. Subdivisions must also meet the requirements of WDEQ subdivision regulations.

Hazardous Material Spills along Interstate 80

(I-80) from milepost 323 to 317 and the Grand Ave. interchange with I-80

Transport of hazardous materials along I-80 poses a threat with a high probability and greatest potential severity of damage to the Casper aquifer. I-80 passes over the area of the aquifer most susceptible to contamination from milepost 323 to 317. The Grand Avenue interchange with I-80 also is located within the Primary Protection Area.

Recommendations

Post-Incident Emergency Response Strategies

- The Wyoming Highway Patrol should notify the Laramie Albany Records and Communications (LARC), which would in turn notify the Laramie Fire Department, and Albany County Sheriff's Office 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 Contingency Plan.

- DEQ will be notified and requested to provide additional spill mitigation assistance, as needed.

Mitigation Measures

To protect the Casper aquifer from contamination, it is recommended that a "Phase 1-Phase 2" investigation be funded to consider mitigation alternatives. Under the Phase 1 investigation, conceptual designs and cost estimates for alternative mitigation designs would be generated. An alternative would be selected for advancement under the Phase 2 investigation, during which the design would be refined and financing plans established.

One potential mitigation alternative that has been discussed is the construction of a lined retention pond. The pond would be located up gradient of the outcrops of primary water-bearing strata comprising the portions of the Casper Formation which supply groundwater to the City's municipal wells.

Because of the high ranking of this potential contaminant source, and the complex design considerations, it is further recommended that the City acquire the professional services necessary to complete this management task. The selected consultant must have demonstrated experience in the design and construction of environmental mitigation projects, expertise in the hydraulics and hydrology of storm water management, as well as a familiarity with the local hydrogeology. The

Wyoming Department of Transportation (WYDOT) should be involved as a partner throughout the design and construction of the project.

Signage

The EAC recommends road signs designating a Water Supply Protection Area be posted along I-80 between milepost 323 to 317. The road signs should be compliant 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 in the protection area to emergency response personnel who can implement groundwater protection measures.

Road Salt Application

Road salt may enter the groundwater after WYDOT performs deicing procedures on I-80 where it passes through the aquifer recharge area.

Recommendations

Monitoring

Sample for salt at monitoring wells in a groundwater monitoring program.

Springs

Springs have been identified throughout the aquifer protection area. Most obvious are the historic springs located adjacent to the City's water supply wells. Other ephemeral springs have been identified in upland areas, some of which have been developed for stock watering. A spring exists in Telephone Canyon along I-80. This spring is especially significant because it presents a pathway for contamination of the aquifer from potential hazardous material spills on the highway.

Recommendations

Public Education

Public education will increase awareness of how springs may provide a potential pathway for migration of contaminants from a surface source to the 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 provide that land use practices in the vicinity of springs are protective of the aquifer.

Mitigation Measure

The "Phase 1-Phase 2" investigation recommended for the I-80 corridor should address mitigation strategies for potential contamination of the spring in Telephone Canyon.

Ordinances

The historic springs adjacent to the City's municipal supply wells fall within the Zone 1 delineation. We recommend the City control and maintain security to restrict access and development of areas within Zone 1.

Wells

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 Department of Environmental Quality, Water Quality Division (WDEQ/WQD). The SEO provides well design requirements in their Regulations and Instructions, Part III, Water Well Minimum Construction Standards. The WDEQ/WQD 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. The WDEQ/WQD regulations do not govern the construction of domestic wells, but it is highly recommended that the well construction design comply with these regulations to help prevent groundwater contamination.

Recommendations

Public Education

Public education will increase awareness of how private wells may be a potential contaminant source. Information in the form of a brochure should be prepared to inform residents of the importance of properly constructing and abandoning wells. The City should use similar techniques to educate the owners of the existing wells in the area about proper well maintenance and encourage proper well abandonment for wells no longer in use.

Existing private water wells probably provide the most direct conduit to the Casper aquifer in the protection area. Through education, the City and County should work to provide that all non-municipal water wells constructed in the aquifer protection area are capped and cased with a surface seal.

Well Design

We recommend the City and County adopt a well completion standard for new wells constructed within the Zone 2 and 3 of the aquifer protection area. The standard includes a cement grout seal that 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.

Well Seal Inspection

The County should establish authority to inspect construction of new and existing wells located within the aquifer protection area. Owners of existing wells should be encouraged through education to retrofit poorly constructed wells.

Abandoned Wells

Plugging of abandoned wells is imperative in maintaining the quality of the water in the Casper aquifer.

Recommendations

Communication

The City Public Works Outreach Coordinator should contact owners of abandoned wells regarding the problem. 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/WQD and the SEO should also be advised of the presence of an abandoned well for the enforcement of existing regulations.

Public Education

Likewise, public education will increase awareness of abandoned wells as a potential contaminant source. Information in the form of a brochure should be prepared,

explaining that abandoned and improperly constructed wells may serve as a conduit allowing surface contamination to reach groundwater resources. The brochure should provide information on how to properly 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 use UICs as Class V subclasses 5B1, 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.

Recommendation

Ordinance

All UIC wells, except Class V subclasses 5B1, 5B2, 5B3, 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.

Hazardous Materials Spills along Union Pacific Railroad (UPRR)

The UPRR Hermosa spur line crosses a portion of the Primary Aquifer Protection Area south of Laramie. Thousands of rail and tanker cars carrying hazardous material use this line annually.

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 the Primary Aquifer Protection Area. It is also important that UPRR understand that if a spill occurs in this area that groundwater contamination prevention measures should be taken immediately.

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 for contingency planning. Signs with contact phone numbers posted along railroad rights-of-way in the protection area will help to facilitate this effort.

Limestone Quarries

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

The quarries strip off the limestone and expose the underlying sandstone. Explosive storage and blasting, as well as large truck traffic occurs within the aquifer protection area. Most of the quarries are located near faults and the blasting process has the potential to generate contaminants and induce additional fracturing. Consequently, quarry operation may increase the vulnerability of the Casper aquifer to contamination. In addition quarrying operations may involve temporary storage of large quantities of fuel in above-ground storage tanks.

Recommendations

MOA/MOU

As part of the MOA/MOU the owners of quarries in the aquifer protection area should be informed of the sensitivity of the aquifer to contamination and the importance of rapid clean up of spills of hazardous materials at the site. The MOA/MOU should establish that the permitee is responsible for mitigating contamination of the aquifer resulting from quarrying operations. Quarry operators should provide the City with a spill or accident notification protocol along with water quality information that is collected annually from monitoring wells near the quarries.

Permitting

The City should request WDEQ Land Quality Division review and approve all applications for permits to mine or quarry within the aquifer protection area.

Local Landfills and Dumps

Landfills and dumps may have materials that could contaminate the aquifer. Landfills are waste disposal sites where the wasted material is placed in trenches, compacted, covered with soil and graded so water does not pass through the buried waste. A properly operated landfill covers the waste every day with impervious soil. The Laramie Landfill is located a safe distance to the west of the aquifer protection area.

Dumps are a broad category of waste disposal that may include broken rock or glass, to potentially dangerous contaminants such as used oil that may be contaminated with heavy metals. There are known dumps in the aquifer protection area.

Recommendations

Ordinance

A County Ordinance should be established that requires landowners to clean-up existing dumps that contain any wastes or materials which have been documented by federal and/or the state government to be hazardous or potentially injurious. Dumps within Zones 1, 2 and 3 containing wastes and/or materials listed on the EPA's CFR 40 document, Table 302.4 shall automatically be deemed a community nuisance due to the high potential for injury to others. Upon identification of illegal dumping sites containing said materials, Wyoming's Department of Environmental Quality 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. If there are implements, appliances or vehicles dumped and are no longer operative, then the county should use Memoranda of Agreement to have the machinery and any contaminated soil removed from the site.

"No Dumping" signs should be posted at active dump-sites. There should be a County Ordinance prohibiting disposal of waste except at approved landfills. Landowners should be made responsible to pay for cleanup and signage. The County should pay for the dump inventory and enforcement.

Clean-Up Days

The EAC encourages the County to pursue county-wide volunteer clean-up days that could work in cooperation with the Laramie Landfill and the Household Hazardous Waste Collection Program.

Laramie Rifle Range

The Laramie Rifle Range Corporation (LRRC) operates a shooting sports facility on more than 320 acres, located in Sections 1 and 12, Township 16 North, Range 73 West. The establishment of the facility predates adoption of the Casper Aquifer Protection Area by the City and County. Nevertheless, the facility is now known to be located in the Primary Protection Area.

The Casper aquifer is the primary source for municipal water for the City of Laramie. Moreover, the City has recently developed the Spur Wells in an area of the aquifer located in the immediate vicinity of the LRRC facility. The area surrounding the facility is also experiencing increased rural residential development and derives drinking water from the Casper aquifer.

The operation of the LRRC facility is important to the residents of Laramie and Albany County. This facility not only directly serves the residents in the County who are interested in shooting sports but also serves to protect the welfare and safety of the general public by providing a safe location for the discharge of firearms.

Recommendations

Investigation

The risk of contamination to the City's municipal water supply as a result of activities at the Laramie Rifle Range is unknown and the potential impact of lead bullets impacting the aquifer should be investigated. 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 threat to the Casper aquifer.

Communication

The City and/or County officials should initiate a meeting with the Laramie Rifle Range Corporation (LRCC). The purpose of the meeting is to:

- Inform the Corporation of the findings of the aquifer protection plan.
- Discuss funding for an independent investigation of the facility as described above.
- Discuss a timeline for completion of the 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 hereinabove should be accomplished by regulation.

Sewer Lines

Recommendations

Inspections

The City should insure that the sewer lines that serve 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 downhole video camera). A break in the sewer line at this location could have serious impacts on water quality from the Turner Well Field.

Natural Gas Pipelines

Recommendations

Inspections

Pipeline owners should ensure the lines are inspected for leaks and take appropriate steps to guarantee the pipes' structural integrity.

Urban Runoff

Paved parking lots near or in the protection area are a potential contamination threat to the groundwater. Rainwater collects oil and grease from motor vehicles, metal particles from tires and brake pads and may carry these pollutants across the recharge area or into storm drains, which eventually flow to the Laramie River.

Recommendations

Design Standards

Even though the City of Laramie currently does not come under any federal storm water management requirements, we recommend that new parking lots be designed to capture the pollutants before they can flow across the recharge area.

The current stormwater management practice in the City today involves the building of detention storage ponds for large parking lots (e.g., Super Wal-Mart on East Grand Avenue). The ponds are an effective means of attenuating peak discharges from a developed site. At some time in the future, restricting peak discharge from the east Grand Avenue corridor will become an issue, inasmuch as stormwater discharge from this area most likely would be routed to Spring Creek. FEMA flood mapping has been completed for the Spring Creek channel and it is unlikely that the City would allow a significant increase to the peak discharge to the channel.

Detention storage is probably not a best management practice for protecting groundwater in the delineated protection area. Unless a pond was lined in a manner protective of groundwater, it would tend to serve as a potential collection facility for contaminants and a concentrated seepage path to the underlying aquifer. Technical approaches other than detention storage need to be assessed for addressing both the water quality and quantity issues in delineated recharge areas for the aquifer.

For example, in Portland, OR the use of bioswales are encouraged. Bioswales are narrow, linear wetlands planted with moisture-tolerant shade trees and a variety of native plants that are commonly found near rivers and streams. Unlike traditional landscape islands, which are raised, these bioswales are lower than the pavement so that stormwater flows off the lot into the swales. The swales are designed to slow down the flow of stormwater. Vegetation in the swales catches toxic sediments as

the water infiltrates into the ground. The soil filters out oil, grease and other pollutants, preventing these from reaching the groundwater or storm drains.

MOA/MOU

The City Planning Manager and Planning Commission should be made aware of the importance of how they permit future parking lots and streets that are located near or within the protection area.

Underground Storage Tanks (UST)

Recommendations

Ordinance

The City should amend the current Underground Storage Tank Ordinance to prohibit installation of all new underground storage tanks within the aquifer protection area. This prohibition should not apply to the repair, maintenance, or replacement of existing USTs. The current ordinance can be found in Appendix G. The County needs to create a parallel ordinance.

An emergency ordinance was passed by the City of Laramie in 1994 that deals with the installation of underground storage tanks within the 5-year time of travel zone established by a study of the area done by Western Water Consultants. The ordinance is in the Laramie Municipal Code, Chapter 8.60 and states that underground storage tanks will require liners, double-walled tanks and interstitial monitoring. The EAC believes the change in the ordinance is needed to protect our community's water supply. Changes to the ordinance should include the following items:

- Make the ordinance consistent with the Casper Aquifer Protection Program.
- Provide for the protection of groundwater sources other than just the Turner Well Field.
- It should provide protection for critical areas to the east of the City that may be annexed in the future.

The ordinance should also require owners to monitor USTs using state of the art leak-detection systems. The monitoring should include monthly visual inspections and testing of leak-detection systems. The ordinance should require owners to report their findings on an annual basis to the City. Other recommended changes to the ordinance include the omission of the reference to the five-year-time-of-travel contour for the Turner Wellfield based on the 1993 Wellhead Protection Report by Western Water Consultants.

The UST design, construction and monitoring requirements proposed in this ordinance should be required in both the Primary and Secondary Protection Areas. No UST should be allowed in the Accident Prevention Zones (Zone 1).

Aboveground Storage Tanks (AST)

Recommendations

Education

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

Design and Location Standards

- We recommend a site-specific investigation be conducted as part of design of ASTs proposed within Zones 2 and 3, or whenever an existing AST is being repaired, replaced, or installed within Zone 2 or 3. The investigation should be certified by a Wyoming registered engineer and/or Wyoming licensed geologist qualified to perform the investigation. Site investigations should address the requirements of site-specific delineations provided in Chapter 3.

- ASTs should be designed and operated according to city or county adopted fire codes, regulations, and/or standards, whichever is appropriate, as well as applicable state and federal fire codes, regulations, and/or standards, whichever is more stringent.

Ordinance

- The county and city should draft an ordinance requiring ASTs meet city or county adopted fire codes, regulations, and/or standards, whichever is appropriate, as well as applicable state and federal fire codes, regulations, and/or standards, whichever is more stringent.

- The AST design, construction and monitoring requirements proposed in this ordinance should be required in both the Primary and Secondary Protection Areas. No AST should be allowed in the Accident Prevention Zones (Zone 1).

Pesticide Spraying and Fertilizer Application

The City Parks and Recreation Division, Mosquito Control Program conducts aerial applications of bacillus thuringiensis israelensis, or Bti each May. Bti is a bacterial-based mosquito control product which is harmless to humans, other mammals, birds and fish. The City's larval control program applies Bti to watery areas and wetlands, which are known to be mosquito breeding habitats. The City's mosquito control program also includes conducting aerial application of ultra low volume malathion in June. Both the applications of Bti and malathion are sometimes sprayed within the aquifer protection area.

Recommendations

Information

All individuals and organizations using fertilizers, herbicides, pesticides, or insecticides are encouraged to apply it according to the manufacturers specifications and only as needed. Brochures should be developed to promote the proper application of pesticides, insecticides, herbicides and fertilizers, especially within the aquifer protection area.

Existing Land-Uses that are Potentially Nonconforming

To the south and west of Turner Well Field there are numerous businesses along Grand Avenue. Tumbleweed Express, located on the eastern edge of the Laramie Plains Subdivision, is a gas station that could potentially impact the Casper aquifer due to its underground storage tank. The station is situated on the Satanka Shale, but there may be less than 30 feet of shale overlying the Casper aquifer at this location.

Recommendations

Information

The City and County should continue to educate all business owners about the importance of pollution prevention practices and to inform them about the aquifer protection area. How to better direct and control stormwater runoff from large parking lots in areas in or adjacent to the protection area should be part of the information provided to business owners.

Future Types of Land Use within the Protection Area

Probably the most important step in the protection of the Casper aquifer is restrictions on future types of land use such as those commercial and industrial land uses that generate hazardous waste (Appendix H – Sources: Horsley and Witten, Inc., and U.S. Environmental Protection Agency, Wellhead Protection Programs: Tools for Local Government, Washington, D.C.; EPA, 1989.).

Recommendations

City and County Planners should develop regulations prohibiting inappropriate land-use within the aquifer protection area. Obvious examples of inappropriate land-use would be landfills, hazardous materials handling/storage facilities and dry cleaners.

DISCLAIMER:

The data used by the Environmental Advisory Committee (EAC) will not be limited to the contaminant sources, land uses and other information used in the Aquifer Area Protection Plan when evaluating future environmental concerns in Albany County. Any contaminant sources, future growth, future land use and any other information affecting the protection plan will be considered by the EAC/Aquifer Area Management Subcommittee in coordination with the City of Laramie and County Planning as changes occur. The pertinent information will be added to the Aquifer Protection Plan using the procedures developed by the EAC.

Chapter
6

Contingency Plan

Introduction

The Safe Drinking Water Act requires that Wellhead Protection Programs include contingency plans. This contingency plan addresses problems that our 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. It defines a chain of command and description of individual roles and responsibilities during an emergency.

A contingency plan to help provide potable water to the public during water supply emergencies is critical to any drinking water protection program. Potential emergencies such as well or wellfield contamination, water shortages due to droughts, and interruption of water supply are issues addressed in a contingency plan. Evaluating potential emergency situations and developing appropriate responses prior to an event can reduce reaction times and reduce the risk of making 'knee-jerk' reactions that result in further harm or extend the emergency.

Organization of Plan

In formulating this contingency plan, the Laramie Regional Drinking Water Protection Program addressed the following: (1) present water source capacity, water demand, and storage capacity; (2) chain of command and areas of responsibilities during an emergency; (3) short-term emergency responses, including developing conservation measures and water decontamination measures; and (4) long-term shortages or abandonment of contaminated supplies, including the development of new ground water sources.

Plan Development

The contingency plan is a part of the Laramie Regional Drinking Water Protection Program. It was developed by the Contingency Planning Subcommittee for the City of Laramie/Albany County Environmental Advisory Committee (EAC) on the basis of the following references:

- 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.

Plan Distribution

It is recommended that this 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 plan will be available at the Albany County Public Library, the City Planning Office, and the County Planning Office.

Procedures for Review and Update

The water demand and source inventory tables, distribution system, and emergency response team roster included in this contingency plan must be reviewed and updated every two years. This contingency plan should also be modified as changes occur in the water system infrastructure.

Water demand and source inventory facts are critical information for this plan. These facts should be reviewed and updated with the same methodology used in the Water Supply Master Plan or use the best professional opinion available at the time of review. These facts should be confirmed with the City Utility Manager. Any time the plan is updated it will be reviewed and signed by the Utility Manager, the County Emergency Management Coordinator, the Public Works Director, and the Environmental Advisory Committee to ensure that the most current information has been supplied to the contingency plan.

The Albany County Exercise Design Team has tested the Contingency Plan several times in 2000 with table-top and in 2001 with full-scale exercises. A full-scale exercise was held up on the summit of I-80 near the east boundary of Zone 3 and simulated a diesel spill within the protection area. The exercise was well supported and attended by all emergency response agencies and city and county officials.

Emergency Probability and Severity Chart

Table 6-1 presents a format that was adapted from EPA (1990) using estimates of local conditions which may be used for evaluating potential threats by assigning estimates for both probability and severity. Those threats with a high probability are more likely to occur, while those with high severity will have more of an effect on the water system.

The estimations were made by James Case, Hazards Staff Geologist at the Wyoming State Geological Survey. The probability rank reflects a relative estimate of the probability that the city's water supply and distribution system might be impacted by the specific event. The severity rank reflects a relative estimate of the likely severity of such a hypothesized event.

Table 6-1 should be used to prioritize future areas of concern in the contingency plan.

City of Laramie Water Demands and Source Inventory

Table 6-2 and Table 6-3 show the water demand projections and the existing source capacity of the water system operated by the City of Laramie. The values in these two tables are in million gallons per day (mgd). The source of this information is from the *Water Supply Master Plan*, *Level 1 (*Western Water Consultants, 1995), *the Draft Executive Summary for Spur Wellfield Project* (Western Water Consultants, December 9, 1997), and water demand projections are based on historical usage and a population projection of 30,742 for the City of Laramie in the year 2000. Existing source capacity information was provided by the City of Laramie Utility Division.

Alternative Potable Water Supplies or Emergency Coordinating Agencies

Emergency agencies that might assist in the distribution of potable water are listed below (See Emergency Notification Roster for more information):

- Culligan
- 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 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 and Albertson's. If the Army Corps of Engineers or the National Guard were called, they would most likely enlist the help of commercial trucking companies to bring in 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 people west of Laramie who haul treated water to supplement or replace the highly mineralized water located in their residential locations.
- An emergency water conservation ordinance would be activated for the residents of Laramie to conserve water limited to essential uses necessary for survival
- The federal and state governments have no responsibility to provide their cities with clean water. Financing for developing or cleaning up water sources due to spills, sabotage, or other man-made activities would most likely entail the City hiring a consultant to perform the work, and then seeking compensation from the responsible parties.

Water Distribution System and Storage Facilities

Maps pertaining to the water distribution system and storage facilities are maintained by the City of Laramie Public Works Department. Requests for updates may be directed to the Project Engineer in the City Engineering Division at 721-5272.

All inspection, decontamination, and reconstruction of the water distribution system are done 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:

1. Coordinate responsible personnel for plan development and training (See Emergency Notification Roster at the end of this section).

2. Maintains channel of communication with Incident Command, which is an onsite Emergency Operation Center vehicle.

3. 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.

4. Makes contact with the Wyoming Office of Homeland Security, Wyoming Department of Environmental Quality (WDEQ), Wyoming Highway Patrol, a geologist from the Technical Review Subcommittee, and other state and federal agencies that are deemed necessary and responsible for coordinating and providing emergency relief.

5. Activates the Emergency Operations Center (EOC), if necessary.

6. Coordinates authorization to hire consultants to perform remediation or source development projects.

7. Coordinates review and exercising of a water conservation program in conjunction with the Environmental Advisory Committee, the Director of Public Works, and elected and appointed city and county officials.

8. 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 production wells or surface water systems are rendered inoperable as a consequence of direct contamination or potential contamination. The County Emergency Management Coordinator will coordinate this effort with the Public Works Director, the Utility Manager, the Environmental Advisory Committee, 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 City of Laramie Water Supply Master Plan

(WWC, 1993). This Plan can be reviewed in the Water Outreach Coordinator's office or the Utility Division Manager's office. A brief review of these procedures follows:

- 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. This source can be developed in two ways: drilling new wells or increasing production from existing wells. There are a number of water prospects for siting new wells described in the Master Plan. While some measures have already been implemented since the plan was written in 1993, such as the development of the Spur Monocline, there are still options that have yet to be developed to increase the amount of water available to the city. An example of a future prospect is Simpson Springs, located on the Monolith Ranch south of Laramie. The city purchased Monolith Ranch to secure its primary water rights, but has not transferred the rights to municipal use nor has it developed the springs as a surface or groundwater supply.

The following plan elements are listed in the recommended order of implementation. 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 with consideration of the duration of the contamination event.

- Set priorities for water use i.e. drinking and food preparation, etc. and for facilities such as hospital, medical clinics, veterinary facilities, etc.

- Curtail water use – can be at-will or mandatory, depending on the severity of the situation. If public health is an immediate issue, the Emergency Broadcast System should be invoked. In 1997, the 24" 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 (pers. comm. with Wes Bressler, 1999).

- **Expected shortfalls of 25 percent** of the anticipated water supply or less can be handled by public notification and a request for ***voluntary*** cooperation or compliance.

- **Greater than 25 percent** shortfalls of anticipated water supply would likely require ***mandatory*** controls to insure minimum delivery to 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 next phase of City's current water plan based upon projected duration of event.

Potential Scenarios

The following three scenarios 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.

Scenario #1 – Contamination of the Laramie River upstream of the Water Treatment Plant

- Potential loss of the Water Treatment Plant.

Winter average, supply reduced to 6.2 mgd:

Average Day Demand (5.5 mgd): Supply is adequate.

Contingency Plan Elements: No implementation of contingency plan needed.

Winter peak, supply reduced to 13.4 mgd:

Peak 7-Day Demand (7.4 mgd): Supply is adequate.

Contingency Plan Elements: No implementation of contingency plan needed.

Summer average, supply reduced to 6.2 mgd:

Average Day Demand (12.6 mgd): Supply is 6.4 mgd short.

Contingency Plan Elements: 1b, 3, 4, 5, 6

Summer peak, supply reduced to 13.4 mgd:

Peak 7-day demand (16.8 mgd): Supply is 3.4 mgd short.

Contingency Plan Elements: 1a, 3, 4, 5, 6

Scenario #2 – Spill occurs on I-80 in Telephone Canyon

- Potential loss of the Turner Wellfield.
- Mitigation would probably allow the continued use of Soldier Springs.
- Severity of this scenario is dependent on spill location (e.g., if the spill occurred in the primary aquifer protection area).

Winter average, supply reduced to 7.0 mgd:

Average Day Demand (5.5 mgd): Supply is adequate.

Contingency Plan Elements: No implementation of contingency plan needed.

Winter peak, supply reduced to 16.2 mgd:

Peak 7-day demand (7.4 mgd): Supply is adequate.

Contingency Plan Elements: No implementation of contingency plan needed.

Summer average, supply reduced to 11.3 mgd:

Average Day Demand (12.6 mgd): Supply is short 1.3 mgd.

Contingency Plan Elements: 1a, 2, 3

Summer peak, supply reduced to 16.9 mgd:

Peak 7-Day Demand (16.8 mgd): Supply is adequate.

Contingency Plan Elements: No implementation of contingency plan needed.

Scenario #3 – Spill occurs south of town on the UPRR

- Loss of Pope Springs Wellfield and Soldier Springs Wellfield.
- Mitigation might stop migration of contaminants to Soldier Springs Wellfield.
- Loss of Turner Wellfield is highly unlikely.

Winter average, supply reduced to 6.2 mgd:

Average Day Demand (5.5 mgd): Supply is adequate.

Contingency Plan Elements: No implementation of contingency plan needed.

Winter peak, supply reduced to 14.8 mgd:

Peak 7-Day Demand (7.4 mgd): Supply is adequate.

Contingency Plan Elements: No implementation of contingency plan needed.

Summer average, supply is reduced to 10.5 mgd:

Average Day Demand (12.6 mgd): Supply is short 2.1 mgd.

Contingency Plan Elements: 1a, 2, 3

Summer peak, supply is reduced to 15.5 mgd:

Peak 7-Day Demand (16.8 mgd): Supply is short 1.3 mgd.

Contingency Plan Elements: 1a, 2, 3, 4, 5, 6

[redacted]

Contaminant Spill Scenarios and Contingency Plan

Two principal transportation corridors, Interstate 80 (I-80) and the Union Pacific Railroad (UPRR), transect the Laramie Regional Drinking Water Protection Area. Transport of potentially hazardous substances along these two corridors indicates the highest probability and highest severity of damage to Laramie's groundwater supply, the Casper aquifer. The interstate highway passes directly over the most susceptible area of the aquifer just southeast of the Grand Avenue exit. It is recommended that future staged mock disasters will be the best way to evaluate and refine the following plan outline.

Plan

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 most susceptible area of the aquifer, 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. The possibility of containment of the spill using earthen dams, or isolation of the contaminant material on the highway and railroad culvert systems will be assessed and assistance requested from the Wyoming Transportation Department and UPRR to proceed with these maneuvers.

5. Once an initial assessment of the emergency is obtained, if necessary, directives to a designated contractor to proceed with further mitigation or decontamination should be ordered by the County Emergency Management Coordinator.

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 stepped-up groundwater source and distribution system testing should be assessed in consultation with the Environmental Advisory Committee, the Director of Public Works, elected and appointed city and county officials, state and federal environmental agencies, and implemented if necessary.

Preventative measures prior to such an emergency can include construction of a containment dam at the end of Telephone Canyon and above the most vulnerable area of the Casper aquifer. Additionally, temporary wells could be drilled at select locations along I-80 and the railroad, which could be pumped in the event of a spill to create a cone of depression in the vicinity of the spill.

This would help to prevent migration of contaminants toward source wells. Locations and details of the containment dam and wells should be defined prior to an emergency event.

Sources of Funds and Disaster Relief

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.

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	766-6184	766-4240
KQ102		
KRQU	745-7397	745-7396
Bresnan Cable		745-7333

Emergency Notification Roster

Position/Agency	Contact/Name	Roles	Work Phone	Home Phone
Wyoming Office of Homeland Security		Respond/Guidance	777-4663	
Federal Bureau of Investigation	Melinda Casey	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 Response Branch One Denver Place 999 18th Street, Suite 500 Denver, CO 80202		Respond/ Guidance	(303) 564-1788	
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	Bob Juve	Guidance	721-5273	742-3155
Public Works Director	Terry Haugen	Guidance	721-5241 Direct 721-5230 Ad. Assit	721-2974
Utility Manager	Bruce Jones	Respond/Guidance	721-5280	745-5696
Water Utility pager person			745-1821	
Chief of Police		Guidance	721-5343	
Wyoming Highway Patrol	Dispatch Lt. M.L. Johnson	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	Pat Gabriel	Guidance	766-4240	745-7112
City Manager		Guidance	721-5289 (direct) 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 KQ 102 Branding Iron Bresnan Cable KIMX	D. Thomsen/T Chesnut Bob Beck		742-2176 745-4888 766-4240 745-7396 766-3856 745-7333 745-5208	
EAC Technical Committee	Ben Jordan Joel Farber	Guidance	745-6118 755-5898	721-8821 721-5917 761-2889 (cell)
City/County Emergency Mgmt	Erin Denson	Respond	721-5314	755-0164 399-3764(cell)

Appendix

A

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

B

Delineation Report Version 1.0

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)

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

Paul G. Etchepare, Jr. (Warren Livestock)

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

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

Todd Jarvis, P.G. (Weston Engineering, Inc.)

Ben Jordan (Weston Engineering, Inc.)

Chris Moody, P.G. (Western Water Consultants, Inc.)

Dr. Lisa Stillings, P.G. (U.S. Geological Survey)

Todd Jarvis is the liaison to The Environmental Advisory Committee.

Keith E. Clarey, P.G.

PROFESSIONAL GEOLOGIST
KEITH E. CLAREY
PG-2819
07-01-99
WYOMING

Dr. Thomas V. Edgar, P.E.

Professional Engineer (Civil)
Thomas V. Edgar
4783
Date 7/8/99
WYOMING

J. Joel Farber, P.G. & P.E.

PROFESSIONAL GEOLOGIST
JOHN JOEL FARBER
PG 1462
WYOMING

Professional Engineer (Civil)
JOHN J. FARBER
#6596
Date 7-8-99
WYOMING

Dr. Peter Huntoon, P.G.

PROFESSIONAL GEOLOGIST
PETER W. HUNTOON
PG-0028
WYOMING

Todd Jarvis, P.G.

PROFESSIONAL GEOLOGIST
W. TODD JARVIS
PG-0025
7/1/99
WYOMING

Chris Moody, P.G.

PROFESSIONAL GEOLOGIST
CHRISTOPHER G. MOODY
PG-1038
7/1/99
WYOMING

Dr. Lisa Stillings, P.G.

PROFESSIONAL GEOLOGIST
LISA L. STILLINGS
PG-2926
7-25-99
WYOMING

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)

_____

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

_____

Paul G. Etchepare, Jr. (Warren Livestock)

_____

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

_____

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

_____

Todd Jarvis, P.G. (Weston Engineering, Inc.)

_____

Ben Jordan (Weston Engineering, Inc.)

_____

Chris Moody, P.G. (Western Water Consultants, Inc.)

_____

Dr. Lisa Stillings, P.G. (U.S. Geological Survey)

_____

Todd Jarvis is the liaison to The Environmental Advisory Committee.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Drinking Water Protection Programs
1.1.1 A National Perspective
1.1.2 A Regional Perspective
1.1.3 A Local Perspective
1.2 History of the Laramie Drinking Water Protection Program
1.3 Wellhead Protection Versus Aquifer Protection
1.3.1 Wellhead Protection Areas
1.3.2 Aquifer Protection Areas

2.0 GEOLOGY AND HYDROGEOLOGY OF THE CASPER AQUIFER

2.1 Geology and Geologic History
2.2 Hydrogeology
2.2.1 Hydrogeology of the Sherman Granite
2.2.2 Hydrogeology of the Satanka Shale
2.2.3 Hydrogeology of the Casper Aquifer

3.0 PHYSICAL CHARACTERISTICS OF THE CASPER AQUIFER

3.1 Groundwater Flow Patterns
3.2 Permeability Characteristics
3.3 Recharge Area
3.3.1 Tritium Data

4.0 DELINEATION METHODS

5.0 DELINEATION PROCESS

5.1 Fundamental Assumptions
5.2 Delineation of Eastern Boundary
5.2.1 Geologic Considerations
5.2.2 Hydrogeologic Considerations
5.3 Delineation of the Western Boundary
5.3.1 Geologic Considerations
5.3.2 Hydrogeologic Considerations
5.4 Delineation of the Primary and Secondary Aquifer Protection Areas
5.5 North and South Boundaries of the Aquifer Protection Area

6.0 AQUIFER PROTECTION MAP

7.0 DATA SHORTFALLS AND FUTURE RECOMMENDATIONS

7.1 Limitations of the Delineation
7.2 Site Specific Modifications to the Delineation
7.3 Revising and Updating the Plan
7.4 Special Areas of Consideration
7.4.1 Transportation Corridors
7.4.2 The Existing Wellfields
7.5 Potential Contamination from Current Landholders in the Aquifer Protection Zones
7.6 Projected Land Uses

8.0 REFERENCES

9.0 GLOSSARY

PLATE I Casper Aquifer Protection Areas Delineated on Geologic Map (Lundy, 1978)

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.

2.2.1 Hydrogeology 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.

8.0 REFERENCES

City of Laramie, Wyoming, 1996, Draft Ordinance to create Division IV (Wellhead Protection Program) of Title 17 and Section 17.09.040(8) of the Laramie Municipal Code: On file at City of Laramie Planning Office.

Environmental Protection Agency (EPA), 1997, State Source Water Assessment and Protection Programs Guidance - Final Guidance: Office of Water, EPA 816-R-97-009.

Frost, C.D., and Toner, R. N., 1996. Tritium and Strontium analyses of Casper aquifer waters in the Laramie area. Report to the City of Laramie.

Huntoon, P.W., 1976. Hydrogeologic properties of the Casper Formation in the vicinity of Laramie, WY. In: Davis, ed., Report on the availability of groundwater for municipal use, Laramie, WY: Report to Laramie City Council, 32pp. and appendices.

Huntoon, P.W., and Lundy D.A., 1979. Fracture-controlled ground-water circulation and well siting in the vicinity of Laramie, WY. *Ground Water*, v. 17, pp. 463-469.

Huntoon, P.W., 1996, Letter to K. Frederick (Wyoming Dept. of Environmental Quality) regarding the Laramie Wellhead Protection Plan: On file at City of Laramie Planning Office, 2 pp.

James M. Montgomery Consulting Engineers, Inc. (JMM), 1989, Centennial Water Supply Project Report. Consultant's report prepared for the Wyoming Water Development Commission and the Centennial Sewer and Water District, 61 pp.

Lundy, Don A., 1978, Hydrology and geochemistry of the Casper aquifer in the vicinity of Laramie, Albany County, Wyoming: University of Wyoming Master of Science Thesis, 76 p.

Morgan, A.M., 1947. Geology and groundwater in the Laramie area, Albany County, WY. U.S. Geological Survey, open-file report, 41 pp.

Thompson, K.S., 1979, Prediction of water level declines in the Casper aquifer in the vicinity of Laramie, WY. University of Wyoming Master of Science Thesis, 74p.

Western Water Consultants, Inc. (WWC), 1993, Wellhead Protection Area Delineation for Turner Well Field, Pope Well Field Soldier Spring, and Simpson Springs: Consultant's report prepared for the City of Laramie, 60 pp.

Western Water Consultants, Inc. (WWC), 1994, Turner Tract Assessment, Laramie, Wyoming: Consultant's report prepared for the City of Laramie, 43 pp.

Western Water Consultants, Inc. (WWC), 1996. Evaluation of the 1941 Turner No. 2 well to supplement Turner wellfield production with implications for future operation and development of the Turner wellfield: Consultant’s Report to the Wyoming Water Development Commission.

Western Water Consultants, Inc. (WWC), 1997a. Hydrogeologic investigation of LaPrele Park prospect. Consultant’s report to the Wyoming Water Development Commission.

Western Water Consultants, Inc. (WWC), 1997b. Volume I: Testing and evaluation of production test wells, Spur wellfield project - Phase I. Consultant’s report to the City of Laramie.

Weston Engineering, Inc. (Weston), 1995, Revised Report on Results of Honken Veterinary Clinic Well Drilling Program: Consultant's report prepared for Coffey and Associates, L.L.C., 6 pp.

Witten, J. and Horsley, S., 1995, A Guide to Wellhead Protection, American Planning Advisory Service Report No. 457/458, American Planning Association, Chicago, Illinois, 102 pp.

Wyoming Department of Environmental Quality, Water Quality Division, 1997, Wyoming's Wellhead Protection Program Guidance Document, Version 3.

Wyoming Department of Environmental Quality, Water Quality Division, 1998, Wyoming's Subdivision Program Guidance Document, Version 2.0.

Appendix

C

Contaminant Source Identification Forms, Source Inventory List and Form IV

Contaminant Source Inventory-Completed September 2000

Nature of Site	Site Address	Source #	Potential Source	Delineation Zone	Priority*
Residential Areas/ City Springs	T15N, R73W: Sec 1, S2 &Sec 1 S2 NW4 (Sherman Hills, Imperial Heights, Laramie Plains); Sec 12 (Country Meadows, Sundial Acres, Valley View)	1	Septic systems, residential wells,	Zones 2, 3	High
Residential Areas/ Pope Wellfield	T15N, R73W: Sec 14 SE4; Sec 13; Sec 23 E; Sec 24	2	Septic systems, residential wells,	Zones 2, 3	High
Residential Areas/ Soldier Springs	T15N, R73W: Sec 23 E2; Sec 26 E2; Sec 25; Sec 24, Sec 35; Sec 36	3	Septic systems, residential wells,	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	4	Hazardous waste spill	Zones 2, 3	High
Springs near Turner Wellfield (one is 20ft north of Grand Ave)	T16N, R73W: Sec 35 S2	5	Conduit for contaminants	Zone 1	High
Springs near Pope Wellfield	T15N, R73W: Sec 14 E2; maybe Sec 13	6	Conduit for contaminants	Zone 1	High
Springs near Soldier Well	T15N, R73W: Sec 23 S2; Sec 26 N2; Sec 24 W2;	7	Conduit for contaminants	Zones 1, 2, 3	High
Wells (municipal, monitor, abandoned, test, domestic)	Refer to Figure 4.5a and 4.5b	8	Conduit to groundwater for whatever is floating, suspended, or dissolved, in surface water	Zones 1, 2, 3	High
Union Pacific Railroad	T15N, R73W: Sec 26 SW4, SW4; Sec 35 W2; T14N, R73W: Sec 2 W2; Sec 11 W2	9	Derailment and hazardous waste spill	Zones 2, 3	Medium
Quarries (ABA and Active)	Refer to Figure 4.2a and 4.2b	10	Quarry activities (refueling spills, residue from blasting compounds-diesel fuel and ammonium nitrate)	Zones 2, 3	Medium

*Priority quantitatively determined based on distance from wellfields and groundwater flow considerations.

Nature of Site	Site Address	Source #	Potential Source	Delineation Zone	Priority*
Unregulated Landfills/ Dumps	Near Soldier and Pope Wellfields	11	Wide range of potential contaminants	Zone 2, 3	Medium
Car Dealerships	T16N, R73W: Sec 35 S2	12	Detail Shop, Automotive wastes	Zone 1	Medium
Rifle Range	T16N, R73W: Sec 12 N2	13	Lead bullets	Zone 2, 3	Low
Municipal Sewer Lines	T15N, R73W: Sec 1	14	Nitrates, fecal coliform	Zone 2	Low
Urban run-off/ Super Walmart & Gem City Bone & Joint	T16N, R73W: Sec 35 SW4, SE4	15	Oils, antifreeze, urban run-off	Zone 2	Low
Mosquito Spraying		16	Malathion @ 3 ounces/acre	Zone 2, 3	Low
Gas Station	T15N, R73W: Sec 1 SW4, NE4	17	UST-potentially less than 30 ft of Satanka Shale overlying the Casper Formation at this location	Zone 2	Low
Gas Pipelines	Refer to Figure 4-2a	18	Fossil fuels by Simpson Springs	Zone 2, 3	Low
Road Salt	Grand Avenue, I-80 Telephone Canyon	19	Increase salinity	Zone 2, 3	Low
KN Energy Pipelines	Refer to Figure 4-2b	20	Possible leaks and pipe corrosion	Zone 2	Low
AST (Above Ground Storage Tanks) Sites	T15N, R72W: Sec 30 NW4	21	5,000 gallon fuel tank	Zone 3	Low

* Priority qualitatively determined based on distance from wellheads and groundwater flow direction considerations.

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	All 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) Above ground storage tank	0078	1	5,000 gallon fuel storage tank and potential fuel spills	Medium
2) Surface mining operations	0101	4	further faulting, fracturing of karst aquifer	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	Low
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 1
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Car Dealership
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	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner, Pope and Soldier Wellfields
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Gas Pipelines
Site Location	T16N, R73W; T15N, R73W
Nature of Property	Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Pipelines	0105	1	natural gas pipeline	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
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 - potentially less than 30 feet of Satanka Shale overlying the Casper Formation at this location	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Soldier Wellfield
WHPA Zone #	Zone 3
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Aboveground Storage Tank
Site Location	T15N, R72W
Nature of Property	Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Aboveground storage tank	0078	1	5,000 gallon fuel tank	Low

Form IV:

Potential and Known Source Hazard, Controls, Assessment and Management

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
Priority Rank: High
Potential Source Type: Septic systems and residential wells, Turner Wellfield and City Springs
Implementation Date: 2004
Strategy: Groundwater monitoring program, overlay zoning, licensing of contractors, sunset on development of conventional on-site septic systems

Potential Source #: 2
Priority Rank: High
Potential Source Type: Septic systems and residential wells, Pope Wellfield
Implementation Date: 2004
Strategy: Groundwater monitoring program, overlay zoning, licensing of contractors, sunset on development of conventional on-site septic systems

Potential Source #: 3
Priority Rank: High
Potential Source Type: Septic systems and residential wells, Soldier Well
Implementation Date: 2004
Strategy: Groundwater monitoring program, overlay zoning, licensing of contractors, sunset on development of conventional on-site septic systems

Potential Source #: 4
Priority Rank: High
Potential Source Type: I-80 hazardous waste spill
Implementation Date: 2004
Strategy: Mitigation study

Potential Source #: 5
Priority Rank: High
Potential Source Type: Springs near Turner Wellfield, conduit for contaminants
Implementation Date: 2004
Strategy: Groundwater monitoring program, overlay zoning, MOU/MOA

Potential Source #: 6
Priority Rank: High
Potential Source Type: Springs near Pope Wellfield, conduit for contaminants
Implementation Date: 2004
Strategy: Groundwater monitoring program, overlay zoning, MOU/MOA

Potential Source #: 7
Priority Rank: High
Potential Source Type: Springs near Soldier Well, conduit for contaminants
Implementation Date: 2004
Strategy: Groundwater monitoring program, overlay zoning, MOU/MOA

Potential Source #: 8
Priority Rank: High
Potential Source Type: Conduit to groundwater for whatever is floating, suspended, or dissolved, in surface water
Implementation Date: 2002
Strategy: Public outreach and education, well sealing & abandonment

Potential Source #: 9
Priority Rank: Medium
Potential Source Type: Derailment and hazardous waste spill
Implementation Date: 2003
Strategy: MOU/MOA with UPRR

Potential Source #: 10
Priority Rank: Medium
Potential Source Type: Quarry activities(refueling spills, residue from blasting compounds-diesel fuel and ammonium nitrate)
Implementation Date: 2003
Strategy: MOU/MOA with Mountain Cement Company

Potential Source #: 11
Priority Rank: Medium
Potential Source Type: Unregulated landfills/ dumps, wide range of potential contaminants
Implementation Date: 2004
Strategy: Overlay zoning

Potential Source #: 12
Priority Rank: Medium
Potential Source Type: Detail shop, automative wastes
Implementation Date: 2004
Strategy: Overlay zoning

Potential Source #: 13
Priority Rank: Low
Potential Source Type: Laramie Rifle Range, lead contaminants
Implementation Date: 2004
Strategy: MOU/MOA with Laramie Rifle Range

Potential Source #: 14
Priority Rank: Low
Potential Source Type: Municipal Sewer, nitrates, fecal coliform
Implementation Date: 2004
Strategy: Overlay zoning, design standards

Potential Source #: 15
Priority Rank: Low
Potential Source Type: Oils, antifreeze, urban run-off
Implementation Date: 2004
Strategy: Overlay zoning, design standards

Potential Source #: **16**
Priority Rank: Low
Potential Source Type: Malathion @ 3 ounces/acre
Implementation Date: 2004
Strategy: Overlay zoning, BMP

Potential Source #: **17**
Priority Rank: Low
Potential Source Type: Existing Gas Station UST-potentially less than 30 ft of Satanka Shale overlying the Casper Formation at this location
Implementation Date: 2004
Strategy: Overlay zoning (no UST's in protection area), BMP for existing site

Potential Source #: **18**
Priority Rank: Low
Potential Source Type: Gas pipeline, fossil fuels by Simpson Springs
Implementation Date: 2004
Strategy: Overlay zoning, BMP

Potential Source #: **19**
Priority Rank: Low
Potential Source Type: Road salt, increase salinity
Implementation Date: 2004
Strategy: Overlay zoning, BMP

Potential Source #: **20**
Priority Rank: Low
Potential Source Type: Natural gas pipelines
Implementation Date: 2004
Strategy: Overlay zoning, BMP

Potential Source #: **21**
Priority Rank: Low
Potential Source Type: AST sites, 5,000 gallon fuel tank
Implementation Date: 2004
Strategy: Overlay zoning, BMP

Appendix

D

Best Management Practices for Single-Family Residences

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 clean up 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

E

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

F

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.*Pi)

F.S= factor of safety
Q= well discharge from average home (gallons/yr)
T= time of travel (yrs)
Por.= Porosity of Aquifer (gallons/ft^3)
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 Q_{leach} (gallons/day)

Q_{leach}= 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 C_r (mg/L)

$$C_r=(Q_{septic}*C_{septic}+ Q_{leach}*C_{leach})/(Q_{septic}+ Q_{leach})$$

Q_{septic}= septic tank discharge (gallons/day)
C_{septic}= septic tank leachate nitrate concentration (mg/L)
Q_{leach}= leach field flux from Eq. 2 (gallons/day)
C_{leach}= 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 C_p (mg/L)

$$C_p=(Q_{leach}*C_r+Q_{well}*C_{well})/ (Q_{leach}+ Q_{well})$$

Q_{leach}= already calculated
C_r= already calculated
Q_{wel}=porosity*Pi*wellscreen*CFR^2/T*365*7.48 (gallons/day)
C_{wel}=ambient nitrate concentration in groundwater samples from area (mg/L)

The concentration of diluted nitrates within the well's zone of contribution is then, C_p. This number is then compared to the EPA designated maximum level of contamination, 10 mg/L. The C_p 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 V_i (gallons/day)

$$V_i=L*W*I*7.48$$

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 V_s (gallons/day)

$$V_s = lots*Q_{septic}$$

Lots= number of lots aligned in down-gradient flow
Q_{septic}=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 V_b (gallons/day)

$$V_b = K*i*A*7.48$$

All taken from previous equations.

The fourth step is to calculate any ground water pumped from wells located within the same aquifer, or V_p 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 C_o (mg/L)

$$C_o = (V_i*C_i + V_b*C_b - V_p*C_p)/(V_i + V_s + V_b - V_p)$$

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 Santanka 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 (Q_{septic}):	300 gal/day	(DEQ)
Leachate Nitrate Concentration (C_{septic}):	40 mg/L	(DEQ)
Ambient Nitrate Concentration (C_{leach}):	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 (C_p)	Nitrate Loading at Down Gradient Subdivision Boundary (C_o)
0.1 ft/day	160 ft	4.0 mg/L	**29.7 mg/L**
0.1 ft/day	350 ft	4.7 mg/L	**27.8 mg/L**
1 ft/day	160 ft	4.4 mg/L	**19.8 mg/L**
1 ft/day	350 ft	3.6 mg/L	**14.0 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

G

Underground Storage Tank Ordinance (8.60)

Chapter 8.60 Underground Storage Tanks

8.60.010 Preamble--Emergency declared.

A. The city council finds that there is an emergency requiring the immediate enactment of the ordinance codified in this chapter to preserve public health and safety, due to

1. The possibility of contamination of a significant portion of Laramie's municipal water supply if underground petroleum storage tanks are installed without adequate design and construction standards within the five-year time of travel area surrounding the Turner wellfield; and

2. The ability of the Wyoming Department of Environmental Quality to refuse to permit modifications to the Turner wellfield if there is an existing or potential risk of pollution entering the Turner wells.

B. For the reasons stated in Section 8.60.020 of this chapter, the city council finds an emergency concerning the public health and safety. By a three-fourths vote of its qualified members, the city council has suspended the requirements of §15-1-15(c), W.S. 1977 as amended, and the corresponding provisions of this code. (Ord. 1158 § 1, 1995).

8.60.020 Legislative findings.

A. The city obtains approximately sixty-eight percent of its municipal water from a single underground water source, the Casper formation. During the cold months, all of the city's municipal water comes from the Casper formation aquifer. If the Casper aquifer were contaminated, Laramie would face a serious municipal water shortage. The Turner wells, which produce up to four million gallons of municipal water per day from the Casper formation, are located adjacent to a developed and developing area along east Grand Avenue in the city.

B. The city commissioned a study by Western Water Consultants, Inc., consulting engineers, to determine how the city could protect the quality of its underground water. As part of the study, WWC produced maps indicating the time of travel of water from locations within the Casper formation to the wells and springs where the city withdraws it.

C. The developed/developing area along East Grand lies entirely within the twenty-year time of travel contour. In some locations, the Casper formation has some protection from contamination by the overlying Satanka formation. In other locations along East Grand, the Casper formation is exposed at the surface. For locations within one-half mile to the west of the Casper/Satanka contact in the vicinity of the Turner wellfield, there are indications that the pressure gradient caused by pumping the Turner wells may cause leakage from the Satanka formation into the Casper formation.

D. The city has a legitimate governmental interest in preventing contamination of its water sources. Any contamination of the aquifer by hazardous materials is unacceptable. To prevent contamination, while respecting the rights of property owners within the area where contaminants which contact the ground could reach the aquifer, the city council authorized its staff to draft a wellhead and aquifer protection ordinance using the recommendations made by Western Water. The vulnerability of the aquifer, the need for such an ordinance, and council's intention to protect the aquifer, have been a matter of public record in Laramie for two years. Staff has considered at least six drafts of the ordinance and is expected to present a final draft to council for consideration in the next ninety days.

E. The city has requested that the Wyoming Department of Environmental Quality provide it with standards for the construction of underground storage tanks installed in such proximity to the city's wells that leakage would cause a serious risk to Laramie's municipal water. The DEQ has provided those standards, which are included in this chapter.

F. The city has in place a program to modify the Turner wellfield in order to make it more productive and to reduce the risk of contamination. The Wyoming Department of Environmental Quality has the authority to refuse to allow modifications to the Turner wellfield (and in fact to require the city to cease using it entirely) if the DEQ finds that there are serious risks to health because of conditions in the area of the wellfield, including but not limited to the presence of underground storage tanks containing hazardous materials. See, e.g., Chapter XII, Sections 6(c)(v)(A)(iii) and 9(b)(B)(i)--(iv) of the Rules of the Wyoming Department of Environmental Quality, Water Quality Division.

G. The conditions for installation of underground storage tanks set forth in this chapter are the least intrusive method of protecting the city's water supply while allowing the reasonable use of private property in the area defined below.

H. In the interest of public health, safety and general welfare, the city council intends this chapter to protect a portion of the Casper aquifer which contributes underground water to the city's municipal water system, and to mitigate potential adverse effects upon the aquifer. Council intends to protect human life and health; minimize expenditure of public money for costly pollution remediation; minimize business interruptions; and to insure that the public is provided with a safe potable water supply now and for future generations.

I. An application to the city for a building permit to construct a convenience store with associated underground gasoline storage tanks within the five-year time of travel contour for the Turner wellfield, on property within two hundred eighty feet of the city's low-level water reservoirs, has created an emergency. The Department of Environmental Quality states that it cannot enforce standards which will adequately protect the wellfield. The city must have standards in place which will reasonably protect the wellfield. (Ord. 1158 § 2, 1995).

8.60.030 Definitions.

A. Hazardous Substance(s). Hazardous substance(s) includes any material, either singularly or in combination, which may pose a present or potential hazard to human health or to the quality of Laramie's municipal water supply if introduced into the Casper formation aquifer; including without limitation those materials identified as hazardous waste in 40 CFR 261 or defined as a hazardous substance in 40 CFR 302; any hazardous substance designated pursuant to Section 311(b)(2)(A) of the federal Clean Water Act; any element, compound, mixture, solution or substance designated pursuant to Section 102 of CERCLA; any hazardous waste regulated under the federal Resource Conservation and Recovery Act; any toxic pollutant listed under Section 307(a) of the Clean Water Act; any hazardous air pollutant designated under Section 112 of the Clean Air Act; any imminently hazardous chemical substance or mixture under Section 7 of the federal Toxic Substances Control Act; and any materials added to those laws, regulations, definitions or lists at any later time, and any amendments to or substitutions for those lists. Hazardous substances include all petroleum products and byproducts, including crude oil or any fraction thereof such as gasoline, diesel, and waste oil, and whether derived from oil or coal, which is liquid at standard conditions of temperature and pressure (sixty degrees Fahrenheit and 14.7 pounds per square inch absolute); include all radioactive substances, include all infectious materials and include all pollutants as defined below.

B. Pollutant. Pollutant means an organic substance, an inorganic substance, a combination of organic and inorganic substances, or a pathogenic organism that, after discharge and upon exposure, ingestion, inhalation or assimilation into an organism either directly from the environment or indirectly by ingestion through the food chain, could, on the basis of information available to the administrator of EPA, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunction in reproduction), or physical deformations in either organisms or offspring of the organisms.

C. Time of Travel Contour. Time of travel contour means the contour line shown upon Plate 3-2 of the November 19, 1993 report "Wellhead Protection Area Delineation for Turner Well Field, Pope Well Field, Soldier Spring, and Simpson Springs" prepared by Western Water Consultants, Inc. for the city, showing the amount of time it takes ground water to travel from a recharge point on the land surface to wells, expressed in years. Copies of the pertinent portion of Plate 3-2 are on file in the office of the city planner. (Ord. 1158 § 3, 1995).

8.60.040 Area where ordinance applies.

This chapter applies to all land within the city limits which is within the five-year time of travel contour for the Turner wellfield. (Ord. 1158 § 4, 1995).

8.60.050 Underground storage tank installation prohibited--Exception.

No person shall install (either as new construction or as a replacement for an existing underground storage tank) any underground tank for the storage of hazardous substance(s) or pollutant(s) within the area defined in Section 8.60.040 except as is allowed under Section 8.60.060 of this chapter. (Ord. 1158 § 5, 1995).

8.60.060 Standards for installation of underground storage tanks.

Within the area where this chapter applies:

A. Except as superseded by specific requirements in this chapter, all requirements of regulatory agencies having jurisdiction over the design, construction and operation of underground storage tanks shall be followed.

B. All underground storage tanks shall be double-walled and made of fiberglass-reinforced materials and shall be provided with interstitial monitoring (nonbrine type). The tanks must be designed, constructed and installed to:

1. Contain a release from any portion of the inner tank within the outer wall;
2. Detect the failure of the inner wall.

C. All piping connected to underground storage tanks, if it routinely contains hazardous substances, and is in contact with the ground, shall be fiberglass-reinforced plastic piping. Metallic fittings, if used, shall be cathodically protected and monitored, following the recommendations of a qualified corrosion engineer.

D. All transfer of liquid hazardous substances from underground storage tanks shall be by suction piping which is designed and constructed to meet these standards:

1. The below-grade piping operates at less than atmospheric pressure;
2. The below-grade piping is sloped so that the contents of the pipe will drain back into the storage tank if the suction is released;
3. Only one check valve is included in each suction line;
4. The check valve is located directly below and as close as practical to the suction pump;
5. A method is provided that allows compliance with this subsection to be readily determined in the field; and
6. Underground piping must be equipped with secondary containment which will contain the capacity of the piping, preventing vertical and horizontal migration of hazardous substances, and must be checked for evidence of a release at least every thirty days.

E. Each underground storage tank (or battery of tanks) shall be provided with secondary containment as provided in this subsection.

1. A secondary barrier shall be installed around and beneath the tank, consisting of artificially constructed material that is sufficiently thick and impermeable (at least 10^{-6} cm/sec for the substance stored), constructed to direct a release to the monitoring point and permit its detection.
2. The barrier shall be compatible with the substance stored so that a release will not cause a deterioration of the barrier allowing a release to pass through undetected.
3. The groundwater, soil moisture, or rainfall will not render the testing or sampling method used inoperative so that a release could go undetected for more than thirty days.
4. If the secondary barrier is not always above the groundwater, or is in a twenty-five-year floodplain, then it shall be designed for use under such conditions.
5. Secondary containment must be designed, constructed and installed to contain the stored substances if released from the tank system until they are detected and removed, and prevent the release of regulated substances to the environment at any time during the operational life of the underground storage tank system.
6. Secondary containment shall be checked for evidence of a release at least every thirty days. External liners must be designed, constructed and installed to contain one hundred percent of the capacity of the largest tank within its boundary, prevent the interference of precipitation or groundwater intrusion with the ability to contain or detect a release of the stored substances, and surround the tank completely (be capable of preventing horizontal and vertical migration of the stored substance).

F. Each installation of underground storage tanks shall be served by at least one monitoring well, installed in a location and constructed to standards approved by the city engineer. The location shall be selected so as to enable the detection of contamination in time to recover released hazardous substances before they contaminate the city's groundwater supply. (Ord. 1158 § 6, 1995).

Appendix

H

Commercial and Industrial Land Uses that Generate Hazardous Waste

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.

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 (1721) = painting, paper hanging, decorating (1742) = plastering, drywall, acoustical insulation (1751) = carpentry (1752) = flooring (1761) = roofing and sheet metal (1795) = wrecking and demolition (1799) = other special construction trades	(1711) - solvents, asbestos, miscellaneous (empty containers, etc.) (1721) - paints, solvents, glues, miscellaneous 1742) - solvents, adhesives, miscellaneous (waste insulation) (1751) - solvents, lacquers (1752) - paint, glues, miscellaneous (1761) - tars, sealants, miscellaneous (1795) - asbestos, miscellaneous chemicals, miscellaneous (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.

Appendix

J

Aquifer Protection Ordinances

ORIGINAL ORDINANCE NO. 1608 INTRODUCED BY: Reisenburg

ENROLLED ORDINANCE NO. 1404

AN ORDINANCE TO CREATE AN AQUIFER PROTECTION OVERLAY ZONE

Section 1. Legislative Findings. Approximately 60% of the City's municipal water supply 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:

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

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

C. Interstate Highway 80 cuts through the entire thickness of the Casper Formation. Numerous hazardous substances are transported each day over I-80.

D. 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's municipal water, the City Council adopts this ordinance.

Section 2. Aquifer Protection Overlay Zone Established.

A. There is established within the City of Laramie an aquifer protection overlay zone (APO zone). The APO zone is effective within the city 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.

B. Copies of the illustrations which accompany the EAC Casper Aquifer Protection Plan shall be kept in appropriate City offices and shall be used to determine the boundaries of the APO zone. All property east of the western boundary of Zone 2 and west of the easternmost outcrop of the Casper Formation along the crest of the Laramie Range as shown upon the Plan's illustrations is zoned APO by default. Upon annexation of any property within the defined area, the annexed property is zoned APO whether another zoning classification is immediately established or not. Property west of the western boundary of Zone 2 shall be included in the APO zone if in the opinion of the city engineer based upon geologic evidence there is less than 75 feet of Satanka Formation overlying the Casper Formation at that location.

C. 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 appropriate City employees 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 City may submit the evidence to qualified professionals for analysis, and may obtain independent evidence bearing upon the question.

D. Any person aggrieved in fact by an administrative decision under this section may appeal the decision to the Zoning Board of Adjustment.

Section 3. Allowed and Prohibited Uses.

A. 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.

B. For the purposes of this ordinance, "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; (iii) any pesticide as defined in Wyoming law; or (iv) any oil or petroleum.

C. 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	Column 2 Examples
The following activities are prohibited in the APO zone:	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 reconstituted wood, which involves the use, storage or disposal of any hazardous material.	Manufacturer of wood veneer, plywood, or reconstituted wood products.
31. Injection wells	
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. Septic tanks and below-ground waste storage tanks. See below on pre-existing septic tanks.	Residential and business uses.
34. 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..	
35. Application of fertilizer at greater than the agronomic uptake rate of the vegetation fertilized.	
36. Quarrying and sand and gravel mining.	

Section 4. Setbacks from vulnerable features.

A. Vulnerable features in the Casper Formation are:

1. 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.

2. Folds which extend to the ground surface.

3. Exposed bedrock.

4. Bedrock not overlain by a sufficient thickness of low-permeability materials to prevent the effective downward migration of contaminants into the aquifer.

5. Defined drainages.

6. 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.

B. No person shall install, maintain, or use any on-site wastewater treatment system or wastewater storage system or any private sewer system not connected to a public wastewater system within 100 feet of a vulnerable feature in the Casper Formation.

C. Within the APO, no building permit shall be issued for any wastewater system until the applicant demonstrates to the Building Official 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 Building Official 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 Building Official's decision to the Zoning Board of Adjustment.

Section 5. Design standards for on-site wastewater treatment systems.

A. 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 ordinance does not grant the right to install a septic system or small wastewater treatment system otherwise forbidden by the Laramie Municipal code. A septic system on property annexed to the City after the effective date of this ordinance must be replaced by a connection to the Publicly Owned Treatment Works or, if no connection is available at the time of annexation, brought into compliance with subsection B below within one year of annexation and must comply with Section 6 of this ordinance.

B. 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

1. During installation before and during backfilling;
2. Any time the ownership of the property is transferred; and

3. Upon annexation and at least once each three years thereafter.

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.

C. Upon initial installation of a new system, or upon allowed replacement of any failed septic system, a two-tank or two-piece compartment system is required.

Section 6. Sunset date for small wastewater treatment systems.

A. For properties annexed to the City after the effective date of this ordinance and 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 within 100 feet of the property on which the system is located; or

2. One year after the inclusion of the property containing the on-site system in a sewer district connected to the City's sewage treatment system; or

2. Seven years from the effective date of this ordinance.

B. The city council may grant a single extension of up to one additional year beyond the seven year requirement where municipal or district sewer lines to serve the property will be constructed within one year.

Section 7. Pre-existing nonconforming uses.

Pre-existing nonconforming uses within the APO zone are subject to the terms of this ordinance and not to the general ordinances on pre-existing nonconforming uses. Septic systems and other privately–owned wastewater treatment systems are controlled exclusively under Sections 5 and 6 above and are not subject to these provisions on pre-existing nonconforming uses.

A. A pre-existing nonconforming use is a use prohibited by this ordinance 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, the date of annexation of the property into the City, or the date a use becomes nonconforming because of an amendment to this ordinance.

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, best available

control technology shall be in place to prevent contact between hazardous materials and the surface of the ground.

C. A pre-existing nonconforming use may be expanded under these conditions:

1. The expansion does not increase the hazard to the aquifer; or

2. Control technology built in to the expansion will prevent any increased risk to the 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;

d) Initiation at the subject facility or business of an activity that is not a prohibited activity; or

3. As a result of the expansion the risk to the aquifer will be reduced.

D. Every pre-existing nonconforming use shall:

1. Store hazardous material in an enclosed structure or under a roof which minimizes 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 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.

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 a container that has been certified by a state or federal agency or the American Society of Testing and Materials as suitable for the transport or storage of the material.

6. Except items offered for retail sale in their original unopened containers, store all hazardous material in an area secured against entry by the public.

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. 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 Building Official 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 Building Official to make an informed decision under this section. Appeals from the decision of the Building Official under this section shall be taken to the Zoning Board of Adjustment.

Section 8. 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 aquifer. This ordinance does not supersede or modify the requirements of any federal or state law or local ordinance which makes stricter requirements.

Section 9. 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 10. Effective date.

This ordinance is effective upon publication.

Passed and approved this 15th day of October, 2002.

Joe Shumway, Mayor and President
of the City Council

Attest:
Sue Morris-Jones, CMC
City Clerk

Duly published in the Laramie Daily Boomerang on the 22th day of October, 2002.

First Reading: 9/03/2002
Public Hearing: 9/24/2002
Second Reading: 10/01/2002
Third/Final Reading: 10/15/2002

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.

Appendix

I

Susceptibility Assessment

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 41,23',40", 105,32',32" (Survey EPA 1998)	T16N,R73W, S2,NW,NW 41,23',44",105, 33',22" (Survey EPA 1998)	T15N,R73W, S23,SE,SW 41,14',56", 105,32',53" (Survey EPA 1998)	T15N,R73W, S14,NE,SE 41,18',40",105, 31',39" (Survey EPA 1998)	T16N,R73W, S35,SE,SW 41,20',03", 105,31',53" (Survey EPA 1998)	T15N,R73W, S14,NE,SE 41,16',15", 105,31',55" (Survey EPA 1998)	T15N,R73W, S14,NE,SE 41,16',19", 105,31',08" (Survey EPA 1998)	T15N,R73W, S14,NE,SE 41,16',13", 105,31',58" (Survey EPA 1998)	T15N,R74W, S14,NE,SE 41,16',19", 105,31',05" (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 & 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	Enclosed 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"diam.,0.375" 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

J

Aquifer Protection Ordinances

K

Glossary of Wellhead Protection and Hydrogeologic Terms

The purpose of this Glossary is to provide a list of terms 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.

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 the direction of flow.

Anticline: A fold in rock strata that is convex upward.

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 release 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 groundwa0ter 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 hat 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
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
CERCLIS: CERCLA Information System
CFR: Code of Federal Regulations
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
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
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
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: Wellhead Protection Areas
WOC: Water Outreach Coordinator
WQD: Wyoming Quality Division
WRI: Wyoming Research Institute
WWC: Western Water Consultants, Inc.
WYDOT: Wyoming Department of Transportation
ZOC: Zone of Contribution
ZOI: Zone of Influence