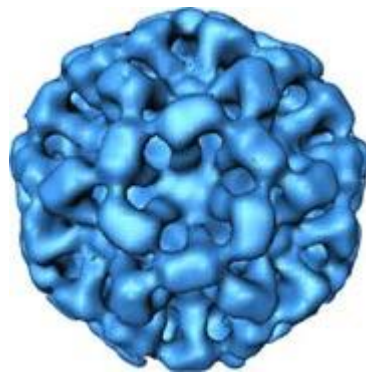


DRINKING WATER NOROVIRUS OUTBREAK AT SKYLINE RANCH IN PLATORO, CO

JUNE – SEPTEMBER 2007



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FINAL REPORT

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Colorado Department
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Introduction

This report is intended to provide an overview of the norovirus outbreak that occurred at the Skyline Lodge (Lodge) in Platoro, Colorado during the period of June 1, 2007 through September 30, 2007 (Figure 1). During this time period, it is estimated that over 77 people were infected with norovirus.

The purpose of this report is to:

- Document the identification of the norovirus outbreak that occurred at the Skyline Lodge in Platoro, Colorado during the summer of 2007;
- Describe the Division's response to the outbreak;
- Report the follow-up activities conducted by the Division; and
- Offer lessons learned after the outbreak.

This report was prepared by the Colorado Department of Public Health and Environment's (CDPHE) Safe Drinking Water (SDW) Program. The SDW Program functions under the Water Quality Control Division (Division).



Figure 1. Map of Colorado and Location of Platoro, CO (Source: MapQuest)

The Skyline Lodge Water System

The Lodge is a seasonal resort located in Platoro, Colorado that typically operates May through October. The site consists of 11 cabins and six lodge rooms. The Lodge has a full service restaurant, mercantile, gift shop, and sells fishing supplies (Figure 2).



Figure 2. Skyline Lodge in Platoro, CO

The Lodge (PWSID CO0211900) is classified as a transient non-community public water system. The system uses groundwater as its primary source water and serves a transient population of 60 persons with 12 service connections. The Safe Drinking Water Information System (SDWIS) database lists three wells for the Lodge. As of 2011, Well No. 1 and the Neighbor Well New 2007 (assumed to be Well 2 at the time of the outbreak) are inactive and Well 28984FR (assumed to be Well #4, the new well constructed after the outbreak) is listed as active. While it is unclear which sources were operating at the time of the drinking water outbreak, a sanitary survey conducted on August 23, 2007 noted that there was no disinfection equipment present, and Well No. 1 and Well 2 could be impacted by surface water. In SDWIS, Well No. 1 was listed inactive on August 23, 2007 and the Neighbor Well New 2007 was listed inactive on September 12, 2009. Well 28984FR had a constructed date of May 29, 2008.

After the drinking water outbreak, Well #1 was abandoned and Well #4 was drilled. The Colorado Division of Water Resources maintains the software AquaMap which lists Well #4's depth at 274 feet with a static water level at 8 feet. A Well Construction and Test Report received at the WQCD dated June 30, 2008 indicated that the well is perforated between 234 and 274 feet (Appendix A). Figure 3 provides an aerial map of the Lodge and identifies the locations of the restaurant, cabins, wells, and leach fields (all identifications are approximations based on correspondence with staff from the Lodge and sanitary inspection reports).

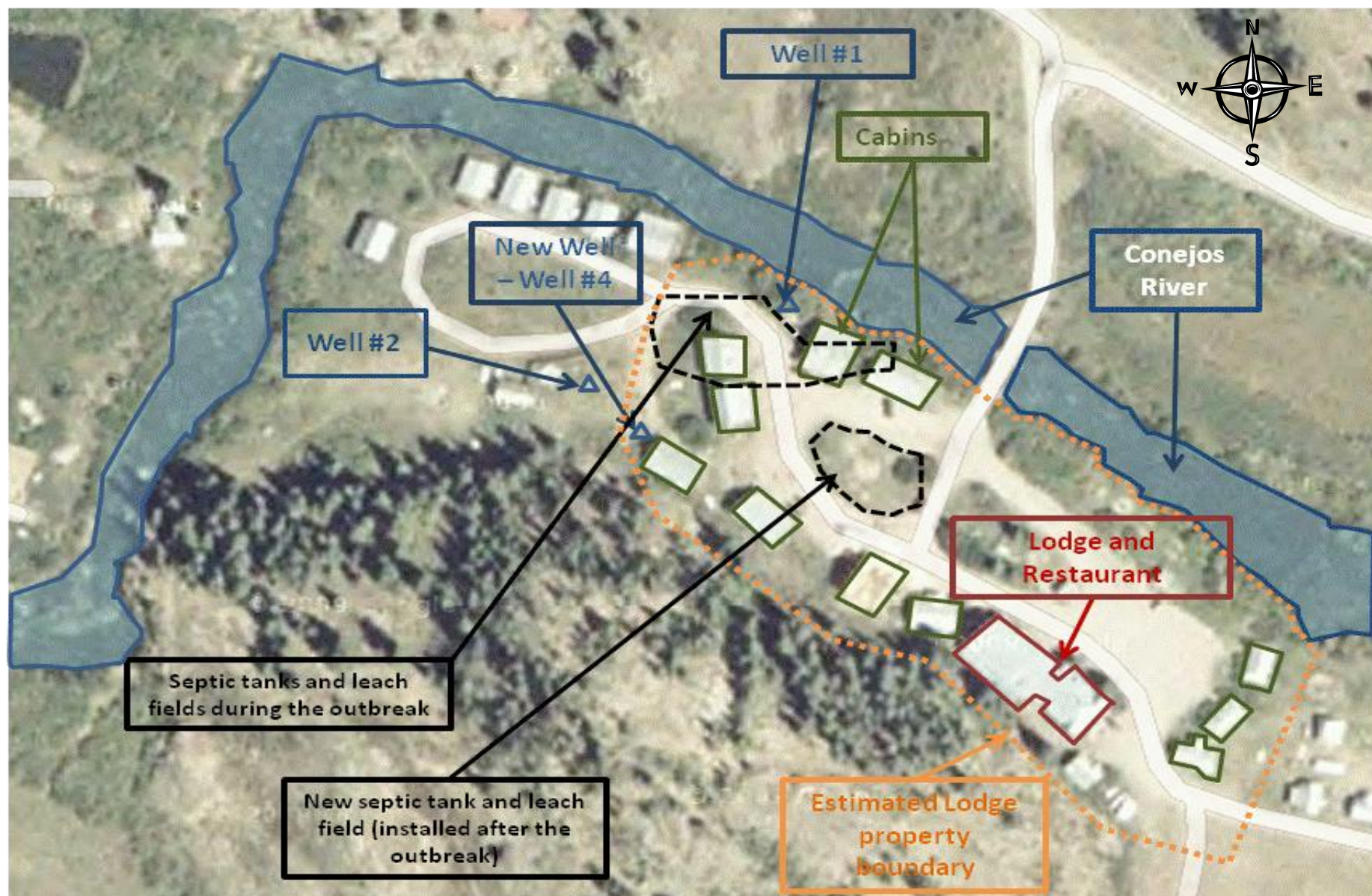


Figure 3. Aerial Map of the Skyline Lodge

During the outbreak, a sanitary survey of the water system was conducted on August 23, 2007 by Division staff. Based on the sanitary survey report, the following observations were noted:

- Well #1's disinfection equipment may not have been properly operating at the time of the outbreak. Disinfection equipment was not connected to Well #2 (also referred to as Neighbor New Well) at the time of the sanitary survey. Well #2 was connected to the system as an emergency measure and was not approved by CDPHE for permanent use. This well was also noted to be in a location that had the potential to be impacted by surface contamination.
- No disinfectant residual was detected in the distribution system at the time of the inspection.
- Well #1 was in a location that could cause it to be impacted by surface contamination. The sanitary survey report also noted that Well #1 had the potential of being impacted by nearby septic tank-soil absorption systems.
- The sanitary survey report also noted that Well #1 did not have adequate disinfection contact time between the point of disinfection and the first tap.

A second drinking water sanitary survey was conducted by the Division on September 2, 2009. Based on the sanitary survey report, the following was noted:

- The Lodge could not produce evidence of CDPHE Division approval for the new well (Well#4) or for the existing disinfection system, 1,200 gallon storage tank, pump facility, or for modifications made to the distribution system.
- A letter dated August 30, 2007 was located in CDPHE's file from Summit Engineering Company. The letter contained recommendations for upgrading the drinking water treatment system, including the installation of a 1,200 gallon storage tank with a resulting detention time of 54 minutes at peak flow.
- Well #4 lacked adequate protection around the well head. The space around the well casing above the pit-less adapter was filled with large 4 to 6-inch diameter rock. Well #4 did not have a concrete pad and the area surrounding the well exhibited uncontrolled vegetation. There were no well casing protection barriers and the surrounding soil was not graded to reduce flooding of the casing (Figure 4).
- The sanitary survey inspector noted a moderate accumulation of sediment in the storage tank. The sediment exhibited a bright green appearance indicating the presence of algae growth. This implies that there was inadequate disinfectant present to prevent algal growth in the tank (Figure 5).
- During the survey, two cabins were tested for chlorine residual and both samples tested below the detection limit of 0.1 mg/L. After the addition of sodium hypochlorite to the tank, chlorine residual was detected at levels above the detection limit.

- The Lodge had multiple septic tanks and drain fields on the property (Figure 2).
- During the outbreak, the Lodge was interconnected to other nearby properties. During the 2009 sanitary survey, staff from the Lodge indicated that historic connections to additional wells on the property and on nearby property were eliminated. Historic connections serving adjoining cabins were also eliminated. No evidence was available to confirm these statements and it could not be verified that all of the connections had been eliminated.

Based on a conversation with the Conejos County Assessor's office, the Lodge was listed for auction in October 2009. The Lodge was purchased by a new owner in 2010 and the Lodge officially opened for business on June 2, 2010. A third sanitary survey was conducted on May 17, 2010 before the Lodge opened. Based on the sanitary survey report, the following was noted:

- At the time of the sanitary survey, the Lodge did not have a certified operator in responsible charge. During the survey, the Lodge indicated that they were actively pursuing a local operator of responsible charge (ORC) and a list of local operators was provided by the Division.
- The water treatment facility and modifications to Well #4 by the previous owners had not been submitted to the Division for approval. The Lodge was requested to prepare and submit the necessary design documents to the Division for review and approval.
- Similar to the 2009 sanitary survey report, a moderate amount of sediment was visible in the existing storage tank. The sediment was bright green, suggesting the appearance of algae and a lack of disinfectant residual. The Division requested that the Lodge clean the sediment from the tank and disinfect the tank prior to opening for the 2010 season (Figure 6).
- A physical connection to an abandoned well existed in the water treatment building (Figures 7 and 8). The abandoned well was separated from the distribution system by a valve which would be a potential route for contamination to be transmitted from the abandoned well pit into the water distribution system. This well provided water after the drinking water outbreak on an emergency basis.
- Due to the failure of Well #4's pump, the Lodge's potable water system was not operable at the time of the sanitary survey and chlorine residual samples were not collected. As a result, the Lodge was required to collect, analyze, and submit bacteriological and chlorine residual samples to the Division prior to opening.
- The current owner indicated that the potable water system had a service tap to three cabins on the adjacent property to the southeast using the existing distribution system. At the time of the sanitary survey, the valve to these cabins was closed and the owner was informed that if they were going to provide water to these cabins that they would need to notify the state, provide a monitoring

location in this area, and modify the Lodge's monitoring plan accordingly. The new owner was not aware of any additional connections to other raw water sources or distribution systems. However, since no distribution system records exist, other interconnections may be present. At this time, the Division cannot determine or verify this.

- The Lodge currently lacks a general monitoring plan, operations and maintenance plan, line flushing program, and a raw water sample tap.



Figure 4. Well #4 from the 2009 Sanitary Survey



Figure 5. Green Sediment in the Lodge's Storage Tank Observed During the 2009 Sanitary Survey

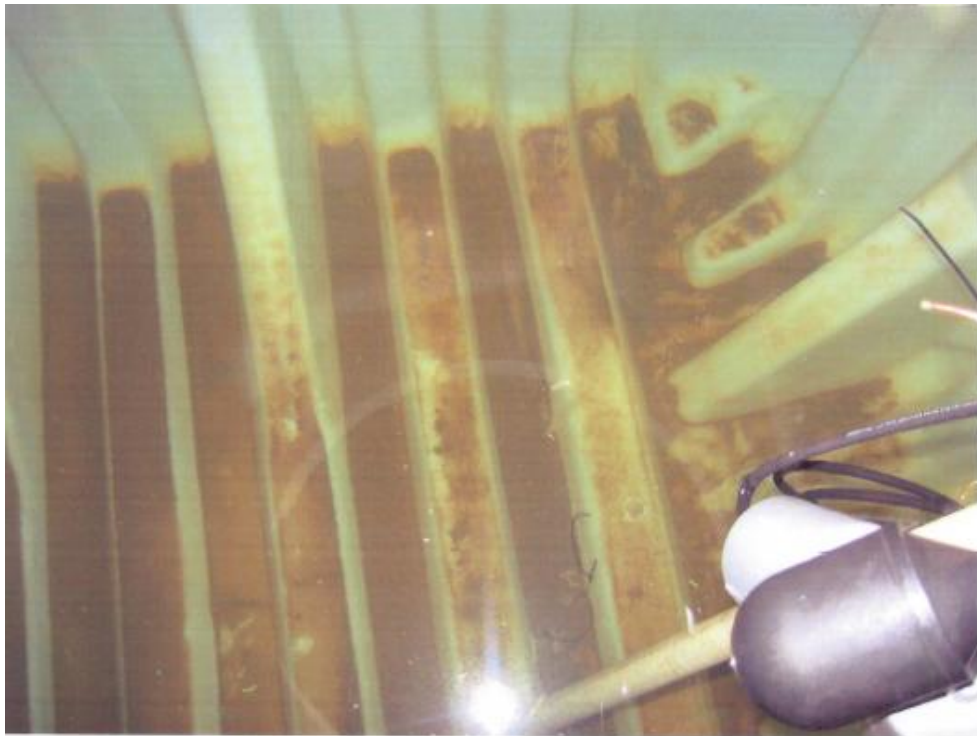


Figure 6. Green sediment in the Lodge's Storage Tank Observed During the 2010 Sanitary Survey (appears orange due to the lighting)



Figure 7. Abandoned Well Observed During the 2010 Sanitary Survey

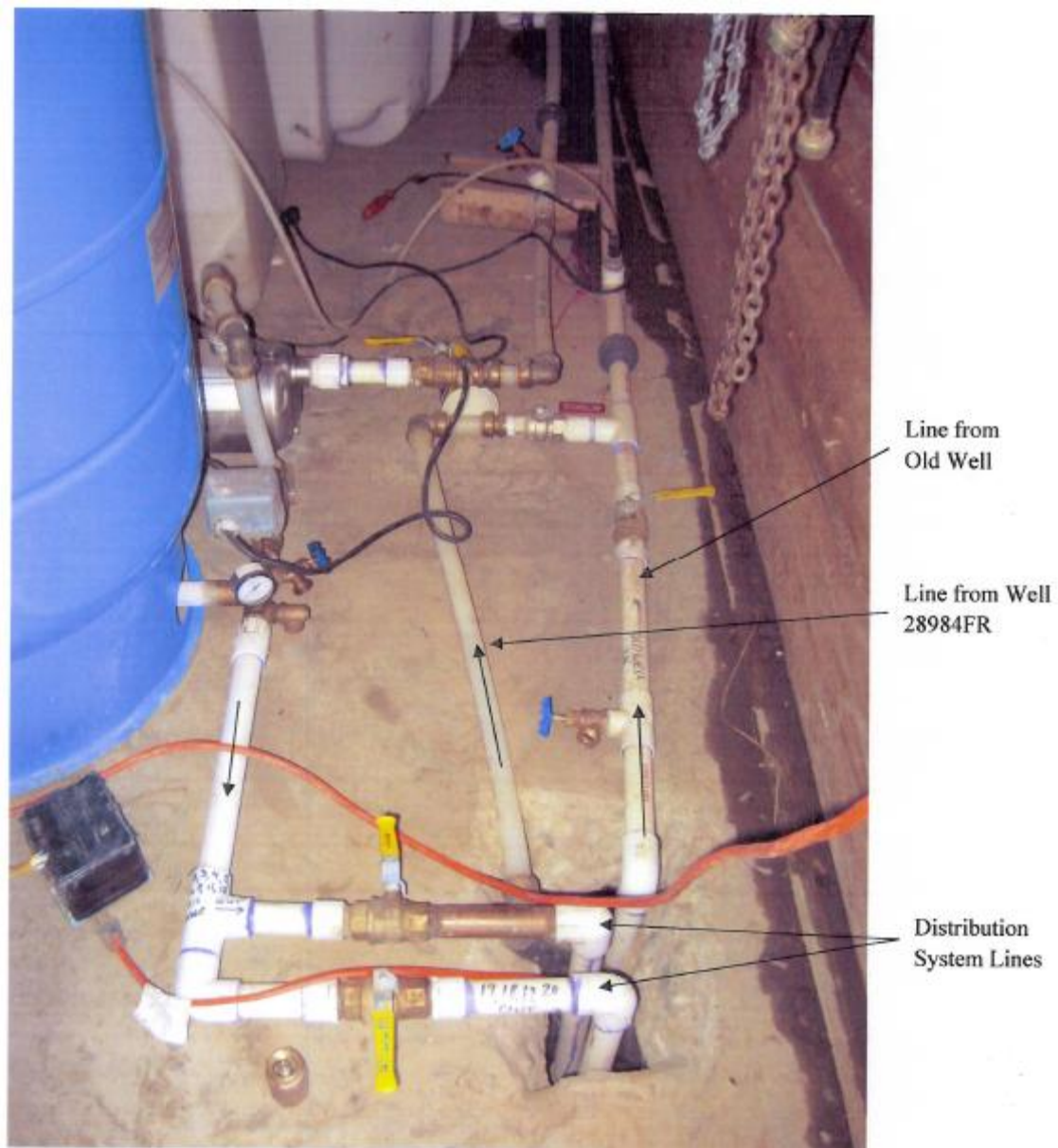


Figure 8. A Physical Connection to an Abandoned Well Observed During the 2010 Sanitary Survey

Norovirus in Drinking Water

Norovirus is the official name for a group of viruses previously described as “Norwalk-like viruses” and is a group of related, single-stranded RNA, non-enveloped viruses that cause acute gastroenteritis in humans. Norovirus has been associated with outbreaks on cruise ships and in communities, restaurants, camps, schools, institutions, and families and can be found in every part of the United States and throughout the world. Norovirus is highly contagious and is usually spread from person to person. As few as 10 viral particles may be sufficient to infect an individual¹.

The Centers for Disease Control and Prevention (CDC) estimates that 21 million cases of acute gastroenteritis each year are due to norovirus infection and it is believed that at least 50% of all food-borne outbreaks can be attributed to norovirus. From July 1997 to June 2000, the CDC reported 232 norovirus outbreaks. Of the 232 outbreaks, 57% were food-borne, 16% were due to person-to-person spread, 3% were waterborne, and 23% could not be attributed to a single cause¹.

The most common symptoms of norovirus infections include nausea, vomiting, diarrhea, and abdominal cramps. Headache and low-grade fevers may also occur. Dehydration is the most common complication, especially among the young and elderly, and may require medical attention. Symptoms typically appear within 24 to 48 hours after exposure. Most people recover within 48 to 72 hours without serious or long-term adverse health effects. Laboratory tests are required to determine if noroviruses are the primary etiological agent.

Norovirus has been found in water sources that have been impacted by wastewater. Typical pathways for sewage to enter drinking water can be sewage overflows or sewage/septic systems that are not operating properly. According to current knowledge, noroviruses is moderately resistant to chlorine. The CDC states that **“Noroviruses can survive in up to 10 ppm chlorine, well in excess of levels routinely present in public water systems”**¹.

Research by Keswick et al.² determined that norovirus appears to be resistant to chlorine. In the study, viruses were treated with 3.75 to 6.25 mg/L of chlorine per liter to yield a free chlorine residual of 0.5 to 1.0 mg/L after 30 minutes of contact time, a common range for free chlorine residual concentration for most drinking water distribution systems. One group of eight volunteers received a norwalk virus inoculum which was treated with a dose of 3.75 mg/L of free chlorine (and targeted a 0.5 to 1.0 mg/L free

¹ Centers for Disease Control and Prevention. “Norovirus: technical Fact Sheet.” CDC’s Division of Viral Services. Accessed December 7th, 2009. <http://www.cdc.gov/ncidod/dvrd/revb/gastro/norovirus-factsheet.htm>.

² Keswick, B., Satterwhite, T., Johnson, P., DuPont, H., Seco, S., Bitsura, J., Gary, G., and Hoff, J., 1985. “Inactivation of Norwalk Virus in Drinking Water by Chlorine.” *Applied and Environmental Microbiology*. 50:2:261-264.

chlorine residual after 30 minutes) and five of the eight volunteers developed signs of illness and five of the eight seroconverted (i.e., developed detectable norovirus-specific antibodies in the blood serum as a result of infection).

In the second part of the Keswick et al. study, water contaminated with norovirus was treated with 10 mg/L of free chlorine to simulate post-contamination treatment of an impacted drinking water supply. One of the eight volunteers became ill but did not seroconvert. The study also noted an outbreak where disinfection data were recorded before and after a norovirus outbreak. In this case, a waterborne disease outbreak occurred at a Maryland campground. Water pumped from a 95-foot deep well and then a storage tank was found to contain between 0.7 to 1.0 mg/L of iodine during a norovirus outbreak. Over 133 persons became ill and the evidence suggested that under field conditions, norovirus is very resistant to disinfection. The researchers state that “the resistance to chlorination exhibited by norwalk virus in this study is most likely due to the aggregation of particles in the inoculum, a condition which reflects actual contamination of a water supply [contaminated] with human wastes.”

An EPA study similarly concluded that enteric viruses, such as norovirus, are more resistant to treatment processes, including chlorination. Volunteer studies concluded that a residual chlorine concentration of 5 – 6 mg/L is needed to inactivate norovirus completely (1-2 mg/L greater than the Maximum Residual Disinfectant Limit (MRDL)). Similar to Kesnick et al., the EPA study concluded that norovirus may be more resistant to disinfection because the virus particles become entrained in the floc particles created during the coagulation/flocculation process. Any particles that are not removed during sedimentation and/or filtration may be “shielded” from the applied disinfectant. The literature review from the study indicated that a 2 mg/L dose of monochloramine achieved a 1-log reduction of norovirus after three hours of contact time. However, there is evidence that ozone may be more effective for norovirus inactivation than chlorine. In one study, an ozone dose of 0.37 mg/L at a contact time of 10 seconds achieved a 3-log reduction of norovirus³.

Numerous norovirus outbreaks have been documented in the Centers for Disease Control and Prevention’s (CDC) “Surveillance for Waterborne-Disease Outbreaks Associated with Drinking Water”. The reports identify 11 reported norovirus waterborne disease outbreaks responsible for 1,226 of cases of illness. Table 1 provides an overview of each outbreak.

³ Eisenberg, J., Moe, C., and Uber, Jim. 2005. “Progress Report: Examining Epidemiologic and Environmental Factors Associated with Microbial Risks from Drinking Water.” Grant Number R831727. http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/7429/report/2005

Table 1. Reported Waterborne Norovirus Outbreaks in the United States that Occurred Between 2000 and 2006⁴

Outbreak Date	State	System Type ¹	Number of Persons Infected	Case Description
June 2000	KS	NCWS	86	Untreated well water sickened attendees of two separate social events at a rented reception hall. Well water tested positive for fecal coliforms. The water was not filtered or treated. Norwalk-like viruses were isolated from individual stool specimens from both groups. Inspection of the facility indicated improper well construction and sampled water tested positive for coliforms.
June 2000	WV	NCWS	123	This outbreak occurred at a camp. Consumption of food items and a history of swimming were ruled out as vehicles of contamination. While the epidemiological investigation could not statistically implicate water as the vehicle of exposure, the environmental investigation determined that the two wells (which served as the source water) were located near a lagoon and one well was visibly contaminated with sewage. Both wells tested positive for fecal coliforms.
July 2000	KS	NCWS	86	Untreated well water at a camp resulted in this outbreak. Testing confirmed the presence of total and fecal coliforms in one of the wells and in the distribution system.
Jan. 2001	WY	NCWS	230	This outbreak occurred at a snowmobile lodge and was attributed to an increased sewage load and the geological conditions of the site. The lodge was served by three wells that were located in close proximity to a septic tank/outhouse and were drilled in fractured granite with a sandy, porous upper soil.
Sept. 2001	WY	NCWS	83	This outbreak occurred at a local tourist saloon when a well was contaminated with human waste from a nearby septic tank leach field. The wells were drilled in fractured basalt (at a depth of 80 feet) and had perforations in the screens (located between 65 and 75 feet below grade) that covered the well casing. The cause of the outbreak was attributed to the close location of the well to a septic tank and leach field. A pellet chlorinator installed at the wellhead failed at the time of the outbreak due to pellet dust blockage of the “drop hole”.
June 2002	CT	NCWS	142	Attendees of a camp became ill when the source water became contaminated due to a high precipitation event. The outbreak ended within two days of chlorinating the water supply and provision of alternative water supplies.

⁴ Centers for Disease Control and Prevention. “Surveillance for Waterborne-Disease Outbreaks.” Volumes 51, 53, 55, and 57. www.CDC.gov.

Outbreak Date	State	System Type ¹	Number of Persons Infected	Case Description
July 2002	AZ	CWS	71	This outbreak occurred among users and employees of a golf course. Ice and water dispensers and ice-making facilities were not safely maintained and not properly cleaned and sanitized. One death occurred as a result of asphyxiation induced by vomiting. Norovirus was detected in stool specimens from three of nine persons.
Jan. 2004	PA	NCWS	70	Visitors to a ski facility became ill after drinking beverages from a soda fountain that had been cross-connected with a non-potable water line drawing water from a pond. The pond water was untreated and tested positive for fecal coliforms. Potential sources of contamination of the pond water included snow melt and an adjacent septic system.
June 2006	WY	NCWS	139	Outbreak investigators concluded that the camp's two wells, which were drilled into fractured rock aquifers, may have been contaminated with raw sewage released from the main septic system. Water from the wells repeatedly tested positive for fecal and total coliforms. The septic tank was noted to be in a poor location, at capacity, and not meeting the State's recommended standards at the time of the outbreak. The well water was not filtered or chlorinated prior to consumption.
July 2006	MD	NCWS	148	This outbreak occurred at a camp. General concerns included toilet facilities with plumbing deficiencies and limited hand washing stations throughout the camp. The water distribution system did not contain a detectable level of chlorine. Nine of ten water samples collected from garden hoses tested positive for total coliforms and <i>E. coli</i> . Well construction deficiencies were noted that included the absence of backflow-prevention devices on the pool bath house water heaters and on water distribution system lines to the latrines.
Aug. 2006	OR	NCWS	48	This outbreak occurred at a bed and breakfast. The system's well and onsite wastewater disposal system were located in close proximity. A well water sample was positive for <i>E. coli</i> and may have been contaminated from a poorly maintained and leaking sewage system used by nearby cottages. The geology of the area was primarily fractured bedrock. Contamination of the well likely resulted from waste that was released by the leaking seasonal sewage system or onsite wastewater systems.

1. NCWS = non-community water systems and CWS = community water system

There currently is no drinking water Maximum Contaminant Level (MCL) for norovirus. However, as part of the Safe Drinking Water Act (SDWA), the EPA is required to list unregulated contaminants which are known or anticipated to occur in public water systems and which may require a national drinking water regulation in the future. Every five years, the EPA must publish a list of contaminants called the Contaminant Candidate List (CCL) and decide whether or not to regulate at least five contaminants from the list⁵. The EPA uses the CCL to prioritize research and data collection efforts to determine potential regulatory actions. In September 2009, the EPA published the third drinking water CCL and Caliciviruses (including norovirus) were included on the listing.

⁵ EPA. Drinking Water Contaminant Candidate List and Regulatory Determinations. <http://www.epa.gov/ogwdw000/ccl/index.html>

Skyline Lodge Drinking Water Compliance History

The Division's historical records for the Lodge date back to 1986. Currently, the Lodge is required to collect the following samples required as a transient, non-community public water system:

- One total coliform sample every month in the distribution system
- One chlorine residual sample every month which should be collected at the same location and time as the total coliform sample
- One nitrate and one nitrite sample every year after disinfection but prior to water's entry into the distribution system.

Dating back to 1983, the Lodge had numerous documented violations for failure-to-monitor (FTM). Overall, the Lodge had 28 violations for failing to monitor total coliforms, three acute violations for exceeding the Total Coliform Rule (TCR) Maximum Contaminant Level (MCL), seven violations for failing to monitor for nitrate/nitrite, and two violations for failing to monitor for disinfectant residual. These violations are summarized in Table 2.

Table 2. Type and Number of Monitoring Violations by Year

Year	Routine TCR Sample FTM	Acute TCR MCL	Nitrate FTM	Chlorine FTM	Comments
1986	1				
1987	2				
1988	1				
1989	1				
1991	1				
1992	1				
1993	1				
1994	1				
1995	1	1			4 th quarter tested positive and no repeat samples were submitted
1996	1		1		
1997	2		1		
1998	2				
1999	1		1		
2001	2		1		
2002		1			3 rd quarter tested positive and no repeat samples were

Year	Routine TCR Sample FTM	Acute TCR MCL	Nitrate FTM	Chlorine FTM	Comments
					submitted
2003	2		1		
2004	1				
2005	1				
2006	2				
2007		1			Positive during the disease outbreak
2008	2		1		
2009	2		1	2	

The Division's files indicate that six non-community drinking water sanitary surveys were conducted between 1986 and 2000. Table 3 presents a summary of key findings.

Table 3. Key Deficiencies by Non-community Drinking Water Inspections from 1987 to 2000

Year	Complies with Legal Requirements	Meets Water Quality Standards	Treatment is Adequate	Free of Sanitary Defects
1987	No	No – no record	Yes – chlorination or equivalent	Yes
1988	No	Yes - water sample < 2.2 for coliforms	No – no chlorine could be detected in the system	Yes – however, it was noted that the well seal was not properly installed
1990	Not indicated	Yes – water sample adjusted count < 2.12 for coliforms	Yes – chlorine detected	Yes
1991	Yes	Yes – MPN= 0	No – none detected	Yes
1999	Not indicated	Yes – sample absent	Yes – chlorination or equivalent	Yes
2000	In 2000, the Division used a modified form. The form indicated that the well was non-compliant due to numerous issues (e.g., the well did not have a permit or driller's log and was not flood proofed, sealed, screened, etc.)			

Per Article 11 of the Colorado Primary Drinking Water Regulations (CPDWR), public water systems receive a sanitary survey performed by either the Division or a local health department representing the Division at least once every five years. If a public water

system has a continued record of unresolved significant deficiencies, the Division will take on the responsibility of performing the sanitary survey in place of the local health department. Since 2000, there have been four sanitary surveys performed by the Division. Table 4 provides key deficiencies noted during each sanitary survey.

Table 4. Key Deficiencies by Sanitary Survey from 2001 - 2010

Identified Issue	2001	2003	2007	2009	2010
Lack of design approval		√		√	√
No certified operator	√	√	√	√	√
Lack of disinfectant residual			√	√	Could not be tested
Not using approved chlorine monitoring equipment	√			√	
Not sampling at the proper locations				√	
Not maintaining records		√		√	√
Not conducting the proper monitoring	√			√	
No disinfection equipment present or equipment not operating			√		
Source water may be impacted by surface contamination			√	√	√
Lack of proper plans (e.g., monitoring, cross connection, emergency response, seasonal start-up, etc.)	√	√	√	√	√
Lack of proper contact time			√		

Summary of Skyline Lodge's Norovirus Outbreak

Drinking water outbreaks can be identified by routine surveillance of drinking water quality conducted by a water system. Additionally, outbreaks can be identified through routine surveillance of disease occurrence reported by laboratories or medical providers and to local, state, and national epidemiology departments. According to CDC, the following two criteria must be met for an event to be defined as a waterborne-disease outbreak associated with drinking water: 1) two or more persons must be epidemiologically linked by location of exposure to water, and by time, and characteristics of illness and 2) the epidemiological evidence must implicate water as the probable source of illness. This outbreak was first identified when a physician contacted CDPHE's Disease Control and Environmental Epidemiology Division (Epidemiology) (see Appendix B for an abbreviated timeline of the outbreak). The following provides a summary of the event:

- A physician contacted Dr. Bill Brinton, the regional epidemiologist, on June 20, 2007 after treating five people for acute gastroenteritis from an extended family.
- A Conejos County nurse and regional epidemiologist visited the Lodge on June 21, 2007, interviewed community members and family members, and inspected the Lodge and its restaurant where the sick family (see above) ate their only meal together on June 16, 2007. Upon further investigation, 12 of the 14 family members were considered ill. A stool specimen collected from one family member who was still ill tested positive for norovirus. A cohort analysis of food histories demonstrated no significant association between illness and any of the 24 foods or beverages served at the common meal. However, all the family members consumed drinks that contained ice. This ice was made on-site using the Lodge's ground water source. The inspectors also collected a water sample from the kitchen sink. This sample tested negative for coliforms (see Appendix C for all water sample analyses). Because there were several ill Lodge employees and food handlers, Epidemiology strongly suspects foodborne transmission from a sick Lodge food handler as the source of the outbreak.
- On June 23, 2007, the Consumer Protection Division (CPD) conducted an inspection of the restaurant. The inspector noted two critical items: a lack of proper food preparation/handling knowledge and improper food temperature control. Other observations included soiled preparation surfaces, a refrigerator lacked a thermometer, and the facility lacked a utility/mop sink.
- Based on the June 21, 2007 and June 23, 2007 site visits, the following control measures were implemented:

- The sick family members were instructed on the prevention of enteric disease;
 - Lodge management and employees were instructed on enteric disease infection control measures which placed emphasis on hand hygiene, disinfection of surfaces, and proper food handling to avoid cross-contamination;
 - The Lodge was required to immediately report any new cases of illness;
 - Foods in the kitchen were voluntarily condemned;
 - The Lodge was instructed to implement and maintain a “sick employee” policy; and
 - The Lodge’s water supply should undergo further testing.
- On July 20, 2007, responding to a complaint forwarded from the CPD, a regional epidemiologist interviewed (by telephone) nine people who stayed at the Lodge from July 14 - July 18, 2007. These people indicated that they arrived at the Lodge and immediately had dinner at the restaurant on July 14, 2007. Six of the nine people interviewed met the case definition of illness but no samples could be collected as all of the individuals had left the state. None indicated that they had a bloody stool or sought medical care.
 - On July 24, 2007, the county nurse and regional epidemiologist visited the Lodge and its restaurant again. Repeat violations were identified in the restaurant. The restaurant kitchen tap and tap water samples from two cabins tested negative for coliforms. Ice from a restaurant ice machine tested positive for fecal coliforms. The two ice machines were taken out of service. The well and chlorinator from the Lodge and restaurant appeared to be working properly, but inspectors heard of abnormal water tests from private wells allegedly connected to the system (of which, CDPHE was not able to verify) and continuing gastrointestinal illnesses within the local community. The CPD inspector indicated that they were more concerned about the drinking water than food as the potential source of the illnesses.
 - Twenty more cases of illnesses were reported between August 2, 2007 and August 13, 2007. All ill persons ate at the restaurant and consumed ice water. Five stool samples were collected and one tested positive for norovirus. On August 10, 2007, the county nurse, a Board of Health member, and a regional epidemiologist inspected the Lodge again. Two cooks at the Lodge restaurant reported having diarrhea 10 days prior. Illnesses were reported among five guests staying at one cabin at the facility. These guests were not at the Lodge at the time of the visit and could not be interviewed.

- On August 15, 2007, the county nurse, assisted by the sheriff, travelled to the Lodge to obtain voluntary closure of the Lodge and its restaurant and the Lodge complied with the closure request. While there, the nurse interviewed several members of another group staying at the Lodge who had experienced vomiting and diarrhea. All indicated that they had consumed tap water but several members of the party had not eaten at the restaurant.
- On August 17, 2007, on-site testing showed no disinfectant residual present in water at the restaurant kitchen tap. Septic tank maintenance workers reported a malfunction and breakage in the septic tanks. The Lodge also received a Notice of Violation by the Conejos County Land Use office. In addition to improperly disposing of “trash, junk, and garbage”, the Lodge was cited for not having an adequate wastewater system that could properly convey and dispose of all sewage. Cabins #17, #18, #19, and #20 were identified as being connected to a non-functional out-of-compliance sewage system. As a result, the Lodge could not open these cabins until an approved sewage system was installed and approved by the County Septic System Inspector (Figure 9).

In addition to the septic issues, four water samples collected on August 17, 2007 from the kitchen sink, ladies’ restroom, and cabins #12 and #17 tested positive for fecal coliforms. The Division understands that a 55 liter sample was collected from the restaurant kitchen sink which tested negative for norovirus. Wastewater from the two septic tanks at the Lodge tested positive for norovirus.

- On August 21, 2007 the Division issued the Lodge a “Bottled Water Advisory” due to the four fecal coliforms positive samples that were collected August 17, 2007. The Lodge distributed the required Public Notice on August 22, 2007. Observations noted from the sanitary survey are provided in the Skyline Lodge Water System section of this report.
- On August 31, 2007, after an extensive cleaning and the requirement to revise the wastewater treatment system, the Lodge and restaurant reopened under a “Bottled Water Advisory” pending installation of an approved and tested well.
- On September 6, 2007, the Conejos County Land Use Office approved the Lodge’s permit for a new sewage disposal system and the system was subsequently installed by Robins Construction. The date of the actual installation is unknown.
- By September 17, 2007, no new cases of illness were identified. It is unknown when the Lodge was permanently closed for the season.
- On October 3, 2007, the “Bottled Water Advisory” was lifted noting that the Lodge was responsible for the following:

- Because a well driller's log and permit for the private well that was placed into use were not available, the chlorine residual in the distribution shall be maintained between 1 and 1.5 mg/L continuously. This was a precautionary measure as the well may be under the influence of surface water (GWUDI).
- Design and construction documents for any permanent improvements must be submitted the Division for review and approval.
- All other deficiencies and administrative requirements related to ongoing operations, maintenance, and monitoring noted in the sanitary survey report must be addressed.



Figure 9. The Lodge's Septic Tank Installation in 2007 (Source: Conejos County Land Use office)

Summary Observations and Recommendations

The following conclusions were made as a result of this investigation:

- In June 2007, after the first reports of illnesses from Lodge patrons, investigators initially thought poor employee hygiene and unsanitary conditions in the restaurant may have been the source of the outbreak. Recommended control measures focused on personal hygiene and proper food handling. It was not until July 24, 2007 that drinking water was the suspected outbreak vector.
- Additional cases of illness continued to be reported in July. Some of the cases were most likely from person-to-person spread from “incubating” family members. However, due to inspections and results from collected water samples, issues remained about the safety of the drinking water supply and food handling in the restaurant.
- During the first half of August, multiple visitors continued to become ill with norovirus-like symptoms. The laboratory confirmed norovirus in two groups of patrons that stayed at or ate at the Lodge. Drinking water samples showed evidence of contamination and it was noted that on-site septic systems were deemed faulty and in non-compliance during the time of the outbreak.
- Drinking water at the Lodge was unchlorinated at the time of the outbreak and likely caused the outbreak. Ill employees at the Lodge were also a potential source for foodborne transmission and person-to-person spread.
- Closure of the Lodge and its restaurant and the repairs made to the septic tank serving cabins #17, #18, #19, and #29 appeared to have ended the outbreak. No additional cases of norovirus-like illness were reported after September 17, 2007.
- The Lodge had a history of drinking water monitoring violations and documented significant deficiencies that the system never addressed. Specifically, a lack of a disinfectant residual had been noted in numerous sanitary surveys and restaurant inspections conducted by the CPD. The Lodge also consistently did not receive design approval for its drinking water system, employ a certified drinking water treatment operator, or have the “human infrastructure” needed to properly operate and maintain the Lodge’s drinking water system. While the Division sent numerous notifications of non-compliance and noted deficiencies, the Lodge did not address or correct many of the violations and/or deficiencies and the Division never pursued enforcement.
- The Lodge has changed ownership several times since 1996.

- Norovirus was never detected in the drinking water system.
- This drinking water outbreak was similar in nature to several other drinking water outbreaks reported by the CDC. Commonalities included untreated well water, proximity of the source water near septic tanks, and the detection of fecal coliforms and/or *E. coli*.

The following recommendations were made based on this investigation:

- This outbreak investigation involved complex jurisdictional issues and numerous parties were involved (e.g., regional epidemiologist Dr. Bill Brinton, Conejos County Nursing Service, Conejos County Land Use office, and CDPHE's Epidemiology, CPD, and the WQCD units). Such coordination requires a substantial communication effort.
- The Division is currently undertaking a project to document a formal business process to address acute drinking water situations. This business plan should address procedural concerns and well as jurisdictional roles and responsibilities.
- Additionally, the Division should document all aspects of an outbreak during the event, or just after it is over, and immediately begin working on the outbreak investigation report.
- Staff from Engineering, Compliance Assurance, Capacity Building Unit, and Operator Certification should work closely together and ensure that significant deficiencies, such as the historical lack of disinfection, be resolved on a timely basis and stronger enforcement actions should be taken at systems that have a long history of non-compliance.
- Water should be sampled routinely in any potential outbreak where water may be a potential transmission route. The Division should be consulted during these events to help provide sampling advice (e.g., number of samples to collect, sampling locations, and sampling procedures). For every bacteriological sample, a disinfectant residual should be collected.
- Staff from the Division should visit any potential drinking water disease outbreak site at the beginning of any investigation.
- Pathogen-specific protocols should be developed. While chlorination may be very effective for some drinking water pathogens (e.g., *Salmonella*), other contaminants may be more resistant to disinfection (e.g., norovirus).

- The Division should investigate using *E. coli* as another surrogate for fecal contamination in drinking water supplies. Total coliforms may be inadequate as a sole surrogate for fecal contamination as total coliforms can naturally grow in distribution systems, are present in natural environments with no evidence of fecal contamination, and have not been proven to be sensitive indicators in actual waterborne outbreaks⁶. No *E. coli* samples were collected during the outbreak. Currently, systems are only required to analyze positive total coliform samples for fecal coliforms. Therefore, it may be beneficial to analyze any positive total coliform sample for both fecal coliforms and *E. coli*.
- The Division should continue to promote the benefits of properly designed disinfection and contact time.
- Violations and penalties (e.g., monetary fines, revocation of licenses, system closure, etc.) should be levied to dissuade drinking water systems from continuously violating Colorado's drinking water requirements.
- The Operator Certification Program should also be used to leverage civil penalties for systems that do not have a certified operator through its Enforcement Response Guidance. The current Water and Wastewater Facility Operators Certification Statute states that any owner of a drinking water treatment facility or distribution system in the state of Colorado that operates without a proper certified operator shall be subject to a civil penalty of no more than \$300 per day for each day during which such violation occurs.
- The Safe Drinking Water Program should work with other units within CDPHE (e.g., Environmental Health and Sustainability Division, Air Pollution, etc.) and other entities (e.g., County Health Departments, County Land Use offices (i.e., county septic tank inspectors), Liquor Enforcement Division, etc.) to further leverage any necessary penalties to ensure that a recalcitrant drinking water system implements the required actions to ensure safe drinking water. For the Lodge, the system had a long history of non-compliance and never addressed any of the deficiencies. When the Conejos County Land Use office closed four of the Lodge's cabins due to the faulty septic system, the owners promptly made the necessary repairs in order to quickly reopen their business.
- All SDWP staff should receive basic training on waterborne disease outbreaks.

⁶ Standridge, J., 2008. *E. coli* as a Public Health Indicator of Drinking Water Quality. *Journal of the American Water Works Association*, 100:2:65.

FORM NO. GWS-31 04/2005	WELL: CONSTRUCTION AND TEST REPORT	For Office Use Only
STATE OF COLORADO, OFFICE OF THE STATE ENGINEER 1313 Sherman St., Room 818, Denver, CO 80203 Phone - Info (303) 866-3587 Main (303) 866-3581 Fax (303) 866-3589 http://www.water.state.co.us		RECEIVED JUN 30 2008 WATER RESOURCES STATE ENGINEER COLO.
1. WELL PERMIT NUMBER: 28984 F R		
2. WELL OWNER INFORMATION		
NAME OF WELL OWNER: LANCE COCHRAN(SKYLINE RANCH RESERVE)		
MAILING ADDRESS: 2124 FARRINGTON #400		
CITY: DALLAS	STATE: TX.	ZIP CODE: 75207
TELEPHONE NUMBER: (214) 742 - 6916		
3. WELL LOCATION AS DRILLED: SE 1/4, NE 1/4, Sec. 22, Twp. 36N <input checked="" type="checkbox"/> N or <input type="checkbox"/> S, Range 4E <input checked="" type="checkbox"/> E or <input type="checkbox"/> W		
DISTANCES FROM SEC. LINES: 1858 ft. from <input checked="" type="checkbox"/> N or <input type="checkbox"/> S section line and 1031 ft. from <input checked="" type="checkbox"/> E or <input type="checkbox"/> W section line.		
SUBDIVISION: PLATORO TOWNSITE LOT _____ BLOCK 29 FILING (UNIT) _____		
Optional GPS Location: GPS Unit must use the following settings: Format must be UTM, Units must be meters, Datum must be NAD83, Unit must be set to true N, <input type="checkbox"/> Zone 12 or <input checked="" type="checkbox"/> Zone 13		
STREET ADDRESS AT WELL LOCATION:		Easting: 364335
		Northing: 4135240
4. GROUND SURFACE ELEVATION ? feet		DRILLING METHOD AIR ROTARY
DATE COMPLETED 5/29/08	TOTAL DEPTH 274	feet DEPTH COMPLETED 274 feet
5. GEOLOGIC LOG:		
Depth	Type	Grain Size Color Water Loc.
0-41	Cobble rock,	gravel & sand
41-274	Granite	
6. HOLE DIAM (in.) From (ft) To (ft)		
8 5/8 0 42		
6 1/2 42 274		
7. PLAIN CASING:		
OD (in)	Kind	Wall Size (in) From (ft) To (ft)
6 5/8	Steel	.188 +2 42
5	PVC	Schd 40 -14 234
PERFORATED CASING: Screen Slot Size (in): .032		
5	PVC	Schd 40 234 274
8. FILTER PACK:		
Material _____		
Size _____		
Interval _____		
9. PACKER PLACEMENT:		
Type _____		
Depth _____		
10. GROUTING RECORD		
Material	Amount	Density Interval Placement
Cement	9 sx	6-1 42-4 Poured
Remarks: _____		
11. DISINFECTION Type HTH Amt Used 5-3" Tablets		
12. WELL TEST DATA: <input type="checkbox"/> Check box if Test Data is submitted on Form Number GWS 39 Supplemental Well Test.		
TESTING METHOD AIR LIFT		
Static Level 8 ft.	Date/Time measured: 5/29/08 5:00 p.m.	Production Rate 50 gpm.
Pumping Level _____ ft.	Date/Time measured _____	Test Length (hrs) _____
Remarks: _____		
13. I have read the statements made herein and know the contents thereof, and they are true to my knowledge. This document is signed and certified in accordance with Rule 17.4 of the Water Well Construction Rules, 2 CCR 402-2. [The filing of a document that contains false statements is a violation of section 37-91-108(1)(e), C.R.S., and is punishable by fines up to \$5000 and/or revocation of the contracting license.]		
Company Name: PHYTHIAN DRILLING		License Number: 972
Mailing Address: 180 Ash St. Sanford, Co. 81151		
Signature: <i>Gayln F. Olsen</i>	Print Name and Title: GAYLN F. OLSEN, DRILLER	Date: 6/25/08

APPENDIX B: Outbreak Investigation Timeline: June – October 2007

	June	July	Aug.	Sept.	Oct.
Reported cases	<p>*June 20: Physician reports treating a family of 5 for acute gastroenteritis</p> <p>*June 21: 12 of 14 family members considered ill</p>	<p>July 20: Six of nine people who stayed at the Lodge met the case definition of illness but no samples were collected</p>	<p>*Aug. 2: Physician reported a tourist couple with illness</p> <p>*Aug. 10: Another physician reported 3 illnesses from people who ate at the restaurant</p> <p>*Aug. 11: Regional epidemiologist identifies 4 more cases</p> <p>*Aug. 13: 11 more cases are reported – one sample tests positive for norovirus</p>		
Sample Results	<p>June 21: From County nurse visit, one stool sample tests positive for norovirus and water sample collected tests negative for coliforms and below the nitrate MCL.</p>	<p>July 24: Kitchen tap and two cabins negative for coliforms and ice machine tests positive for fecal coliforms</p>	<p>Aug. 17: Restaurant kitchen sink tests negative for disinfectant residual. 4 sinks and cabins test positive for fecal coliforms. Septic system workers report malfunction and break in septic tanks. Lodge kitchen negative for norovirus but septic water tests positive.</p>		
Inspections	<p>June 23: Consumer Protection Division (CPD) conducted an inspection and noted improper food hold temperatures and lack of employee knowledge in proper food handling</p>	<p>July 24: County nurse and CPD visited the site again. Samples were collected and lack of proper food hold temperatures, poor hygiene, and lack of personnel training were observed.</p>	<p>*Aug. 10: The county nurse, a Board of Health member, and the regional epidemiologist inspect the Lodge again.</p> <p>*Aug. 15: Nurse visits site. Two more samples collected and both test positive for norovirus.</p>	<p>Sept. - Oct. : The Lodge works with Summit Engineering and submits a sketch of the proposed system improvements. No official design documents were submitted the WQCD for review and approval. The Lodge ultimately made changes to the drinking water treatment system without the WQCD's review or approval.</p>	
Events	<p>June 21: County nurse goes to site to conduct interviews and collect samples from ill individuals.</p>	<p>*July 20: Regional epidemiologist telephone interviewed nine people who stayed at the Lodge. Six were classified as ill.</p> <p>*July 24: Ice machines taken out of service after testing positive for fecal coliforms.</p>	<p>*Aug. 13: Conference call conducted between regional epidemiologist and CDPHE</p> <p>*Aug. 15: Site is voluntarily closed. The Lodge was closed for seventeen days.</p> <p>*Aug. 21: System issued a "Bottled Water Advisory"</p> <p>*Aug. 27: CDPHE conducted a sanitary survey</p> <p>*Aug. 31: Lodge reopened under a bottled water advisory</p>		<p>Oct. 3: "Bottled Water Advisory" lifted</p>

APPENDIX C. Data Collection Summary

Date Collected	Sample Location	Total Coliform, presence/absence ₁	Fecal Coliform, presence/absence ¹	Chlorine Residual, mg/L	Notes
7/24/07	Cabin #2 (kitchen sink)	ABS	ABS	Not tested	
7/24/07	Restaurant kitchen sink	ABS	ABS	Not tested	
7/24/07	Restaurant ice machine	PRES	PRES	Not tested	
7/24/07	Restaurant kitchen sink	ABS	ABS	Not tested	
7/31/07	Kitchen ice maker	ABS	ABS	Not tested	
8/10/07	Kitchen deep sink	PRES	PRES	Not tested	The sample was not collected according to proper procedures. The sample was a first water draw.
8/10/07	Kitchen ice machine	ABS	ABS	Not tested	
8/17/07	Cabin #12	PRES	PRES	Not tested	
8/17/07	Cabin #17	PRES	PRES	Not tested	

8/17/07	Restaurant ladies washroom	PRES	PRES	Not tested	
8/17/07	Kitchen hand sink	PRES	PRES	0	There was no residual chlorine in the adjacent deep sink when this sample was collected
8/24/07	Cabin #12	ABS	ABS	Not tested	
8/24/07	Kitchen hand sink	ABS	ABS	Not tested	
8/24/07	Restaurant ladies washroom	ABS	ABS	Not tested	
8/24/07	Cabin #17	ABS	ABS	Not tested	
8/24/07	Cabin #2	ABS	ABS	Not tested	
9/4/07	Cabin #4 dish sink	ABS	ABS	3	
9/4/07	Cabin #17 dish sink	ABS	ABS	3	
9/4/07	Kitchen dish washing sink	ABS	ABS	3	
9/4/07	Kitchen dish washing sink	ABS	ABS	3	

1. PRES = presence and ABS = absent