TOWN OF BAIROIL
WATER SUPPLY PROJECT
LEVEL II PHASE V REPORT
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LEVEL II PHASE V REPORT

Prepared for:

TOWN OF BAIROIL
P. O Box 58
Bairoil, WY 82602

And:

WYOMING WATER DEVELOPMENT COMMISSION
Herschler Building, 4W
122 West 25th Street
Cheyenne, WY 82002

Prepared by:

Lidstone and Associates, Inc.
4025 Automation Way, Building E
Fort Collins, CO 80525-3448

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1.0 INTRODUCTION

1.1 Authorization

The Town of Bairoil (Town) is located 40 miles north of Rawlins on Highway 73 in Sweetwater County, Wyoming as shown on Figure 1.1. In 1998, the Town of Bairoil submitted an application to the Wyoming Water Development Commission (WWDC) to fund a Level II study for a conceptual design of a long-term, reliable water supply source for the Town. On June 1, 1999, Lidstone and Associates, Inc., (LA) entered into a contract with the WWDC to provide professional services on behalf of the Level II Bairoil Water Supply Project (Project). The purpose of the Project was to conduct a system audit, explore ground water development options, and to make recommendations for the development of an additional long-term reliable water supply source.

1.2 History

The initial phase of the Project included a master plan evaluation of the water supply, transmission, storage and distribution system. After a complete evaluation of the water system (Phases I and II), LA recommended the Town complete a deep Battle Springs well to replace and/or supplement their existing supply. LA proposed a test drilling and geophysical logging program in advance of any production well completion that was specifically targeted to address water quality and water quantity concerns. LA's hydrogeologic investigations found that although the Battle Springs was a relatively prolific aquifer, water quality (in particular, radionuclides) can be problematic in the Battle Springs sands. At the time of their initial investigation, LA anticipated that some of the more prolific sands encountered during the drilling would have to be cemented off to attain acceptable water quality. The Phase II and III test drilling data supported this hypothesis.

During Phase III of the Level II study, LA successfully completed a deep Battle Springs Aquifer well for the Town that had a sustainable yield estimated to be 60 to 70 gpm. The water quality of the new well met EPA requirements. The Town requested Level III funding to bring this new well on-line and to prepare designs and upgrades for the Abel Springs system. In addition to the Level III funding request, the Town of Bairoil requested an extension of the LA Level I effort for the purpose of completing a second supplementary water supply well. LA's production goal for this second well was to achieve the long term municipal demand with a combination of the first and second well. In the absence of any continuous meter records, LA utilized data from a nine month metering effort in 1997 to establish Maximum Daily Demand (MDD). This metering effort found that the MDD during the summer of 1997 was 150,000 gallons or 105 gpm. With this in mind the design goal for the second well was 35 to 45 gpm of high quality water. Total system redundancy was not considered essential since the Town of Bairoil had two other supplementary supply sources: Abel Springs and the Battle Springs Well Field Pipeline.

The Phase IV effort included the completion of a second Battle Springs Well. This second well met the water quality, but did not meet the water quantity goal. The sustainable yield of this second well was estimated at 10 to 20 gpm, depending on how the Town chose to operate the new well. The Town chose not to bring this second well on-line.
Figure 1.1. Bairoil Water Supply
Project Level - Phase V
Location of Project Site
1.3 Purpose

Questions remained as to why the per capita design water demand for the Town was nearly twice the Wyoming statewide average, and whether the current Abel Springs or an Abel Springs design alternative would actually serve as a supplementary water supply. The WWDC and LA recognized that there were very little usage data to document the Town’s needs and that the Abel Springs collection system was poorly understood and documented. To address these questions, the WWDC and the Town chose to extend the Level II study. In May of 2002, the LA contract was amended to include Phase V of the Project. The Phase V work included a system audit of the Town’s Abel Springs water supply, and an evaluation of the Town’s water system for leaks.

The Town has concerns about both the quality and quantity of water provided by Abel Springs. Abel Springs does not provide sufficient water to supply the Town during peak demand periods. During these peak periods, the Abel Springs supply is supplemented with water from several deep Battle Springs wells in the Merit Energy, Inc well field. The Merit Energy wells and transmission line into Town are expensive to operate because of the deep pump settings and long transmission distance. Operational issues associated with the transmission line further compound these problems. The Town does not currently pay for water from these wells, and is concerned that they may not be able to use water from this source indefinitely. In addition, water quality from these wells may exceed EPA standards for radionuclides. Therefore, the Town would like to be independent of the Battle Springs well field, and anticipates that the new well and some second source would permit that independence.

With respect to quality, the Town’s Abel Springs water supply currently meets primary drinking water standards. However, the Environmental Protection Agency (EPA) generally classifies an infiltration gallery as ground water under the direct influence of surface water subject to the requirements of the Surface Water Treatment Rule (SWTR: 40 CFR Part 141, Subpart H). There has been no action taken against the Town to date. However, this could become an issue in the future. If the EPA reclassifies the Abel Springs source or if waterborne pathogens are detected, filtration will be required. The Abel Springs water has also shown elevated iron concentrations. In addition to the anticipated regulatory requirements, the Town is concerned about watershed protection, source contamination in the vicinity of the water source, and livestock grazing in the area.

Gratefully, LA would like to thank Kevin Boyce of the WWDC for his assistance throughout this project, and Tony Rigano of the Town for making maps and plans of the water system available to us and for personally showing us key aspects of the water system. We would also like to express our appreciation to Mayor Sue Rigano, and the Town Council of Bairoil.

1.4 Previous Studies

The Town of Bairoil has contracted several previous studies of water system alternatives. These studies include a 1979 study by Corewood, Inc., of Riverton, Wyoming, a 1982-1983 study and well drilling program by Hydro-Search, Inc., of Denver, Colorado, and the initial phase of the current Project. In addition, several engineering firms have completed system upgrades.
The 1979 Corewood study described the geology and hydrology of Abel Springs, the construction of Abel Creek wells #1 and #2, and the Abel Springs collection system. In addition, it described the water rights for the infiltration gallery. Water samples were collected from the Abel Springs infiltration gallery and the Abel Creek wells and were tested for major ions. These analyses showed no water quality problems (Corewood, 1979).

A ground water exploration project was conducted in 1983 for the WWDC by Hydro-Search, Inc. This project assessed the water usage of Bairoil, reviewed the hydrogeology of the area, and selected primary target aquifers and drill sites for test well installation. The project identified the need for an additional water supply that would produce at least 100 gpm. The Fort Union and Battle Springs Formations were both selected as potentially suitable aquifers for ground water development; however, the Battle Springs Formation was preferred because of its potentially higher yields. A site was selected for the construction of a well screened in the Battle Springs Formation, located approximately one and one half miles west of Abel Springs. A test well was installed in November and December 1984. The well was briefly pump tested and water samples were collected. Unfortunately, the concentrations of tested radionuclides in the water exceeded the water quality standards and the well was abandoned (Hydro-Search, 1983; Hydro-Search, 1984). Finally, the ground water exploration projects, which were completed by Lidstone and Associates for the WWDC and The Town and are documented in the Level II reports. (Lidstone and Associates, Inc., 2000 and Lidstone and Associates, Inc. 2001)

1.5 Summary of Current Project

The WWDC and the Town of Bairoil sponsored the Level II, Phase V investigation to conduct a system audit and Abel Springs evaluation as well as submit a source water assessment application on behalf of the Town. The Phase V Scope of Work included the following:

- Evaluate and document the existing Abel Springs collection and supply;
- Establish and prepare design alternatives to increase the ground water supply at the Abel Springs collection system;
- Collect data to address the Town’s water usage;
- Complete a leak detection survey;
- Predict system upgrades, improvements, and expansions over the next 30 years;
- Assist the Town in the preparation of a Source Water Assessment Plan application.

2.0 SUMMARY OF EXISTING SYSTEM

2.1 General

The Bairoil water system is classified as a community water supply (EPA, 1998) and provides water to a current resident population of 115 via 60 active service connections. It also supplies water to the Bairoil School and several commercial establishments including Merit Energy’s Wertz Unit CO₂ recycling facility. Historically, there have been as many as 80 service connections.
In addition, there are nearly 60,000 linear feet of transmission line; 350,000 gallons of storage in one tank; and 18,000 linear feet of distribution line. An overall layout of the system is presented on Figure 2.1.

The water into each service is unmetered with an initial tap fee of $500 for a residential connection and $750 for a commercial connection. Monthly user fees differ based on user’s age, a flat rate of $17.00 and a discounted rate of $10.00 for senior citizens. These rates do not include fees for a sinking fund, for major repairs, or for replacement of the system. The annual water system budget for 2001-2002 was $21,027 with 3.2% of this budget being spent annually for maintenance and water quality testing. The Town has a Wyoming certified operator on site and a backup operator is in the process of being trained.

2.2 Water Supply Overview

The Town presently receives its water supply from two sources:

- Abel Springs: Primary Source
- Battle Springs Well Field: Supplemental Source

The Town Engineer has prepared a permit application to appropriate ground water from the new well, Bairoil No.1, which is located northwest of Abel Springs.

2.2.1 Abel Springs

Abel Springs, the primary source of water for the Town of Bairoil, was developed in the 1950s. The springs are located approximately three miles northwest of the Town and provide an estimated flow of 35 to 75 gallons per minute (gpm) from an infiltration gallery. The infiltration gallery was constructed in the bottomland of the Abel Creek drainage, approximately one half to one mile upstream of the springs. The flow rate is thought to vary seasonally, although no data are available to support this. The springs are susceptible to drought and reportedly fail to provide a satisfactory water supply during these dry times.

To the extent possible and without potentially intrusive subsurface excavation, LA defined the nature, characteristics and construction of the Abel Springs supply system. LA delineated the location of pipelines above the collection boxes that are fed by the infiltration gallery. Figure 2.2.1 shows the location of the existing main lines to the gallery as well as the location of the collection boxes.
There are four collection boxes. Each of the upper three collection boxes has its own collector feeder lines into them and has gravel floors. These boxes are labeled "Top", "Middle" and "West" respectively in the Figure 2.2.1. The "Top" box's collector arm is fed by the main infiltration gallery to the north, which consists of several collector arms feeding into the transmission line into the "Top" box. The upper three boxes have nine four inch diameter lines on three sides feeding into the bottom of the boxes below the inlet. It appears that these four inch diameter lines are additional collection lines from the local area springs. (See Figure 2.2.2.) All three upper collection boxes feed into the main larger collection box to the south. This box has a concrete bottom and feeds into the six inch transmission line to the tank. (See Figure 2.2.3)

As shown in Figure 2.2.4, the layout of the Abel Springs collection, transmission and storage system was prepared based on field observations only, and may be incomplete. No as-built plans were found documenting the infiltration gallery configuration or materials. The collection boxes are kept locked and the area patrolled weekly. The water flows a distance of approximately 3.5 miles from the collection boxes at Abel Springs through a 6-inch PVC pipe to a 350,000 gallon steel storage tank located above town. The transmission line was upgraded in 1984 and an as-built plan was filed with the Wyoming Department of Environmental Quality/Water Quality Division (WDEQ/WQD). The accuracy of the as-built drawing may be questionable given that the actual location of the line relative to Abel Creek is incorrect on the as-built plans.

The recharge area and spring occupy unfenced rangeland. The actual infiltration gallery is partly located on land owned by the Sun Ranch, and partly on Bureau of Land Management (BLM) land. Currently, there is no recorded easement for the portion of the gallery that is on BLM property. The Town Engineer has filed an amendment to add this portion of the infiltration gallery to the Town of Bairoil's 1984 Application for Utility Systems on Federal Lands.

There are no records of improvements to the infiltration gallery; however, there is a substantial amount of construction debris in the vicinity of the gallery including pipe fragments. From this debris it appears that some concrete-asbestos lines have been replaced with C-900 PVC lines. The replacement lines have a nominal diameter of six inches, and it appears that this collection system upgrade work may have taken place in 1984 at the same time as the Abel Springs transmission line replacement project.

Given the age and design materials for the main Abel Springs transmission line LA has assumed that it remains in good condition. However, there was a possibility that there was some water loss between the infiltration gallery and the Bairoil storage tank. Areas where leakage was of concern were addressed in the American Leak Detection survey that was done in September 2002. This survey is discussed further in section 3.0.
Figure 2.2.2
Typical Collection Box Detail

Plan View

Elevation

10 FT.

10 FT.

12 IN.

36 IN. OPENING
WITH COVER

CONCRETE

OVERFLOW

INLET

36 IN. OPENING
WITH COVER

CONCRETE

10 FT. 3 IN.
AVERAGE DEPTH

10 FT.

INLETS

GROUND SURFACE

OVERFLOW

INLETS

OUTLET

OUTLET

9-4 IN DIA PVC
(RADIAL ARMS)
PERFORATED
COLLECTION PIPES.
Figure 2.2.3
Main Collection Box at Abel Springs
2.2.2 Battle Springs Well Field

Currently utilized as the supplemental water source for the Town of Bairoil, the Battle Springs well field is comprised of six deep wells, as shown on Figure 2.1. Each is screened in the Battle Springs Aquifer with individual reported yields ranging from 347 to 589 gpm. The combined yield for all wells is approximately 2,650 gpm. Well details are provided in Table 2.1.

Table 2.1: Details of the Battle Springs Well Field

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Permit Number</th>
<th>Total Depth (ft)</th>
<th>Yield (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battle Springs Water Supply #1</td>
<td>SW SW Sec. 14 T27N R92W</td>
<td>UW 14775</td>
<td>2080</td>
<td>392</td>
</tr>
<tr>
<td>Battle Springs Water Supply #2</td>
<td>SW SW Sec. 19 T27N R91W</td>
<td>UW 14776</td>
<td>2084</td>
<td>347</td>
</tr>
<tr>
<td>Battle Springs Water Supply #3</td>
<td>NW NW Sec. 24 T27N R92W</td>
<td>UW 14777</td>
<td>2010</td>
<td>388</td>
</tr>
<tr>
<td>Battle Springs Water Supply #4</td>
<td>SW SW Sec. 15 T27N R92W</td>
<td>UW 14793</td>
<td>2043</td>
<td>420</td>
</tr>
<tr>
<td>Battle Springs Water Supply #6</td>
<td>SE SW Sec. 24 T27N R92W</td>
<td>UW 26762</td>
<td>2010</td>
<td>589</td>
</tr>
<tr>
<td>Battle Springs Water Supply #8</td>
<td>NE NW Sec. 31 T27N R91W</td>
<td>UW 26764</td>
<td>2002</td>
<td>514</td>
</tr>
</tbody>
</table>

The wells provide source redundancy and additional fire fighting capacity for the Town. These wells are 2,000 to 2,080 feet deep and are located 13 to 18 miles west of the Town. The primary purpose of these wells is to supply water to Merit Energy’s production facilities. In 1984, the Town constructed a 2,500-foot, 4-inch PVC pipeline to connect the Merit Energy transmission line to the Town’s storage tank.

2.3 Disinfection

The Town’s potable water is disinfected prior to going into the storage tank. No other treatment is applied to the water. Disinfection is accomplished using a 12% hypochlorite solution and injection pump. The disinfection apparatus is located in its own building adjacent to the storage tank and chlorine is injected into the water line prior to entry into the storage tank. The contact time in the tank is estimated to be seven hours. Trained personnel adhere to chlorine safety guidelines. The disinfection residual is monitored on a weekly basis and BacT samples are taken on a monthly basis from the town’s distribution system.
2.4 Storage

Storage for the water system is provided by a 350,000 gallon covered steel tank, which was built in 1985. The tank is structurally sound, well maintained, and in good condition. The outside of the tank was re-coated in 1996. The ground elevation at the tank is 7,006 feet. During the winter months the tank is kept about half full to prevent damage from ice build up. The area where the tank is located is not subject to flooding. The tank area and chlorine facility are fenced, locked and inspected on a daily basis. The tank is inspected annually. The tank has both high and low overflow levels. The high overflow is located 38 feet above the base of the tank and the low overflow is located 20 feet from the base of the tank. This configuration allows more rapid fresh water circulation during the lower flows of winter, and for ice buildup control. In addition, a drain is located at the bottom of the tank such that it can be emptied for maintenance.

2.5 Transmission System

Water from the Abel Springs infiltration gallery flows to the southeast through a six-inch PVC pipe and through a four-inch PRV vault before flowing into another six-inch pipe and into the storage tank. Water from the Battle Springs transmission line flows into the Bairoil water system through a four-inch line. There are three CLA-VAL PRV valves, an altitude valve, and a flow meter prior to passing through a six-inch line into the storage tank. The altitude valve had not been operational for the past ten years, and excess water from the Battle Springs field would overflow once the tank was full, if the line was not manually shut off. In July 2002, LA measured the overflow rate of treated water from the tank into the surface drainage at approximately 220 gpm. In September of this year, the valve was repaired and is now functional; it closes the Battle Springs line when the tank is full. The water flows out of the storage tank through a six-inch pipe that connects with an eight-inch pipe that, in turn, connects with the ten-inch transmission line to carry the water to the Bairoil distribution system. The precise location of each connection between the different line sizes is not known. Figure 2.5 presents the best analysis of the line schematic including valves and controls into and around the storage tank. A water meter is located in the eight-inch portion of the transmission line, approximately 300 feet southwest of the tank. The water meter is contained in a meter vault and can be bypassed if necessary. Until the beginning of this project the water meter had not been operational since 1997.

2.6 Distribution System

Treated water from the storage tank is gravity conveyed to the distribution system by the 10-inch PVC pipeline. The distribution system is also gravity-based. The distribution system consists of the following lines listed in Table 2.2 and shown on Figure 2.6.
Table 2.2: Distribution System Line Diameters and Lengths

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Diameter (inches)</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,500</td>
<td>8</td>
<td>PVC</td>
</tr>
<tr>
<td>11,770</td>
<td>6</td>
<td>PVC</td>
</tr>
<tr>
<td>2,100</td>
<td>4</td>
<td>PVC</td>
</tr>
<tr>
<td>560</td>
<td>2</td>
<td>PVC</td>
</tr>
</tbody>
</table>

The line types and their function in the distribution system are detailed below.

- Main lines: 8-inch to 4-inch PVC
- Distribution lines: 6-inch to 2-inch PVC
- Service lines: ¾-inch to ½-inch PVC and copper

In addition to these pipelines there are approximately two miles of two-inch line that extend from the meter east of the Town to Merit Energy’s Wertz Unit CO$_2$ recycling plant. Prior to 2002 this meter was not operational. It was repaired in September 2002. There is also approximately 1,620 feet of ¾-inch PVC service line pipe that goes to the corrals at the south end of Town. The line to the corrals is a service line. The exact locations of these lines are unknown.

The water system has 31 fire hydrants in town. According to the plat map there are numerous shutoff valves that allow the lines to be isolated, but some of these are covered and are hard to find. There are also six dead ends to the existing system, which make it necessary to flush out the line out periodically. Measured at the Town Hall during a 1993 survey by RCH & Associates, pressure in the line ranged from 72 psi at the low volume storage to 80 psi for the full tank. In September 2002, an additional six inch line was installed along Beebe Avenue, from Indian Paint Brush Avenue to Rodeo Road, and additional curb stops were added to the properties along that portion of Beebe Avenue.

Several line replacement projects have taken place over the last 20 years. The distribution system map on file with the WDEQ/WQD and the Town is not current. As part of this project, LA incorporated the operator's detailed notes with their field observations of line locations, pipe sizes, and critical shutoff valves to prepare Figures 2.5 and 2.6. However, because of inaccuracies of the original surveyed platting, LA was unable to rectify the line length with the plats.

2.7 Water Quality

A water sample was collected from Abel Springs for analysis in 1982. The results of this analysis showed that the water quality met the DEQ Chapter VIII standards for the tested constituents. The tested constituents and results were calcium (18.9 mg/L), iron (0.056 mg/L), magnesium (2.85 mg/L), manganese (<0.01 mg/L), potassium (0.33 mg/L), sodium (4.31
mg/L), alkalinity as CaCO₃ (61.9 mg/L), pH (8.05 s.u.), sulfide (3.99 mg/L), chloride (2.35 mg/L), TDS (108 mg/L), and hardness (Ca, Mg as CaCO₃ - 58.9 mg/L). Microparticulate analyses (MPA) have been performed on raw water from Abel Springs in 1992 and 1993. These analyses showed that small populations of algae were present in the water. The water was free of Giardia and/or other surface water organisms. No additional MPA data have been collected since 1993.

Over many years, several other samples of the system water have been collected from the storage tank prior to entrance into the distribution system. These samples could contain commingled Abel Springs and Battle Springs field well water. The sample results of radiological parameters from the storage tank indicate that the water meets the WDEQ-WQD Chapter VIII standards for Class I water. Samples were collected from the storage tank in July 1996 and March 1999 and were analyzed for EPA Primary and Secondary Parameters. Concentrations of all chemical constituents in the water were below their respective MCLs.

3.0 LEAK DETECTION

Part of the scope of work for this Phase V of Contract Amendment No. 4 was to conduct a leak detection survey. After reviewing the Town’s per capita water use data, LA determined that a leak detection survey would greatly assist the Town. Part of the leak detection program included an evaluation of all existing meters and valves within the distribution system and transmission program. LA with Town support inventoried all meters and critical valves within the Town’s system. Two non-operational meters were identified and either repaired or replaced. Critical valves were exercised in order to isolate portions of the Town in preparation for a third party subcontractor, American Leak Detection.

American Leak Detection (ALD) from Denver performed a system leak survey in the Town during the period of September 3-5, 2002. The survey was performed by electronically testing all accessible valves, hydrants and curb stops for vibration indicative of leakage. Many curb stops were electronically located and excavated for testing. The routes of water main lines were tested for leak indications, at six foot intervals, with a ground vibration survey, a distance of approximately 3.53 miles. The detailed results of this survey are included in Appendix A.

The estimated total system leakage rate was 12-17 gpm (518,400-734,400 gallons per month). On an annual basis, this amounts to approximately 7.6 million gallons of water lost to leaks. Assuming the measured average daily demand, approximately 36 percent of the Town’s production is lost to leakage. All leak locations were identified to Town personnel. Ten to fifteen gpm of leaks were associated with residences on the resident side of the curb stop and are not “Town responsibility”. Without a metering program in place, the residents have limited incentive to repair leaks. Two to three gpm were associated with a leak at the saddle that feeds water to the chlorine injection system in the chlorine building prior to entry into the storage tank. This leak will need to be repaired by the Town.
4.0 WATER DEMAND

Few detailed records of water consumption exist for the Town. A flow meter was installed in the transmission line that exits the water storage tank in January 1997. Unfortunately, the remote readout ceased to work after one year and metered records were only available for 1997. In July of 2002, the meter was returned to service and is now operational. Meter readings have been recorded since that time and the available mean measurements are summarized in Table 4.1.

The daily water usage varied from a low of 30,000 gallons in the fall of 1997 to a maximum of approximately 150,000 gallons during July 1997. Over the entire year of 1997, water usage averaged 56,260 gallons per day. Assuming that the population at that time of 160 people were provided with water, this equates to a daily usage ranging from 187.5 gallons per capita per day (gpcpd) to 938 gpcpd, or an average daily demand of 352 gpcpd. At the maximum daily usage, the demand is 105 gpm as shown Table 4.1.

Table 4.1: Water Demand Estimates for the Town of Bairoil

<table>
<thead>
<tr>
<th></th>
<th>1997 (Population 160)</th>
<th></th>
<th>2002 (Population 115)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gallons</td>
<td>Average Day Use</td>
<td>Gallons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(gpcpd)</td>
<td></td>
</tr>
<tr>
<td>Demand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Measured)</td>
<td></td>
<td>(Annualized)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Daily</td>
<td>56,250</td>
<td>352</td>
<td>57,250</td>
</tr>
<tr>
<td>Maximum Daily</td>
<td>150,000</td>
<td>938</td>
<td>131,143</td>
</tr>
<tr>
<td>Peak Hourly</td>
<td>12,500</td>
<td>210</td>
<td>10,928</td>
</tr>
</tbody>
</table>

Water usage was recorded from July 4, 2002 through October 9, 2002. These recorded measurements were annualized using the monthly percentage usage from 1997. These indicate that the daily water usage varied from a low daily average of 26,870 gallons to a maximum daily usage of approximately 131,143 gallons. Over this period, water usage averaged 57,250 gallons per day. Assuming that 115 people were provided with water, this equates to an average daily demand of 498 gpcpd. At the maximum daily usage, the demand is 91 gpm. These water consumption figures show that the demand on the system has increased on a per capita basis by 41 percent but the total demand has decreased coincident with population.

WDEQ requires water systems within Wyoming to be designed for the maximum daily demand at the design year. Where water use records are not available to establish water use, the
equivalent per capita water use should be at least 125 gpcpd and 340 gpcpd to size facilities for average and maximum daily water demand, respectively.

The Wyoming statewide average day and maximum daily use for 2002 is 266 and 548 gpcpd. Typical water demands for towns in the area around Bairoil are listed in Table 4.2. These figures are from the 2002 Wyoming Water System Survey Report, and are provided for comparative purposes.

Table 4.2: Water Demand Estimates for Towns around Wyoming (2002)

<table>
<thead>
<tr>
<th>Town</th>
<th>Average day use (gpcpd)</th>
<th>Maximum day use (gpcpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wyoming (Average)</td>
<td>266</td>
<td>598</td>
</tr>
<tr>
<td>Bairoil</td>
<td>498</td>
<td>1140</td>
</tr>
<tr>
<td>Sinclair</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Wamsutter</td>
<td>161</td>
<td>645</td>
</tr>
<tr>
<td>Rawlins</td>
<td>205</td>
<td>465</td>
</tr>
<tr>
<td>Medicine Bow</td>
<td>325</td>
<td>459</td>
</tr>
</tbody>
</table>

In the 2000 Level II Report, the 1997 maximum daily demand was used to establish the design capacity of the system. Thus the design capacity from 1997 of 105 gpm is greater than the current demand of 91 gpm. One should note that the 2002 water usage data include significant leakage within the Town’s distribution system. Approximately 10-15 gpm of water leaks were measured. (See Section 3.0) If the existing leaks, 10-15 gpm were to be repaired the maximum daily demand on the system would be approximately 76 to 81 gpm. This reflects a significant reduction in required production capacity.

Table 4.3: Hypothetical Water Demand Without Leakage

<table>
<thead>
<tr>
<th>Town</th>
<th>Average day use (gpcpd)</th>
<th>Maximum day use (gpcpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bairoil</td>
<td>343</td>
<td>777</td>
</tr>
</tbody>
</table>

5.0 EVALUATION AND TESTING OF ABEL SPRINGS

In July and August 2002, LA conducted a site investigation at Abel Springs and recorded flows into the various collection boxes and the total flow into the main collection box at the south end of the gallery. The results are summarized in Table 5.1. The purpose of this investigation was to quantify each production component of the Abel Springs collection system. During August, LA tried shutting off the various valves along the collection lines from the gallery area to the boxes to ascertain which lines were providing the most flows. The only valve that was operable was valve B along the supply line. (See Figure 2.2.1) With this valve shut off, the flows into the top box were measured and recorded. With valve B shut off, the flow into the top box decreased from 17 gpm to 2.6 gpm. This decrease indicates most of the flow into this box comes from the two collection feeder lines north of valve B that consist of approximately 1270 ft of collector lines.
Table 5.1

**Measurements of Flows into the Collection Boxes at Abel Springs**

<table>
<thead>
<tr>
<th>Total Flow into Main Collection Box from the Three Upper Collection Boxes</th>
<th>Average Flow (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Top Collection Box</td>
<td>30</td>
</tr>
<tr>
<td>From Middle Collection Box</td>
<td>10</td>
</tr>
<tr>
<td>From West Collection Box</td>
<td>3</td>
</tr>
<tr>
<td>Total Flow into Main Collection Box</td>
<td>43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow Into Individual Collection Boxes</th>
<th>Average Flow (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Flow From Upper Infiltration Area Into Top Collection Box</td>
<td>17</td>
</tr>
<tr>
<td>Inlet Flow Into Middle Collection Box</td>
<td>9</td>
</tr>
<tr>
<td>Inlet Flow into West Collection Box</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flows From the Nine Localized Four Inch Lines and Gravel Floor at Each of the Three Upper Collection Boxes</th>
<th>Flow (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Top Collection Box</td>
<td>13</td>
</tr>
<tr>
<td>From Middle Collection Box</td>
<td>1</td>
</tr>
<tr>
<td>From West Collection Box</td>
<td>0.1</td>
</tr>
</tbody>
</table>

| Inlet Flow From Upper Infiltration Area Into Top Collection Box with Valve B Closed | 2.60 |

Note: Flows averaged from July 12 and August 8, 2002 Measurements.

From these measurements it can be concluded that:

1. The largest of the water flows, approximately 40 percent, comes from the upper Abel Springs collection system,
2. The upper box is the most prolific providing approximately 30 percent of the total flows,
3. The middle box provides an additional flow volume of approximately 23 percent, and
4. The west box provides approximately seven percent of the overall flow.

These figures show that the upper length, approximately 1270 feet of the top collection lines, contributes approximately 14.40 gpm (17.00 – 2.60). Thus the flow per foot of collection line is approximately 0.0113 gpm/ft. Based on these measurements, approximately 950-1000 ft of new collection lines would need to be added to obtain an additional 10 gpm from the gallery, assuming similar conditions.
6.0 ABEL SPRING REDEVELOPMENT AND EXPANSION

This section presents an approach to expand the Abel Springs infiltration gallery, protect the watershed collection area, and provide filtration for the water supply. In order to evaluate the potential of this alternative, a series of soil pits were excavated in 1999 to establish the material gradation of the alluvium. Examination of the walls of the open test pits indicated that the shallow material in the Abel Springs area is very fine-grained sandy and stiff green clay with low hydraulic conductivity. Appendix B contains the results of the tests that were conducted in 1999 (EEC Report). Thin seams of coarser, more permeable sediment are present. Based on the measured flows established in section 5.0, adding an additional 1,000 ft of four inch collection lines in the main filtration gallery could increase the flows by about ten to fifteen percent. The current existing trunk lines above the collection boxes would still be used to convey the water to the main transmission line.

During the course of this project, LA observed that even during drought conditions there were areas of seepage water just to the north of (the) Kids Pond and approximately 3,300 ft south of the main collection box. The seep was near the existing six inch line to the storage tank. An additional 450 ft of four inch collection lines and a new collection box could be added at that location and tied into the line going to the storage tank thus capturing the runoff from the area to the west of the six inch main and enhancing the overall springs flow.

Adding approximately 1,450 ft of additional four inch PVC collector arms could expand the infiltration gallery and increase the flows by approximately 15 to 20 percent assuming similar conditions. Figures 6.1 and 6.1.1 illustrate alternative sites and cross-sectional views of the collection trench for system expansion. Prior to final design, all proposed areas of system expansion should be “pitholed” and material sampled. LA recommends that sampling and testing take place during the late summer or fall of the year.

In order to meet the EPA rules and to ensure continued health and safety for the Town, LA strongly recommends filtration of the current or expanded Abel Springs source. This filtration system will need to be sized to include the upcoming flows from the new Bairoil No.1 well, and would be sized for a minimum of 105 gpm. The filtration system recommended by LA would consist of either a multimedia prefilter or a bag prefiltering system followed by a U.F. Stainrite High Pro Micro performance bag filtration system or equivalent technology. To determine the type of prefiltration system a particle size analysis would need to be done. The prefilter would extend the “High Pro Micro” filter bag life by an average of three to five months. The filter would consist of a six bag filter unit, each unit having a capacity of 20 gpm giving a capacity of 120 gpm.
PREVIOUSLY EXCAVATED BACKFILL PLACED IN 6 IN. LIFTS AND COMPACTED TO MIN. OF 90% PROCTOR AND WITHIN ± 3% OPTIMUM MOISTURE

6 IN. COMPACTED CLAY LINER @ 95% STANDARD PROCTOR ± 3% OPTIMUM MOISTURE OR 60 MIL HDPE GEOMEMBRANE

3 FT

30 IN.

6 IN. DIA. SCREENED CONTINUOUS SLOTTED PVC COLLECTION PIPE

SAND FILTER PACK

6 IN.

3 FT.

Figure 6.1.1
Typical Collection Trench Detail
It is also recommended that the Town fence the area around the collection system for source water protection. The Town, at LA's recommendation has filed a special use permit to exclude the BLM portion of the collection system from grazing.

Costs for the Abel Springs enlargement are outlined in Table 6.1.

<table>
<thead>
<tr>
<th>Table 6.1: Abel Springs Redevelopment and Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>Pipeline Construction and Emplacement</td>
</tr>
<tr>
<td>Granular Filter</td>
</tr>
<tr>
<td>New Collection Box with Radial arms and</td>
</tr>
<tr>
<td>Collection System</td>
</tr>
<tr>
<td>Clay Barrier (or geomembrane)</td>
</tr>
<tr>
<td>Fencing (Woven Wire)</td>
</tr>
</tbody>
</table>

**SUBTOTAL (1)** $139,850.00

**ENGINEERING 10% OF SUBTOTAL (1)** $13,985.00

**SUBTOTAL (2)** $153,835.00

**CONTINGENCY @ 15% OF SUBTOTAL (2)** $23,075.25

**TOTAL CONSTRUCTION COSTS** $176,910.25

**SURVEYING** $10,000.00

**GEOTECHNICAL EXPLORATION** $5,000.00

**PERMITTING COSTS** $25,000.00

**FINAL PLANS/SPECIFICATIONS** $25,000.00

**SUBTOTAL (3)** $241,910.25

7.0 **SOURCE WATER ASSESSMENT**

Source Water Assessment and Protection (SWAP) is a program to help public water systems protect their water supply from contamination. The 1996 Safe Drinking Water Act Amendments directed all 50 states to develop SWAP programs. While SWAP is voluntary in Wyoming the Wyoming Legislature set aside $1.2 million dollars of federal EPA funds for the WDEQ to develop and implement the SWAP program.

The SWAP program has two parts. The first part is to conduct an assessment of the public water supply. WDEQ will complete assessments for public water systems that apply. The second part is to encourage the public water systems to develop a protection program to safeguard the water supply. LA submitted a draft SWAP program application to the Town of Bairoil for their approval and submission to the State. This completed application has been submitted to the WDEQ, Water Quality Division, who will assist the Town in the system evaluation and system protection.
8.0 DISTRIBUTION SYSTEM MODIFICATIONS

8.1 Additional System Improvements

WDEQ/WQD Rules and Regulations require a minimum operating pressure of 20 psi under all operating conditions (including fire flow) and 35 psi under normal operating conditions. After modeling the Town’s distribution system, it became apparent that these requirements were not currently met and that inadequate pressures are provided under minimal fire flow conditions (1000 gpm) throughout most of the system. This situation is a direct result of the line sizes and demand at the dead-end mains. To bring the Town’s system into compliance, the following modifications are recommended.

- Connect the dead-end main on Badger Circle to the eight-inch system main on Antelope Drive, by adding approximately 166 feet of six-inch line.
- Connect the dead-end main at the end of Deer Court to the dead-end main at the end of Elk Court (the two cul-de-sacs extending north west from Purple Sage Avenue), and then extend this main to the six-inch main on Iris Avenue, by adding approximately 538 feet of six-inch line.
- Connect the six-inch dead-end main at the intersection of Beebe Avenue and Iris Avenue to the eight-inch service main on Antelope Drive with approximately 1,180 feet of six-inch pipe following Iris Avenue.
- Connect the six-inch main from Rodeo Road to the six-inch main at the intersection of Rodeo Road and Antelope Drive with approximately 1,216 feet of six-inch line.
- Install approximately 1,650 feet of 6-inch PVC from the junction of Hwy 73 and Primrose Avenue and connect it to the 8-inch main on Antelope Drive.
- Connect the new line at the corner of Beebe Avenue and Rodeo Road to the proposed extension at the intersection of Rodeo Road and Antelope Drive for approximately 1230 feet.

Making the above improvements to the system would help to reduce operations and maintenance expenses associated with the flushing of mains at dead-ends. Looping the system to eliminate this requirement may also help to reduce the elevated copper levels that have been observed in various parts of the system because of improved flow through the entire system. Table 8.1 presents the cost estimates for the distribution system improvements and miscellaneous work. Figure 8.1 shows a diagram of the proposed improvements.

The water distribution modeling was performed by BRS, Inc., under Phase III and does not include any system improvements since 1999. The BRS report is presented in Appendix C.
Table 8.1: Bairoil Distribution System Improvements and Miscellaneous Work

<table>
<thead>
<tr>
<th>Price</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-inch PVC</td>
<td>L.F.</td>
<td>5980</td>
<td>$25.00</td>
<td>$149,500.00</td>
</tr>
<tr>
<td>6 inch gate valves</td>
<td>E.A.</td>
<td>17</td>
<td>$750.00</td>
<td>$12,750.00</td>
</tr>
<tr>
<td>Hydrants</td>
<td>E.A.</td>
<td>7</td>
<td>$3,100.00</td>
<td>$21,700.00</td>
</tr>
<tr>
<td>Fittings</td>
<td>L.S.</td>
<td>1</td>
<td>$10,000.00</td>
<td>$10,000.00</td>
</tr>
<tr>
<td>Resurface road (Approximately 1500 ft)</td>
<td>L.S.</td>
<td>1</td>
<td>$25,000.00</td>
<td>$25,000.00</td>
</tr>
<tr>
<td>Filtration System</td>
<td>L.S.</td>
<td>1</td>
<td>$45,000.00</td>
<td>$45,000.00</td>
</tr>
<tr>
<td>Filtration Building - 20ft X 20ft Fiberglass</td>
<td>L.S.</td>
<td>1</td>
<td>$20,000.00</td>
<td>$20,000.00</td>
</tr>
<tr>
<td>Labor (pressure testing, cleanup, mobilization)</td>
<td>L.S.</td>
<td>1</td>
<td>$15,000.00</td>
<td>$15,000.00</td>
</tr>
<tr>
<td>Install new meters in the Town (Approx 65)</td>
<td>L.S.</td>
<td>1</td>
<td>$40,000.00</td>
<td>$40,000.00</td>
</tr>
<tr>
<td>Abandon three wells along Abel Creek</td>
<td>E.A.</td>
<td>3</td>
<td>$2,000.00</td>
<td>$6,000.00</td>
</tr>
<tr>
<td>Remove old storage tank</td>
<td>E.A.</td>
<td>1</td>
<td>$4,000.00</td>
<td>$4,000.00</td>
</tr>
<tr>
<td><strong>SUBTOTAL (1)</strong></td>
<td></td>
<td></td>
<td></td>
<td>$348,950.00</td>
</tr>
<tr>
<td><strong>ENGINEERING 10% OF SUBTOTAL (1)</strong></td>
<td></td>
<td></td>
<td></td>
<td>$34,895.00</td>
</tr>
<tr>
<td><strong>SUBTOTAL (2)</strong></td>
<td></td>
<td></td>
<td></td>
<td>$383,845.00</td>
</tr>
<tr>
<td><strong>CONTINGENCY @ 15% OF SUBTOTAL (2)</strong></td>
<td></td>
<td></td>
<td></td>
<td>$57,576.75</td>
</tr>
<tr>
<td><strong>TOTAL CONSTRUCTION COSTS</strong></td>
<td></td>
<td></td>
<td></td>
<td>$441,421.75</td>
</tr>
<tr>
<td><strong>SURVEYING</strong></td>
<td></td>
<td></td>
<td></td>
<td>$20,000.00</td>
</tr>
<tr>
<td><strong>PERMITTING COSTS</strong></td>
<td></td>
<td></td>
<td></td>
<td>$2,000.00</td>
</tr>
<tr>
<td><strong>FINAL PLANS/SPECIFICATIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td>$40,000.00</td>
</tr>
<tr>
<td><strong>SUBTOTAL (3)</strong></td>
<td></td>
<td></td>
<td></td>
<td>$503,421.75</td>
</tr>
</tbody>
</table>

8.1.1 Removal of Old Water System Structures

Research and field investigation by LA and their subcontractors indicates that there are a number of other problems, potential sources of contamination, and/or precautionary measures associated with the water system, which should be addressed. These include the following:

- **Completely abandon the three alluvial wells along Abel Creek.**
  The wells were taken "off line" because they could not maintain the required yields. The wells should be abandoned by removing the pumps and plugging the casing to the surface with cement in compliance with State regulations.

- **Remove abandoned water storage tank, old valves and appurtenances.**
  An old water storage tank is located near the 350,000 gallon storage tank and should be removed. There are also a series of valves, which serve the old tank. It appears that none of these old lines have been properly abandoned and there is a potential for leakage between these lines and the current water system, which could result in water quality problems. These valves to unused lines should be removed and the lines currently required for service re-plumbed accordingly as shown on Figure 8.1.1
8.1.2 Installation of Water Meters

Although water conservation measures are not funded by the WWDC, funding for eligible water system upgrades or rehabilitation now requires a metered system and it is prudent to recommend water conservation and the installation of water meters at each service. Water meters will allow the Town to balance water use and water demand throughout the year and enhance the ability to detect leaks at an early stage. It would also aid in the enforcement of repairs when on the customer side of the curb stop. An estimated loss of 7.6 million gallons of treated water or 36% of the system’s annual production is a serious problem and could be monitored and controlled with a metering program. In addition, installation of individual water meters at all points in the distribution system and the institution of a rate schedule based on water usage will promote water conservation and reduce operations and maintenance costs. Meter costs are included in Table 8.1.

8.1.3 Water Treatment

The EPA Surface Water Treatment Rule requires that all surface water and ground water under the direct influence of surface water systems must either be:

- Filtered or,
- The municipality shall meet certain sampling and watershed protection guidelines.

Bairoil’s current and proposed future systems will commingle water from Abel Springs with deep ground water. Although no decision has been rendered by the EPA, the Town of Bairoil should recognize and prepare for a “Surface Water Determination”. LA recommends that Abel Springs water or any ground water/surface water combination be filtered in accordance with federal treatment guidelines. EPA has accepted and LA has utilized Alternative Filtration Technology to meet these guidelines. Table 8.1 includes costs for this treatment technology and the cost for a new filtration building. Appendix D includes manufacturers literature and filtration specifications.
9.0 PERMITTING AND ENVIRONMENTAL ISSUES

For this project to proceed with construction, the Town will be required to obtain certain permits, rights of way, and easements. State, county, and federal agencies must be contacted as part of the Level III process. In some instances, the initial contacts have already been made. The following issues for each alternative must be addressed during final design.

9.1 Abel Springs Redevelopment and Expansion

**BLM Easements.** The majority of the existing infiltration gallery is located on lands under BLM jurisdiction and a records search indicates that an easement has not been secured. The Town was notified of this during a previous phase and is currently attempting to secure a BLM special use permit. Any additional expansion of the system onto BLM lands will require an amendment to the Special Use Permit application. A Cultural Resources Survey would need to be completed in the area of the proposed activity and clearance obtained from the Wyoming State Historical Preservation Office and BLM. The US Fish and Wildlife would most likely require a survey for Threatened and Endangered species.

**USACE §404 Permit.** The area of the existing infiltration gallery lies within the bottom of the Abel Springs Creek drainage and this area would potentially be considered a Jurisdictional Wetland. These activities may require a §404 permit from the US Army Corps of Engineers (USACE) and 401 authorization from the State of Wyoming. Depending on the projected impact, a wetlands mitigation plan could be required.

**WDEQ/WQD Permit to Construct.** Modifications to the existing infiltration gallery would require a “Permit to Construct” from the WDEQ/WQD.

**Water Rights Permit.** The current water right for Abel Springs is 0.176 cubic feet per second (cfs) or 79 gpm. An enlargement to this water right should be registered with the Wyoming State Engineer’s Office (WSEO) including a Statement of Beneficial Use. Upon completion of construction, completion forms should be submitted to the WSEO and the water right adjudicated before the State Board of Control. A legal opinion regarding the existing Abel Springs water system easement is recommended.

9.2 Distribution System Improvements

**WDEQ/WQD Permit to Construct.** The distribution system upgrades will require a “Permit to Construct” from the WDEQ/WQD.

10.0 ECONOMIC ANALYSIS AND ABILITY TO PAY

LA’s recommendations to the Town can be considered in two parts: (1) Abel Springs redevelopment and expansion; and (2) upgrades and modifications to the distribution system. There are several potential sources for funding this project. These include the following:
- Private financing through the Town of Bairoil
- Wyoming Water Development Commission
- Rural Utilities Service Loan
- Wyoming State Revolving Fund
- Wyoming Mineral Royalty Grant
- Wyoming State Lands and Investments Grant/Loan program

Funding from the Wyoming Water Development Commission can only be secured for the water supply portion of the project. The money available would be in the form of a 50% grant and 50% loan at an interest rate of 6.0 percent for 30 years.

Funding through the Rural Utilities Services (RUS) is limited because of the median household income for the Town, which according to the 2000 Census was slightly in excess of $40,000. This income level does not allow for a grant from the RUS, but a 30 year loan is available. This loan rate is currently at 4.875%. To obtain a RUS loan, an Environmental Report (ER) must be prepared. An ER was prepared by LA and has been submitted to the WWDC.

Funding from the Wyoming SRF is available at an interest rate of 2.5% for 20 years. This funding can be used for both the supply and distribution loan portions of the project. To obtain a SRF loan, an ER must be prepared. Money from this program is made available based on a “need basis” which is judged on a point system. The previously referenced ER may be utilized by the Town.

The Mineral Royalty Grant is either a 50/50 Grant/Loan or a 75/25 Grant/Loan both at 2.5% for 20 years. An application can only be submitted for one or the other rates, but not for both. The available funding for the 75/25 portion of the grant is limited and the need must be of a high priority. There are more monies available for the 50/50 portion of this grant/loan.

Funding from the Wyoming State Lands and Investments Board can be secured for the water distribution and treatment portion of the project. The money available would be in the form of a 50% grant and 50% loan at an interest rate of 6.0 percent for 30 years.

LA has estimated the cost of the Abel Springs redevelopment and expansion to be $241,910.25. In addition, LA has included recommendations to bring the water distribution system up to the standards outlined in the WDEQ/WQD Chapter XII Rules and Regulations. These improvements are estimated to cost approximately $503,421.75.

Tables 10.1 and 10.2 present the financing options for the Abel Springs redevelopment and expansion, and the distribution system improvements, respectively. The Town of Bairoil had previously made the determination that they will not apply for RUS funding. With that in mind, LA has only presented the WWDC funding option in Table 10.1. For the purposes of this presentation we have incorporated a WWDC grant/loan and a SRF loan portion of the grant/loan package.
TABLE 10.1
Financing for Abel Springs Redevelopment and Expansion
(WWDC/SRF Funding)

<table>
<thead>
<tr>
<th>Item</th>
<th>Financing Amount</th>
<th>SRF Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction cost WWDC eligible</td>
<td>$241,910.25</td>
<td></td>
</tr>
<tr>
<td>WWDC 50-percent Grant</td>
<td>$120,955.13</td>
<td></td>
</tr>
<tr>
<td>Loan Amount</td>
<td>$120,955.13</td>
<td>$120,955.13</td>
</tr>
<tr>
<td>WWDC Loan @ 6.0% - 30 yr. Monthly Payment</td>
<td>$725.19</td>
<td>SRF Loan @ 2.5% - 20 yr. Monthly Payment</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly Loan Payment</td>
<td>$725.19</td>
<td>$640.94</td>
</tr>
<tr>
<td>Monthly Tap Cost Increase @ 60 taps</td>
<td>$12.09</td>
<td>$10.68</td>
</tr>
</tbody>
</table>

The work defined in Table 10.2 is not eligible for WWDC funding. LA has presented financing options for funding for a grant/loan from the State Loan and Investment Board and an option for a SRF loan in this table.

TABLE 10.2
Financing of the Existing System Upgrades
(SLIB/SRF Funding)

<table>
<thead>
<tr>
<th>Item</th>
<th>Financing Amount</th>
<th>SRF Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction cost SLIB eligible</td>
<td>$503,421.75</td>
<td></td>
</tr>
<tr>
<td>SLIB 50-percent Grant</td>
<td>$251,710.88</td>
<td></td>
</tr>
<tr>
<td>Loan Amount</td>
<td>$251,710.88</td>
<td>$251,710.88</td>
</tr>
<tr>
<td>SLIB Loan @ 6% - 30 yr. Monthly Payment</td>
<td>$1,509.13</td>
<td>SRF Loan @ 2.5% - 20 yr. Monthly Payment</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly Loan Payment</td>
<td>$1,509.13</td>
<td>$1,333.82</td>
</tr>
<tr>
<td>Monthly O&amp;M: Filtration Costs</td>
<td>$43.63</td>
<td>$43.63</td>
</tr>
<tr>
<td>Monthly Tap Cost Increase @ 60 taps</td>
<td>$25.88</td>
<td>$22.96</td>
</tr>
</tbody>
</table>

NOTES:
1. The monthly tap cost does not include the initial community cost.
2. Wyoming Water Development Commission (WWDC) Grant money is only available for supply and transmission.
3. Monthly O&M Costs are based on estimated $523.50 yearly O&M Costs for the filtration system.
11.0 RECOMMENDATIONS

This report documents the results of the Level II Phase V investigation for the Town of Bairoil Water Supply Project. Based on this investigation LA, recommends the following work.

Rehabilitate and expand the Abel Springs infiltration gallery. This alternative is considered a viable means of increasing the quantity Abel Springs water in the system and provides a partial system redundancy and augments the new ground water supply. Based on the current production, the estimated increase in yield is expected to be approximately 15 to 20 percent. LA’s recommendation to expand the Abel Springs system also includes a recommendation to filter and meter this water source. It is LA’s opinion that the Abel Springs source is susceptible to surface water contamination and therefore needs to be treated as ground water under the direct influence of surface water. The majority of this work is eligible for WWDC funding. Treatment costs are not eligible for WWDC funding but can be accommodated with other state sources. Costs have been prepared for this alternative and are presented in Table 5.1.

Make modifications to the distribution system. LA recommends several improvements be made to the distribution system to increase water pressures throughout the system to improve fire flow, and to improve the water quality. The improvements will allow the system to meet the pressure requirements as outlined in the WDEQ/WQD Rules and Regulations. The improvements will also eliminate the requirement for the constant flushing required under the current configuration. These improvements consist mainly of looping dead-end mains. This work is not eligible for WWDC funding. Costs have been prepared for this alternative and are presented in Table 8.1.

Remove old water system structures. LA recommends that the old storage tanks and water system components be removed. Costs have been prepared for this work, although it is not strictly an improvement to the distribution system. These costs have been presented in Table 8.1. The recommended removals are:

- Abandon the three alluvial wells along Abel Creek.
- Remove the old water storage tanks in Bairoil.
- Clean up old water system components that are no longer in use.

Perform miscellaneous work. LA also recommends that the following miscellaneous work be performed on the system. Costs have not been prepared for all of this work.

- Add water meters at the points of service.
- Repair leaks found during the leak survey
- Install a backflow preventer at the junction between all the ¾-inch service lines to the corrals and the distribution line, if one is not already in place. The backflow preventer should be an approved reduced pressure principal backflow prevention device in the system line, as specified by Chapter XII of the DEQ/WQD Rules and Regulations.

Obtain all easements. The Town’s engineer has already initiated this process.
Keep Merit Energy’s Battle Springs well field on-line. The Merit Energy Battle Springs well field should continue to be utilized for supplemental water to meet high demand flows, as long as there is no cost to the Town for doing so.

**Operation**

- If water meters are installed the rate structure could be, but not necessarily, modified such that residents pay according to usage.
- Establish a fire hydrant flushing program at a minimum of once per year for each hydrant. This will help prevent biofilm from building on iron pipes that produce bacteria buildup.
- Exercise all gate valves within the distribution system at least once a year. This will help to get to know where all the valves are especially those in gravel roads, as these tend to get lost during the winter when snow plowing buries them and they are not relocated after the snow melt.
- Establish a good record keeping protocol for all testing done, meter records, disinfection testing results, dates of hydrant flushing, valve exercising, etc.
- A representative from the Town should attend the American Water Works Association Annual Meeting/Convention at least once every three to four years. The classes and seminars are the best available and will keep staff abreast of the changes in technologies and useful products as well as Federal Rules and Regulations regarding the Safe Drinking Water Act, etc.
- Consider instituting a water conservation program to reduce water demands. A public awareness program for such a program typically addresses issues such as leak detection (taps, toilets, etc.), hydrant flow restrictors (showers), and lawn watering.

If the above recommendations are implemented, a filtration system installed, and with the chlorination system already in place, the Town should be able to meet anticipated future EPA ground water treatment rules without any change in personnel requirements to operate the system.

**12.0 REFERENCES**


Appendix A
American Leak Detection Survey
American Leak Detection performed a system leak survey in the Town of Bairoil during the period of September 3-5, 2002. The survey was performed by electronically testing all accessible valves, hydrants and curb stops for vibration indicative of leakage. Many curb stops were electronically located and excavated for testing. The routes of water main lines were tested for leak indications, at six-foot intervals, with a ground vibration survey, a distance of approximately 3.53 miles. The results are note below.

Leak #1: Service leak at private home, corner of Blue Bell and Antelope Drive, may be internal plumbing related. Estimated leakage rate of 1 GPM.

Leak #2: Service leak at trailer, corner of Blue Bell and Antelope Drive, leak is internal plumbing related. Estimated leakage rate of 1 GPM.

Leak #3: Irrigation leak, house immediately east of school, estimated leakage rate is 2-5 GPM.

Leak #4: Service leak. 506 Antelope Drive, may be internal plumbing related, estimated leakage rate of 1 GPM.

Leak #5: Service leak, 209 Paint Brush Drive, estimated leakage rate of 1 GPM.

Leak #6: Service leak, at frost free hydrant, stock pen next to goose pen, surrounded by yellow barricade (no address available), estimated leakage rate of 4-5 GPM.

Leak #7: Main leak, at storage tank chlorine tap, between curb stop and saddle, estimated leakage rate of 2-3 GPM.

Total estimated leakage rate located: 12-17 Gallons per Minute (518,400-734,400 Gallons per Month). All leak locations were identified to on site personnel. Please call if we can provide additional information or clarification.

Warmest regards,

Mike Parish, American Leak Detection
Appendix B
Earth Engineering Consultants, Inc. Report
November 8, 1999

Lidstone & Associates
760 Whalers Way, Suite B-200
Fort Collins, Colorado 80525

Attn: Ms. Kate Laudon

Re: Laboratory Testing
EEC Project No. 1995007A

Ms. Laudon:

As requested, Earth Engineering Consultants, Inc (EEC) personnel have completed the laboratory testing on materials that were delivered to our laboratory on November 8, 1999. That laboratory testing consisted of washed sieve analysis (ASTM Specifications C-117 and C-136) tests on three separate samples. Results of the laboratory testing are shown on the attached summary sheets.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we can be of further service to you in any other way, please do not hesitate to contact us.

Very truly yours,
Earth Engineering Consultants, Inc.

[Signature]

Brian D. Thomas
Laboratory Manager

BDT/dmf
## SUMMARY OF GRADATION TEST RESULTS

**Project:** Lidstone & Associates  
**Location:** Fort Collins, Colorado  
**EEC Project No:** 1995007A  
**Date:** November 1999  
**Sample Location:** Test Pit #1, WDC 101 - Bairoil

### GRADATION OF AGGREGATE (ASTM C-117 and C-136)

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# Summary of Laboratory Sieve Analysis

**U.S. Standard Sieve Openings in Inches**

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<th>Hydrometer</th>
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**Project:** Lidstone & Associates  
**Location:** Fort Collins, Colorado  
**EEC Project No.:** 1995007A  
**Date:** November 1999  
**Sample Location:** Test Pit #1, WDC 101 - Bairoil

---

### Gravel

- **Coarse**
- **Fine**

---

### Sand

- **Coarse**
- **Medium**
- **Fine**

---

### Silt or Clay
**EARTH ENGINEERING CONSULTANTS, INC.**

**SUMMARY OF GRADATION TEST RESULTS**

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Project: Lidstone & Associates  
Fort Collins, Colorado  
EEC Project No: 1995007A  
Date: November 1999  
Sample Location: Test Pit #2, Abel Springs - Bairoil
Earth Engineering Consultants Inc.

Summary of Laboratory Sieve Analysis

U.S. Standard Sieve Openings in Inches  U.S. Standard Sieve Numbers  Hydrometer

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Project: Lidstone & Associates
Fort Collins, Colorado
EEC Project No: 1995007A
Date: November 1999
Sample Location: Test Pit #2, Abel Springs - Bairoll
### SUMMARY OF GRADATION TEST RESULTS

**Project:** Lidstone & Associates  
**Fort Collins, Colorado**  
**EEC Project No:** 1995007A  
**Date:** November 1999  
**Sample Location:** Test Pit #3, W Abel Springs - Bairoil

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Earth Engineering Consultants Inc.

Summary of Laboratory Sieve Analysis

U.S. Standard Sieve Openings in Inches U.S. Standard Sieve Numbers Hydrometer

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EEC Project No: 1995007A

Date: November 1999

Sample Location: Test Pit #3, W Abel Springs - Bairoil

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Gravel

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</table>

Sand

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Coarse</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>Fine</td>
</tr>
</tbody>
</table>

Silt or Clay
Appendix C
Bairoil Distribution System Modeling
BAIROIL DISTRIBUTION SYSTEM MODELING

Existing System

The Bairoil distribution system consists of a single 350,000 gallon ground-level storage tank located approximately one mile from town at a reported surface elevation of 7040 feet. The tank elevation is approximately 140 feet above town yielding static pressures within the distribution system of approximately 50 to 60 psi. The distribution system consists of PVC piping ranging in size from two inch to ten inch and a limited portion of four inch transite pipe serving the Amoco facility. As constructed the system has several dead-end mains, i.e., the north end of Beebe Avenue, Rodeo Road and Primrose Avenue. Normally dead-ends are to be avoided in the design of water supply systems. This is due both to system flows and water quality due to stagnation.

System Model - Base Conditions

A Cybernet flow model was developed based on the available information relative to pipe size and type. No data was available relative to pipe condition and/or actual pipe flows and pressures. As a result, rather than calibrating the model, typical roughness values were used. Model junctions used in the model are shown on Figure 1.

Demands were place on the system based on average and peak demands of approximately 300 and 600 g.p.m. respectively. These demands are the hypothetical demands of all taps simultaneously using water, and should not be confused with the water demand estimates presented in chapter III of the report. The location of demands was selected in the field based on the location of active taps. Under average demand modeled pressures ranged from 51 to 73 psi at junctions J20 and J12 respectively. Under peak demand pressures dropped to a range of 44 to 69 psi. Thus, under normal and peak operating conditions the system performed acceptably.

Distribution System Evaluation

To assess the integrity of the distribution system under high demands (minimal fire flow or a line break) a 500 g.p.m. demand was place at various locations throughout the system when the system was operating at peak demand. The following table shows the impact of such an instantaneous demand on the system.
Table 1. Model Results with 500 g.p.m. Demand at a Junction

Base Case - No System Improvements

<table>
<thead>
<tr>
<th>Junction</th>
<th>Location</th>
<th>Pressure (psi)</th>
<th>Junction&lt;20psi</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>J18</td>
<td>West end Rodeo Road</td>
<td>17-60</td>
<td>17,18,20,24,26</td>
<td>Most of system in low 20's psi</td>
</tr>
<tr>
<td>J24</td>
<td>North end Beebe Ave.</td>
<td>7-60</td>
<td>19 through 26</td>
<td>20's and low 30's psi</td>
</tr>
<tr>
<td>J13</td>
<td>Primrose at Amoco</td>
<td>(-42)-52</td>
<td>J13</td>
<td>Negative pressure at J13</td>
</tr>
<tr>
<td>J12</td>
<td>East end Primrose</td>
<td>34-52</td>
<td>None</td>
<td>System acceptable</td>
</tr>
<tr>
<td>J23</td>
<td>Cul-de-sac off Purple Sage</td>
<td>5-60</td>
<td>19,21-26,28</td>
<td>Many junctions in low 20's psi</td>
</tr>
<tr>
<td>J30</td>
<td>Town Hall</td>
<td>21-60</td>
<td>None</td>
<td>Several junctions in low to mid 20's psi</td>
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</table>

In summary, the model indicates based on the assumed flow conditions, that inadequate pressure is provided by the system under minimal fire flow conditions at junctions J18, J24, J13 and J23. This situation is a direct result of line size and demand at the dead-end mains. WQD Regulations Chapter XII requires minimum pressure of 20 psi under all conditions of flow, including fire flow where hydrants are provided, and 35 psi under normal operating conditions. Typical water system design would require:

1. Dead-end mains should be minimized by looping.
2. Any main smaller than six inches shall be justified by hydraulic modeling and analysis.
3. Water mains serving fire hydrants shall be a minimum of six inches when served from two directions, or where the maximum length of six inches is 250 feet or less in one direction. Otherwise hydrants should be served by a minimum eight inch line.

Potential System Improvements

Based on the flow model results the following potential system improvements, if implemented, would alleviate the apparent deficiencies in the distribution system.

1. Connect the dead-end main on Beebe to the eight inch system main and connect the ends at the Cul-de-sac off Badger Circle.
2. Connect the main from Rodeo Road to the six inch main at the intersection of Rodeo Road and Paintbrush.
3. Replace the four inch transite line on Primrose with six inch PVC and connect to the eight inch main on Antelope Drive.
If these system improvements were implemented a minimum of 20 psi system pressure would be maintained in accordance with WQD regulations as shown on the following table.

**Figure 2. Model Results with 500 g.p.m. Demand at Junction WITH System Improvements**

<table>
<thead>
<tr>
<th>Junction</th>
<th>Location</th>
<th>Pressure (psi)</th>
<th>Junctions&lt;20psi</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>J18</td>
<td>West end Rodeo Road</td>
<td>24-60</td>
<td>None</td>
<td>System pressure</td>
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<td></td>
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<tr>
<td>J24</td>
<td>North end Beebe Ave.</td>
<td>22-60</td>
<td>None</td>
<td>System pressure</td>
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<tr>
<td>J13</td>
<td>Primrose at Amoco</td>
<td>34-58</td>
<td>None</td>
<td>System pressure</td>
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<td>System pressure</td>
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<tr>
<td>J23</td>
<td>Cul-de-sac off Purple Sage</td>
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<td>None</td>
<td>System pressure</td>
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<td>J30</td>
<td>Town Hall</td>
<td>24-60</td>
<td>None</td>
<td>System pressure</td>
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These potential system improvements, as shown on Fig 6.3, would solve the identified possible system deficiencies relative to flow/pressure. Prior to design of such improvements on site flow/pressure testing from hydrants should be completed to calibrate the flow model and determine final line sizes. Further, there is no current development south of Paint Brush Drive between Antelope and Beebe Avenues. If this area was developed a looped main along Rodeo Road to Beebe Avenue and proceeding north to Paint Brush Drive would be recommended.

**Water Quality**

Reportedly a substantial amount of operating and maintenance expense is currently incurred flushing mains at dead-ends and in some cases lead and copper have been elevated in analyses. It is a typical requirement that dead-end mains be flushed regularly at a velocity in excess of 2.5 ft/sec to remove scaling etc. Looping the system would eliminate this requirement and would provide for better distribution of chlorine in the system. The source of the lead copper is most likely individual service lines. Although looping the system may provide for greater dilution of these constituents it will likely not solve the problem. The individual service connections responsible for the source of these constituents would need to be isolated and replaced.
Appendix D
Details of Pre-Filtration and Filtration Units
INDUSTRIAL WATER FILTRATION SYSTEMS

- SAND MEDIA FILTERS
- MULTI-MEDIA FILTERS
- GRANULAR ACTIVATED CARBON FILTERS

MOORE ENGINEERING & SALES, INC.
1500 West Hampden #5D
Englewood, CO 80110
(303) 789-1009 • Fax 789-1467
Yardney Water Management Systems offers a complete line of single media, multi-media and granular activated carbon filtration systems for industrial and commercial uses. Yardney has been providing dependable water filtration systems since 1965. Yardney filters have been used across a broad spectrum of industries to meet varied water quality standards where suspended solids removal or reduction is required.

The standard Yardney product line includes three types of automatic backwashing filters. These three distinctly different types of backwashing media filters include the filtration technologies of sand media filtration, multi-media filtration and granular activated carbon filtration. Through the proper selection of the Yardney filter best suited for your specific applications, suspended solids can be removed to meet your specified water quality needs.

Yardney Single Media Sand Filters are commonly used for pre-treatment of reverse osmosis or deionized water systems, prefiltration for cartridge or bag filtration systems, filtration of industrial water for plant reuse and general filtration applications where removal of suspended solids down to 20 microns in size is desired.
Yardney Multi-Media Filtration provides the benefits of Single Media Sand Filtration with the enhanced capabilities of smaller particle removal with the ability to entrap greater amounts of suspended solid contaminants between backwash cycles.

Through the use of multiple layers of specially selected filter medias "progressive filtration" is achieved through the media layers. The top layer of the filter media entraps and holds the larger size particles of contamination allowing the smaller particles to be passed to the next media layer for progressive removal. The final media layer "polishes" the water removing suspended solids particles down to 10 microns in size.

Depending upon the nature of the particles to be removed and the solids loading level, three to five individual media layers will be used in the Yardney Multi-Media Filtration System. The permanent medias used in Yardney Multi-Media Filters are selected based upon media particle size as well as its specific gravity to assure stratification of the media layers.

As with the Yardney Sand Media Filter the Multi-Media Filter operates automatically with the backwashing function being initiated by elapsed time or pressure differential to assure consistent performance.

Yardney Multi-Media Filtration provides optimum particle removal, high dirt load capability, low pressure drop and on-line automatic backwashing operation.
Yardney Granular Activated Carbon Filtration Systems utilize the principles of adsorption for the removal of compounds too small for removal with multi-media filtration technology. These automatic systems are extremely effective in removing chlorine and chlorine related compounds, organic chemicals, tastes and odors, halogenated organic compounds and other highly dispersed contaminants.

The use of granular activated carbon in removing these substances from water streams is extremely successful through the adsorption properties of granular activated carbon media. With the activated carbon's strong affinity for impurity adsorption, water being processed with activated carbon must generally be pre-filtered utilizing sand media or multi-media filtration prior to contact with the carbon media.

Through the pre-filtration process suspended solids that tend to foul the porosity of activated carbon are eliminated, thus extending the useful life of the activated carbon media. During the adsorption process granular activated carbon provides micro-purification of water removing both micronic as well as sub-micronic materials.

Yardney Carbon Filtration Systems incorporate the use of automatic backwashing controls to maintain the carbon bed in a clean and uncompacted condition. Granular activated carbon is available in various grades and types. Selection of the proper carbon media is dependent upon the contaminant types to be removed and the specific operating objectives of the system. Granular Activated Carbon Media requires periodic replacement with new carbon as the adsorption capabilities of the carbon are diminished over time and use.
Media Filtration is the most effective method for removal of suspended organic and inorganic solids from water. Yardney media filters operate on the same basic principle as nature's own ground water filtering process. Contaminated, unfiltered water enters the system through a deflector in the top of the filter and flows, under pressure, through the media where solid particulate is entrapped. Yardney media filters are known for their capacity to extract and hold large amounts of water-borne particulate while continuing to deliver a rated flow of clean water.

In addition to the Yardney filter's ability to filter large volumes of water with very little pressure drop, one of the outstanding features is the simple backwash operation. This excellent cleaning process is possible due to the highly efficient underdrain systems utilized in Yardney media filters.

During the filtration process, suspended solids are trapped in the filter media. Periodically this contaminant must be removed. This procedure is called backwashing.

The Yardney backwash process is one of the outstanding features of this unique media filter. Through the use of a special three-way valve the flow through each tank is reversed, causing a turbulent expansion of the media and the flushing of entrapped particulate matter. The backwash flow is segregated for proper disposal in a separate discharge line. With the Yardney filter, backwash is accomplished with clean water from adjacent tanks.

Single tank Yardney filtration systems require an external backwash water source but operate in much the same way as multiple tank systems.
The Yardney Industrial Filtration product line encompasses three different types of filtration technology: Sand Media, Multi-Media and Carbon Media in flow ranges from 10 GPM up to several thousand gallons per minute. This is accomplished in the Yardney standard product line using filter tanks from 18” in diameter through 54” in diameter. Yardney custom designed engineered systems utilize filter vessels up to 10’ in diameter. The design of standard systems includes both single tank as well as multiple tank systems. A.S.M.E. code stamped systems are available on special request.

Yardney systems feature as standard the finest quality system construction including type 304 stainless steel underdrains and internal fusion bonded epoxy tank linings.

Standard systems are shipped skid mounted on a structural steel skid ready for simplified installation and start up. Yardney industrial filtration systems are complete including filter vessels, interconnecting piping, valves and automatic system controls.

Yardney filtration systems provide creative solutions to the problems of suspended solids removal. Whether the solution to your contamination removal is a standard Yardney system or a Yardney engineered system, the same high quality construction and attention to engineering details are employed. Yardney industrial filtration systems are the solution to industrial water quality problems... Yardney eliminates the cause rather than treating the symptoms of industrial water quality problems.
Liquid Filtration Vessels

MOORE ENGINEERING & SALES, INC.
1600 West Hampden #5D
Englewood, CO 80110
(303) 769-7709 • Fax 769-7497

U.F. STRAINRITE®
Strainrite: Reliable, environmentally sound solutions

Liquid Filtration Solutions
Since 1978, U.F. Strainrite has been designing and manufacturing filtration products for industry. We are a worldwide supplier of industrial liquid filtration equipment and bulk packaging materials, and committed to innovative and environmentally sound solutions.

Long-term Partnerships
Our consultative selling approach to marketing focuses on custom solutions to filtration problems. We commit the time and resources to tailor our products to our clients' unique requirements. By working with us, our clients receive:
- Realized operational cost savings
- Improved process efficiency
- Enhanced finished product quality
- Reduced waste costs

Expanding Product Line
We specialize in the manufacture of ASME code pressure vessels, liquid filter bags, and semi-rigid bulk packaging bags, producing all our products in our Lewiston, Maine plant. Extensive research and development, coupled with rigid quality control provides our clients with consistent, reliable filtration products.

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Complete line of quality filter bags
conscious filtration solutions.

Liquid Filtration Vessels
We manufacture a variety of standard design vessels to handle flow rates between 10 gpm to 2,500 gpm at pressure ratings ranging from 75 to 600 psi. For special system requirements, our engineers will custom design a system. Standard CM and UF design filter vessels are constructed from the highest quality carbon steel, 304 or 316 stainless steel and conform to ASME code standards.

Assurance Testing
Hydro-static testing is performed on all vessels at 1.5 times the designed operating pressure. We also offer special quality assurance tests which include X-ray, Magnetic Particle, Ultra-sonic and Brinell hardness testing.

Call Us-1-207-777-3100
Our field sales professionals and distributors, in conjunction with our technical support engineers, will work with you to provide a needs assessment outlining which U.F. Strainrite product, service or combination will best suit your requirements. Call our corporate office, and we will provide you with detailed information about how a relationship with U.F. Strainrite would benefit your firm.
Inline low flow filter vessels
UF1-30 and UF1-65

Inline filter vessels come in two standard sizes 4.5" ID x 16" L, UF1-30, and 4.5" ID x 27.5" L, UF1-65. Both sizes come in two different designs (Band Clamp & Swing Bolt) and three different pressure ratings. All cover-sealing designs are easily accessible and don’t require special tools to release the cover seal in order to access the filter bag or basket.

Standard Features
- Available in Carbon Steel, 304 and 316 Stainless Steel
- Inlet/outlet orientation: Side-in Bottom-out or Side-in Side-out
- Low pressure drop
- Positive cover seal
- Available O’ring materials: Buna N, EPR, Viton A, Teflon, & Teflon Encapsulated
- Easy cleanability
- Heavy duty perforated basket
- ASME code stamp available on all designs
- Band clamp and swing bolt closures
- .25" NPT differential pressure gauge/vent tap
- Pipe sizes from .5" to 2" NPT, RFF or Quick Disconnect connections
- Greater surface area than our competitors equivalent models (see Comparison Chart)
Optional Features
- Epoxy coating, electro-polish and fuse coating
- Higher pressure ratings available up to 3,000 psi
- Steam jacketed
- Bag hold down devices
- Custom designs
- Sanitary constructions
- Mesh-lined basket for straining applications - 50 micron and higher

Maximum Recommended Flow Rates
For the following recommended flow rates, vessels need a minimum inlet/outlet size of 1" NPT. The recommended flow for basket and filter combination is for nominally rated filter bags not for our high efficiency filter bag line.

<table>
<thead>
<tr>
<th>Product</th>
<th>Basket Strainer</th>
<th>Mesh Lined Basket Strainer</th>
<th>Retainer Basket with Filter Bag</th>
</tr>
</thead>
<tbody>
<tr>
<td>UF 1-30</td>
<td>60 gpm</td>
<td>45 gpm</td>
<td>30 gpm</td>
</tr>
<tr>
<td>UF 1-65</td>
<td>125 gpm</td>
<td>90 gpm</td>
<td>65 gpm</td>
</tr>
</tbody>
</table>

Surface Area Comparison Chart

<table>
<thead>
<tr>
<th>Company</th>
<th>Style No.</th>
<th>Surface Area Sq. Ft.</th>
<th>Style No.</th>
<th>Surface Area Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.F. Strainrite</td>
<td>UF 1-30</td>
<td>0.95</td>
<td>UF 1-65</td>
<td>2.1</td>
</tr>
<tr>
<td>Rosedale</td>
<td>4-6</td>
<td>0.5</td>
<td>4-12</td>
<td>1.0</td>
</tr>
<tr>
<td>FSI</td>
<td>BFN 13</td>
<td>0.5</td>
<td>BFN 14</td>
<td>1.0</td>
</tr>
</tbody>
</table>
All 90 and 180 style filter bag/strainer vessels are designed with a recessed basket, a volume displacer permanently welded to the top cover, and a 304 stainless steel wire mesh retainer basket. Wire mesh baskets increase available filtration surface area by 30% compared to a perforated retainer basket. We offer our 90 and 180 size vessels in two different styles, UF and CQX, and a variety of pressure ratings with 150 psi being standard.

**Standard Features**
- Available in Carbon Steel, 304 and 316 Stainless Steel
- Adjustable height tri-pod stand
- Built-in volume displacer in cover
- Inlet/outlet orientation: Side-in Bottom-out (standard) or Side-in Side-out
- Low pressure drop
- Positive cover seal
- Available O’ring materials: Buna N, EPR, Viton A, Teflon, & Teflon Encapsulated
- Easy cleanability
- 304 SS wire mesh basket
- ASME Code stamp available on all UF style vessels
- Swing bolt closures
- .25” NPT differential pressure gauge/vent tap
- Pipe sizes from .75” to 3” NPT, RFF or Quick Disconnect connections
Optional Features
- Epoxy coating, electropolish and fuse coating
- Higher pressure ratings available up to 3,000 psi
- Steam jacketed
- Differential pressure gauge taps — .25" or .5" NPT
- Bag hold down devices
- Custom designs
- Sanitary constructions
- Mesh-lined basket for straining applications — 50 micron and higher
- Other materials of construction are titanium and hastelloy

The U.F. Strainrite Advantage
- Recessed basket with welded volume displacer — allows for cleaner operation because liquid is several inches below lid
- Retainer basket with handle — allows for easy and quick access to filter bag and basket
- Wire mesh retainer basket — allows for longer filter time resulting in fewer change-outs as compared to perforated baskets (refer to page 14)
- Double O’ring seal — assures high quality filtration and minimizes bypass potential

Recommended Flow Rates and Surface Area
For the following recommended flow rates, vessels need a minimum inlet/outlet size of 2" NPT. The recommended flow for basket and filter combination is for nominally rated filter bags not for our high efficiency filter bag line.

<table>
<thead>
<tr>
<th>Product</th>
<th>Basket Strainer</th>
<th>Mesh lined Basket Strainer</th>
<th>Retainer Basket with Filter Bag</th>
<th>Surface Area Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UF 1-90</td>
<td>150 gpm</td>
<td>110 gpm</td>
<td>75 gpm</td>
<td>2.25</td>
</tr>
<tr>
<td>UF 1-180</td>
<td>300 gpm</td>
<td>220 gpm</td>
<td>150 gpm</td>
<td>4.50</td>
</tr>
</tbody>
</table>

U.F. STRAINRITE
207-777-3100
Multi-Bag Filter Bag Vessels

Multi-bag/strainer vessels offer large surface areas capable of handling up to 4800 gpm in a single housing. Increasing surface area allows for longer processing time prior to filter change-out. Containing anywhere from 2 to 24 baskets in a single vessel, our standard Side-inlet Side-outlet offers the greatest flexibility and doesn't require a platform to be built in order to change-out or clean the filter elements or strainers (refer to diagram and charts).

**Standard Features**
- Available in Carbon Steel, 304 and 316 Stainless Steel
- Inlet/outlet orientation: Side-in Side-out (standard) or Bottom-in Bottom-out (optional)
- Low pressure drop
- Positive cover seal
- Available O’ring materials: Buna N, EPR, Viton A, Teflon, & Teflon Encapsulated
- Easy cleanability
- 304 SS wire mesh basket (standard)
- ASME code stamp available
- Swing bolt closures
- 1” to 2” NPT drain port on bottom
- .50” to 1” NPT pressure gauge/vent tap
- Pipe sizes from 2” to 14” RFF connections

**Optional Features**
- Epoxy coating, electro-polish, and fuse or teflon coating
- Higher pressure ratings available up to 3,000 psi
- Variety of lid lifting devices — Enerpac, Davit and Manual Wheel
- Steam jacketed
- Bag hold down devices
- Sanitary constructions
- Mesh-lined basket for straining applications — 50 micron and higher

U.F. STRAINRITE
207•777•3100
### Dimensions Chart for Multi-Bag Vessels, Bottom-in Bottom-out

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>No. of Baskets</th>
<th>Std. Conn. RFF</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Surface Area Sq. Ft.</th>
<th>Max. GPM Strainer</th>
<th>Max. GPM Filter Bags</th>
<th>Shipping Weight lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UF 2-180</td>
<td>2</td>
<td>3&quot;</td>
<td>58&quot;</td>
<td>44&quot;</td>
<td>26&quot;</td>
<td>16&quot;</td>
<td>9.0</td>
<td>600</td>
<td>300</td>
<td>275</td>
</tr>
<tr>
<td>UF 3-180</td>
<td>3</td>
<td>3&quot;</td>
<td>67&quot;</td>
<td>44&quot;</td>
<td>26&quot;</td>
<td>20&quot;</td>
<td>13.5</td>
<td>900</td>
<td>450</td>
<td>625</td>
</tr>
<tr>
<td>UF 4-180</td>
<td>4</td>
<td>4&quot;</td>
<td>79&quot;</td>
<td>46&quot;</td>
<td>28&quot;</td>
<td>24&quot;</td>
<td>18.0</td>
<td>1200</td>
<td>600</td>
<td>875</td>
</tr>
<tr>
<td>UF 5-180</td>
<td>5</td>
<td>6&quot;</td>
<td>82&quot;</td>
<td>48&quot;</td>
<td>32&quot;</td>
<td>26&quot;</td>
<td>22.5</td>
<td>1500</td>
<td>750</td>
<td>1108</td>
</tr>
<tr>
<td>UF 6-180</td>
<td>6</td>
<td>6&quot;</td>
<td>82&quot;</td>
<td>48&quot;</td>
<td>32&quot;</td>
<td>26&quot;</td>
<td>27.0</td>
<td>1800</td>
<td>900</td>
<td>1130</td>
</tr>
<tr>
<td>UF 7-180</td>
<td>7</td>
<td>8&quot;</td>
<td>85&quot;</td>
<td>59&quot;</td>
<td>36&quot;</td>
<td>30&quot;</td>
<td>31.5</td>
<td>2100</td>
<td>1050</td>
<td>1170</td>
</tr>
<tr>
<td>UF 8-180</td>
<td>8</td>
<td>8&quot;</td>
<td>89&quot;</td>
<td>59&quot;</td>
<td>36&quot;</td>
<td>30&quot;</td>
<td>35.5</td>
<td>2400</td>
<td>1200</td>
<td>1355</td>
</tr>
<tr>
<td>UF 10-180</td>
<td>10</td>
<td>10&quot;</td>
<td>90&quot;</td>
<td>64&quot;</td>
<td>46&quot;</td>
<td>36&quot;</td>
<td>44.5</td>
<td>300</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>UF 12-180</td>
<td>12</td>
<td>12&quot;</td>
<td>90&quot;</td>
<td>64&quot;</td>
<td>46&quot;</td>
<td>42&quot;</td>
<td>54.0</td>
<td>3600</td>
<td>1800</td>
<td>1610</td>
</tr>
</tbody>
</table>

### Dimensions Chart for Multi-Bag Vessels, Side-in Side-out

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>No. of Baskets</th>
<th>Std. Conn. RFF</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Surface Area Sq. Ft.</th>
<th>Max. GPM Strainer</th>
<th>Max. GPM Filter Bags</th>
<th>Shipping Weight lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UF 2-180</td>
<td>2</td>
<td>3&quot;</td>
<td>55&quot;</td>
<td>40&quot;</td>
<td>14&quot;</td>
<td>16&quot;</td>
<td>9.0</td>
<td>600</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>UF 3-180</td>
<td>3</td>
<td>3&quot;</td>
<td>55&quot;</td>
<td>40&quot;</td>
<td>14&quot;</td>
<td>20&quot;</td>
<td>13.5</td>
<td>900</td>
<td>450</td>
<td>565</td>
</tr>
<tr>
<td>UF 4-180</td>
<td>4</td>
<td>4&quot;</td>
<td>55&quot;</td>
<td>40&quot;</td>
<td>14&quot;</td>
<td>24&quot;</td>
<td>18.0</td>
<td>1200</td>
<td>600</td>
<td>765</td>
</tr>
<tr>
<td>UF 5-180</td>
<td>5</td>
<td>6&quot;</td>
<td>59&quot;</td>
<td>40&quot;</td>
<td>16&quot;</td>
<td>26&quot;</td>
<td>22.5</td>
<td>1500</td>
<td>750</td>
<td>995</td>
</tr>
<tr>
<td>UF 6-180</td>
<td>6</td>
<td>6&quot;</td>
<td>59&quot;</td>
<td>40&quot;</td>
<td>16&quot;</td>
<td>26&quot;</td>
<td>27.0</td>
<td>1800</td>
<td>900</td>
<td>1020</td>
</tr>
<tr>
<td>UF 7-180</td>
<td>7</td>
<td>8&quot;</td>
<td>66&quot;</td>
<td>42&quot;</td>
<td>18&quot;</td>
<td>30&quot;</td>
<td>31.5</td>
<td>2100</td>
<td>1050</td>
<td>1055</td>
</tr>
<tr>
<td>UF 8-180</td>
<td>8</td>
<td>8&quot;</td>
<td>66&quot;</td>
<td>42&quot;</td>
<td>18&quot;</td>
<td>30&quot;</td>
<td>35.5</td>
<td>2400</td>
<td>1200</td>
<td>1220</td>
</tr>
<tr>
<td>UF 9-180</td>
<td>9</td>
<td>10&quot;</td>
<td>78&quot;</td>
<td>53&quot;</td>
<td>18&quot;</td>
<td>36&quot;</td>
<td>40.0</td>
<td>2700</td>
<td>1350</td>
<td>1310</td>
</tr>
<tr>
<td>UF 10-180</td>
<td>10</td>
<td>10&quot;</td>
<td>78&quot;</td>
<td>53&quot;</td>
<td>18&quot;</td>
<td>36&quot;</td>
<td>44.5</td>
<td>3000</td>
<td>1500</td>
<td>1350</td>
</tr>
<tr>
<td>UF 11-180</td>
<td>11</td>
<td>12&quot;</td>
<td>83&quot;</td>
<td>58&quot;</td>
<td>20&quot;</td>
<td>42&quot;</td>
<td>49.5</td>
<td>3300</td>
<td>1650</td>
<td>1420</td>
</tr>
<tr>
<td>UF 12-180</td>
<td>12</td>
<td>12&quot;</td>
<td>83&quot;</td>
<td>58&quot;</td>
<td>20&quot;</td>
<td>42&quot;</td>
<td>54.0</td>
<td>3600</td>
<td>1800</td>
<td>1450</td>
</tr>
</tbody>
</table>

All the above dimensions are for **REFERENCE ONLY.**
600 Series Filter Bag Vessels

The 600 Series filter bag/strainer vessels are designed with a recessed basket and a volume displacer permanently welded to the top cover. These vessels are available in three different sizes and a variety of pressure ratings with 150 psi being standard. Standard swing bolt closure on all three designs allows for quick accessibility when a filter bag or strainer needs to be replaced. No special tools are required to release the cover seal.

**Optional Features**
- Epoxy coating, electropolish and fuse coating
- Higher pressure ratings available up to 3,000 psi
- Steam jacketed
- Bag hold down devices
- Custom designs
- Sanitary constructions
- Mesh-lined basket for straining applications — 50 micron and higher

**Recommended Flow Rates and Surface Area**

For the following recommended flow rates, vessels need a minimum inlet/outlet size of 2" NPT. The recommended flow for basket and filter combination is for nominally rated filter bags not for our high efficiency filter bag line.

<table>
<thead>
<tr>
<th>Unit Type</th>
<th>Basket Strainer</th>
<th>Mesh lined Basket Strainer</th>
<th>Retainer Basket with Filter Bag</th>
<th>Surface Area Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UF 1-612</td>
<td>80 gpm</td>
<td>55 gpm</td>
<td>40 gpm</td>
<td>1.3</td>
</tr>
<tr>
<td>UF 1-618</td>
<td>125 gpm</td>
<td>90 gpm</td>
<td>65 gpm</td>
<td>2.0</td>
</tr>
<tr>
<td>UF 1-630</td>
<td>185 gpm</td>
<td>135 gpm</td>
<td>100 gpm</td>
<td>3.4</td>
</tr>
</tbody>
</table>

**Standard Features**
- Available in Carbon Steel, 304 and 316 Stainless Steel
- Adjustable height tri-pod stand
- Built-in volume displacer in cover
- Inlet/outlet orientation: Side-in Bottom-out (standard) or Side-in Side-out (optional)
- Low pressure drop
- Positive cover seal
- Available O’ring materials: Buna N, EPR, Viton A, Teflon, & Teflon Encapsulated
- Easy cleanability
- Heavy duty perforated basket
- ASME code stamp available on all three designs
- Swing bolt closures
- .25" NPT differential pressure gauge/vent tap
- Pipe sizes from .75" to 3" NPT, RFF or Quick Disconnect connections
U.F. Strainrite is proud to offer a full line of cartridge vessels. These systems are available in a variety of sizes capable of holding between 1 and 200 single or quadruple length string wound, molded or pleated cartridges. Our cartridge vessels are manufactured to the same high quality standards as our filter bag vessels.

**Standard Features**
- Swing bolt closure which requires no special tools to open housing
- Positive sealed lid
- Low pressure drop
- Easy cleanability
- Inlet/outlet orientation: Side-in Bottom-out

**Optional Features**
- Inlet/Outlet size
- Materials of construction: Carbon Steel, 304 or 316 Stainless Steel
- O’ring materials: Buna N, Viton, EPR, Teflon
- V posts or threaded center posts
- ASME code or non-code design

---

**CTK**

<table>
<thead>
<tr>
<th>CTK</th>
<th>Cartridge Vessel (C / N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Diameter of vessel</td>
</tr>
<tr>
<td>2</td>
<td>Length of cartridge: 1 = 10” long; 2 = 20” long; 3 = 30” long; 4 = 40” long</td>
</tr>
<tr>
<td>6</td>
<td>Number of cartridges</td>
</tr>
<tr>
<td>2</td>
<td>Inlet and outlet nominal pipe size</td>
</tr>
<tr>
<td>F</td>
<td>Blank = NPT; F = Ansi B16 Raised Face Flange; TC = Sanitary Connection</td>
</tr>
<tr>
<td>B</td>
<td>A = Carbon Steel; B = 304 Grade Stainless Steel; C = 316 Grade Stainless Steel; D = 316L Grade Stainless Steel</td>
</tr>
<tr>
<td>1</td>
<td>Maximum allowable working pressure: 1 = 75; 2 = 150; 3 = 300; 4 = Special</td>
</tr>
<tr>
<td>N</td>
<td>N = Non code; C = Code U and UM</td>
</tr>
<tr>
<td>*</td>
<td>Special Information:(tp)</td>
</tr>
<tr>
<td></td>
<td>Drawing Number</td>
</tr>
<tr>
<td></td>
<td>TP = Threaded Post</td>
</tr>
<tr>
<td>3M</td>
<td>222 Style Seal / Fin Back</td>
</tr>
<tr>
<td>222</td>
<td>Special PSI</td>
</tr>
<tr>
<td></td>
<td>222 = 222 Style Seal / Flat Back</td>
</tr>
<tr>
<td>TFE</td>
<td>Teflon Coated</td>
</tr>
</tbody>
</table>

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U.F. STRAINRITE
207•777•3100
Manifold Filtration Systems

Duplex filter systems offer the greatest flexibility for continuous on-line filtration requirements. These designs allow for continuous operation by directing the flow from one vessel to another by opening and closing of valves. This allows one side to be serviced, change-out filter media, while the other vessel is in use.

Standard Features
- Utilize butterfly valves — known for their effective seals and low cost
- Valves are easily serviced without having to disrupt other valves or piping
- Soft-seated bubble tight closure
- Designed with four elbows to minimize pressure drop across the system
- Vent and drain ports used to evacuate and fill vessels
- Mechanical stops which assure that valves are completely open or closed
- Available with UF, CQX, CM or multi-bag vessel designs

Multiplex filtration systems consist of three or more filter vessels piped in series or parallel. U.F. Strainrite offers countless configurations and flow designs depending on the customer's specific needs. The standard design is to configure the vessels in parallel with isolation valves on each vessel (refer to multiplex picture). A four-vessel system can also be configured in a box design, which allows for graduated filtration and continuous flow. Contact our design engineers to configure a system that meets your specific needs.
U.F. Strainrite's compact and durable portable filtration carts (PFC) are ready to use filtration systems complete with pump and motor assemblies. The PFC's are designed to offer customers the greatest flexibility to handle a variety of applications throughout a manufacturing facility. Available in a two or four wheel design, these ready for use carts offer many standard features.

**Standard Features**
- Portability to move from one line or application to the next
- Complete prefabricated system
- Four different pump and motor configurations available
- Vessels are either CM, UF, or CQX type
- Swing bolt design
- 304 SS wire mesh retainer baskets
- Two or more vessels will be piped in series (standard)
- Vent and pressure gauge taps
- Side-in Bottom-out flow design
- Heavy duty wheels

**Optional Features**
- Epoxy, Teflon or Fuse coatings of vessels
- ASME code or non-code stamped
- Vessels configured in parallel
- Differential pressure gauges
- Side-in Side-out flow design
Wire Mesh vs. Perforated

Standard Features
• #1 and #2 size baskets use a wire mesh that is a 10 x 10 wire and 1600 micron
• Perforation for the 600 Series, UF 1-30 and UF 1-65 Filter Bag Vessels are 1/8" hole on 3/16" center

Advantages of Wire Mesh over Perforated
• Greater flow rates — increased production capacity — improved profits
• 28% to 38% longer bag life — reduced filter bag operating costs — improved profits
• Less down-time — increased productivity — improved profits
• Less product loss — which occurs during filter bag change-out — improved profits
• Less filter bag waste to dispose of — waste minimization — improved profits
• Easier replacement of filter bags since positive pressure tends to push clogged media deep into the perforated holes of the basket — reduced labor time for change-out — improved profits

Total Flow Filtered

<table>
<thead>
<tr>
<th>Test</th>
<th>10 x 10</th>
<th>Perf. Metal Wire Mesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10 x 10</td>
<td>Perf. Metal 1600 Micron</td>
</tr>
<tr>
<td>ΔP</td>
<td>15 psi</td>
<td>1070 gal. 1070 gal.</td>
</tr>
<tr>
<td></td>
<td>20 psi</td>
<td>2190 gal. 2190 gal.</td>
</tr>
<tr>
<td></td>
<td>25 psi</td>
<td>4380 gal. 4380 gal.</td>
</tr>
<tr>
<td></td>
<td>27 psi</td>
<td>5480 gal. 5480 gal.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>10 x 10</th>
<th>Perf. Metal Wire Mesh</th>
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<tbody>
<tr>
<td>B</td>
<td>10 x 10</td>
<td>Perf. Metal 1600 Micron</td>
</tr>
<tr>
<td>ΔP</td>
<td>15 psi</td>
<td>1005 gal. 1005 gal.</td>
</tr>
<tr>
<td></td>
<td>20 psi</td>
<td>2165 gal. 2165 gal.</td>
</tr>
<tr>
<td></td>
<td>25 psi</td>
<td>4300 gal. 4300 gal.</td>
</tr>
<tr>
<td></td>
<td>27 psi</td>
<td>3550 gal. 3550 gal.</td>
</tr>
</tbody>
</table>
O’Ring Chart

Single Basket Vessels

O’Rings

348 4.3/8” ID x 4 3/4” OD x 3/16” TK
363 6 1/2” ID x 6 7/8” OD x 3/16” TK
369 8” ID x 8 3/8” OD x 3/16” TK
444 7 3/4” ID x 8 1/4” OD x 1/4” TK
447 9” ID x 9 1/2” OD x 1/4” TK

O’Ring Materials

Buna N
EPR
Viton A
Teflon
Teflon Encapsulated

Sizing Filter Bags

1. No. 1 size not to exceed 90 GPM
2. No. 2 size multiply by factor of 2.1 to the flow rate on the chart.

<table>
<thead>
<tr>
<th>Line 1</th>
<th>Line 2</th>
<th>Line 3</th>
<th>Line 4</th>
<th>Line 5</th>
<th>Line 6</th>
<th>Line 7</th>
<th>Line 8</th>
<th>Line 9</th>
<th>Line 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3 AP</td>
<td>1.3 SP</td>
<td>5 AP</td>
<td>5 SP</td>
<td>10 AP</td>
<td>10 SP</td>
<td>15 AP</td>
<td>25 AP</td>
<td>50 SP</td>
<td>250 AP</td>
</tr>
<tr>
<td>75 AP</td>
<td>100 AP</td>
<td>100 AP</td>
<td>100 AP</td>
<td>200 AP</td>
<td>250 AP</td>
<td>500 AP</td>
<td>500 AP</td>
<td>500 AP</td>
<td>600 AP</td>
</tr>
</tbody>
</table>

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Differential Pressure Drop Chart

Fluid Permeability — GPM / Bag / 1.0 PSI

** UF 1-30, 65 300 psi uses Swing Bolt Cover
NOTES:
1. FLOW RATE DESIGN - 801 GPM
2. MAXIMUM WORKING PRESSURE - 283 PSI
3. ELECTRICAL: CENTRALIZED 120VAC
4. AIR SUPPLY REQUIRED - 70 PSI @ 3 CFM
5. MEDIA REQUIREMENTS PER TANK:
   A. CRUSHED BRICK - 90 CU FT.
   B. GABION - MANUFACTURED - 35 CU FT.
   C. GRANITE - POLISHED - 165 CU FT.
   D. PÅTHRAPE - PRIMARY - 165 CU FT.
6. WEIGHTS (APPARENT):
   SHIPPING - 3276 LBS (LESS MEDIA)
   MEDIA - 1320 LBS
   OPERATION - 90,460 LBS

MM 3660-4AD SPECIAL