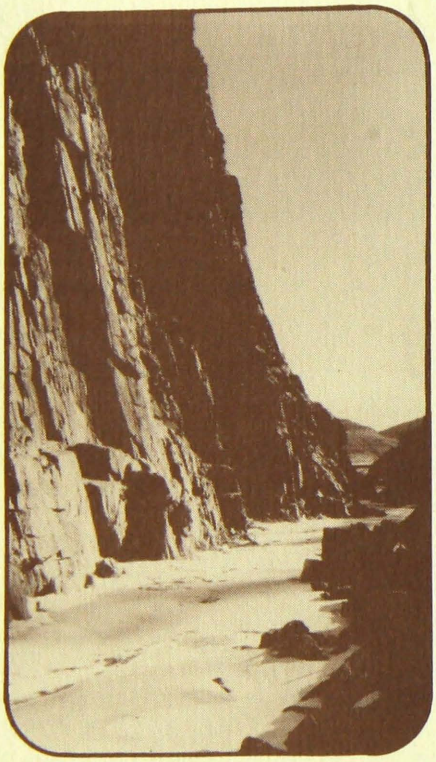
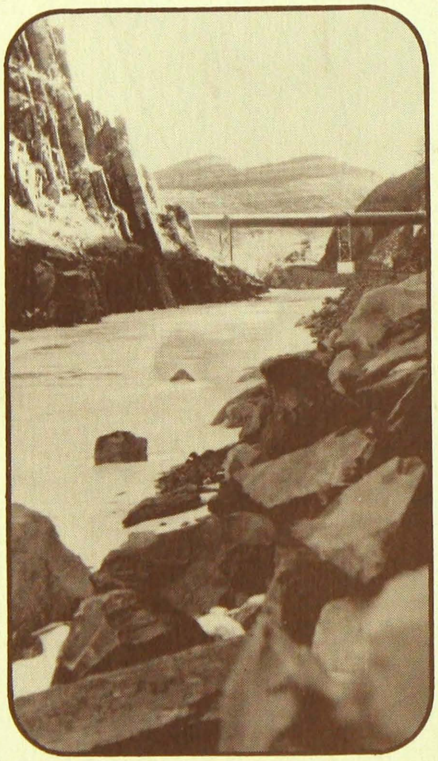
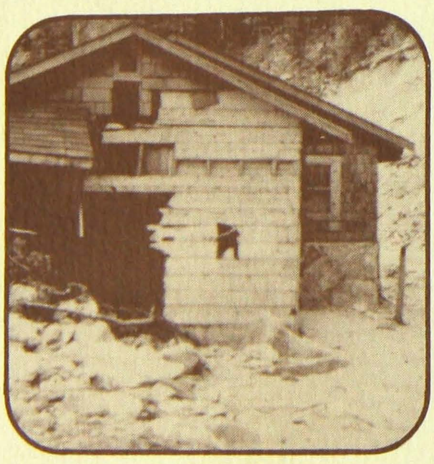
big thompson disaster recovery planning report







toups corporation

VOLUME 6

BIG THOMPSON DISASTER RECOVERY PLANNING REPORT WATER AND WASTEWATER TECHNICAL PLAN

November, 1977

Prepared For: Larimer-Weld Regional Council of Governments
201 East Fourth Street
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(303) 667-3288

and

Big Thompson Recovery Planning Office
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The preparation of this report was financed in part through an urban planning grant from the Department of Housing and Urban Development, under provisions of Section 701 of the Housing Act of 1954, as amended.

November 22, 1977

Big Thompson Recovery Planning Office
201 East 4th Street
Loveland, Colorado 80537

ATTN: Mr. Willard Quirk
Flood Recovery Coordinator

Dear Willard:

Toups Corporation is pleased to submit this report entitled "Big Thompson Disaster Recovery Planning Report - Water and Wastewater Technical Plan" in accordance with our contract with the Larimer-Weld Regional Council of Governments. This report presents the data, alternatives, and optimum solutions for alternatives which were developed during all three phases of the Big Thompson Disaster Recovery Planning Program.

This report documents the method used to develop the water and wastewater alternatives. The optimum water and wastewater plans are fully evaluated and described in detail; as are associated institutional alternatives and methods of financing.

We wish to acknowledge the assistance and consideration demonstrated by all persons and organizations who contributed to the preparation of this report. Special thanks goes to the residents of the study area who provided us with their ideas and concerns which are hopefully reflected during the development of alternatives.

Should any questions arise regarding the content of this report, we would be pleased to discuss them at your convenience.

Very truly yours,

TOUPS CORPORATION

W. B. Heller

W. B. Heller, P.E.
Project Engineer

Curtis E. Smith

Curtis E. Smith
Project Manager

WBH/CS/bt

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CHAPTER I

SUMMARY AND CONCLUSIONS

WATER SUPPLY AND WASTEWATER MANAGEMENT

The Big Thompson River is the water supply for a significant portion of Larimer County, including the Big Thompson Canyon, the city of Loveland, and many irrigators. The recent deterioration of water quality in the river is, in part, the result of inadequate wastewater treatment systems and increased utilization of the water. The flood compounded water quality problems by exposing or eliminating leach fields and septic tanks. In addition, the flood severely damaged many water wells, exposing canyon residents to potential health problems.

In general when restricting new development to [redacted] the final land use plan considered both water quality and public health concerns. Consequently, the population implications of the plan also consider these problems. However, with the construction of water and wastewater facilities, the 10-acre lot restriction could be lifted and additional population accommodated within the designated development areas. For the final analysis of water supply and wastewater management, a population projection based on development on [redacted] was used. Such projection was needed [redacted] that may be required in the canyon areas.

Note density not listed as a factor but total number

The final land use plan specifies that the area below the Narrows should be incorporated into the ongoing comprehensive planning process for the portion of Larimer County east of the mountains. However, in this water and wastewater study, a portion of Sylvan Dale, along the river immediately below the Big Thompson Siphon and above the Loveland Water Treatment Plant, was included because incorporation of this area into any existing water or wastewater service area is geologically restricted.

This volume provides a detailed analysis including the advantages and disadvantages of each water and wastewater alternative. A best alternative is selected and described.

POTABLE WATER SYSTEM

The cluster well system has been selected as the optimum method for potable water supply. A cluster well system involves cooperative use of a well and associated supply system by two or more property owners. Wells supplying more than one property owner should be drilled to a sufficient depth to provide storage for peak demand within the well shaft.

Advantages of the cluster well concept include the following:

- Least cost alternative - The cooperative nature of the system significantly reduces the cost to individual property owners while supplying an adequate and safe volume of water.

see discussion of mgmnt Agency p. 5 bottom

- Phased implementation schedule - Cluster wells can be added as growth occurs rather than sizing a system for full development of the canyon.

- Private ownership possible in initial phases - This system can be implemented immediately and privately without forming a full scale district.

  probably not avail. ok p. 6

- Incorporation by future water district possible - When a water district is established, the existing cluster wells and supply lines can be easily incorporated. Well owners will have to be compensated for the facilities.

The per tap cost of water and wastewater management systems is developed. Taps added in the future will be charged a rate equal to their share of the accrued debt. As more taps are added, the cost of the facilities can be distributed to more people and therefore will be reduced.

Government grants are available to help pay the capital cost of the water supply facilities. The monthly service charge to each customer is dependent on the percentage of grant obtained. The service charge associated with a 100 percent grant reflects only monthly operating costs and would be about $9.00. For comparison, the monthly operating cost of a privately owned well servicing an individual dwelling is $15.00. If this cost were added to the installation cost of $4,300 for an individual well and computed on an annual basis, the monthly expense

How do you get 100 per grant for private well ownership + construction? ok p. 6

772-44
Big T

would be approximately $44. Thus, cost to an individual property owner presently is significantly more than a cooperative water supply would be. Without grant assistance, cluster well cost is about $15.00 a month less expensive than a private system. Many study area residents fail to realize that such a large amount of money is needed for operation and maintenance of a full time well system because large scale costs are often not experienced for many years. A service charge would provide available money for when breakdowns or other major expenses occurred.

WASTEWATER TREATMENT FACILITIES

The complexity of providing wastewater treatment facilities for the study area required a detailed analysis of [redacted] possible alternatives. The technology for a unique area such as the canyon must be [redacted]. A ~~high degree of~~ [redacted]t is required and operating costs must be minimized.

The recommended facility for wastewater treatment is a clarifier/recirculating filter system which consists of a settling tank, a recirculating tank, a sand filter, and a chlorinator.

The first unit is a primary settling tank. The second unit is a recirculating tank and chlorine feed tank. Effluent from these tanks is polished by a sand filter prior to discharge to the Big Thompson River. Approximately 80 percent of the filter effluent is processed through the recirculating tank.

~~Data from technical literature~~ on this type of wastewater treatment indicates that the effluent from this system is very high quality with BOD_5 and total suspended solids values of less than 10 mg/l. Conversion of ammonia to nitrate can be achieved by using a low application rate on the sand filter, ~~particularly~~ during warm weather.

only ?

Seven small wastewater treatment plants would be required ~~to~~ serve the communities in the canyon, although one management agency would operate all the facilities. As with the water systems, the cost to each user will vary depending on the percentage of grant obtained. Costs range from as high as $42.50 per month if no construction grants are obtained to as little as $13.00 per month if a 100 percent construction grant is acquired. ~~The total number of system users also effects the costs. Less taps means more cost to each system used.~~

based of density / acre lots !

It should be noted that the cost for annual operating expenses is $153 for the 100 percent grant. Many canyon residents are on low fixed incomes and cannot afford a high user charge. For this reason, significant grants must be obtained to make the project feasible. To obtain such grants a management system must be established.

MANAGEMENT SYSTEM

A management agency must be formed to obtain the funds to construct water and/or sanitation facilities. Without the formation of a management structure, the existing health and water quality problems will not be solved, even if a no-growth policy is adopted. Formation of a single management agency such as a water and sanitation district will provide substantial benefits in cost and simplicity.

Initially the new district should be primarily responsible for wastewater facilities planning, construction, and operation. The district would also be responsible for grant application and administration of funding programs. It is not necessary for the district to assume control of the recommended cluster well system. Control could be assumed at a later date.

The two most likely sources of financial aid are the U.S. Department of Housing and Urban Development (HUD) and the Colorado Department of Local Affairs. ~~HUD has already funded several private water wells under its disaster assistance and housing rehabilitation program.~~ HUD programs are available to finance up to 100 percent of the cost of the collection lines, including the house taps. The Colorado Department of Local Affairs has a similar program which can be used for the wastewater treatment plants.

Before a detailed funding program can be developed, a management agency eligible to receive grants must be formed. Only such an agency can apply for funding and subsequently determine where and how much funding is available.

In summary, a water pollution potential has been documented and methods to protect the public health and the Big Thompson River water quality have been outlined. The expense of these systems is such that federal or state governmental aid will be necessary to complete any proposed project.

To obtain aid it will be necessary to establish a water and/or wastewater management agency within the canyon study area that will apply for grants. If grants are received, then the management agency can assume control of the project from plan initiation to operation and maintenance. Without a project growth within the study area should be restricted to those users designated in the final land use plan. ~~Any wastewater facilities~~ ~~or potable water supplies~~ ? installed in the canyon should meet all the requirements of the Larimer County Health Department ~~for individual wastewater treatment~~. Those that fail to meet the criteria of the Larimer County Health Department should not be allowed to be used.

Why when they're community type systems.

CHAPTER II

INTRODUCTION

Any complete planning study must include a thorough analysis of utilities. Within the Big Thompson Canyon study area, the most significant of the utility problems are the water and wastewater systems. The resolution of these problems entails a very complex analysis of the various alternatives. Such an analysis is rather lengthy; therefore this volume discussing the water and wastewater utilities was prepared.

This single document contains portions of the four main tasks involved in the Big Thompson River Disaster Recovery Plan. These tasks include:

- Describe pre- and post-flood water related conditions;
- Determine opportunities and constraints;
- Develop alternative solution strategies;
- Describe in detail apparent best water and wastewater project.

The text of this report will generally follow the pattern set by these four tasks. At the end of the third task, the decision was made to reduce the study area to the territory between Sylvan Dale and Estes Park. Thus, the area referred to as Big Thompson Valley East was not studied in detail during the development of the final task because of the present extent of utility service available to this area.

CHAPTER III

WATER QUALITY MANAGEMENT

The present water quality of the Big Thompson River within the flood impacted area is not known in detail. Since the 1976 flood no water quality records are available on the river in the study area. Observation of the river one year after the flood shows a high level of turbidity and considerable amounts of suspended material. This dirty water is a secondary impact of the flood and post-flood construction activities and will remain for some time as a reminder of the summer of 1976. During the past winter, flows within the river were kept to a minimum to assist in flood rehabilitation. In future winters the flow should remain above 25 cubic feet per second (cfs) making the river more attractive and assisting the re-establishment of fish populations throughout the study area.

BIG THOMPSON WATER QUALITY

Natural water quality of the Big Thompson River in the alpine areas above Estes Park is generally low in all water pollutant parameters with few occurrances of high enough ammonia or coliform concentrations to generate water quality concerns.

As the river flows easterly, natural increases in temperature, hardness, conductivity and total dissolved solids would be expected as heat is adsorbed through the canyon and minerals along the canyon are naturally decomposed by chemical processes. Natural increases in other constituents such as nitrogen forms, phosphorus, turbidity, metals and coliforms would be expected; however, increases above three times the existing alpine level would be excessive.

Table III-1 shows the results of a water quality survey of the Big Thompson River conducted in the summer of 1976 by the Colorado Health Department. Table III-1 also includes a yearly average of water quality data collected by Morrison of Colorado State University. Analysis of this data shows that water quality deteriorates as the river moves east. Factors that are altering this water quality include:

- Effluent from the Upper Thompson Sanitation District sewage treatment plant;
- Sediment resulting from construction and travel along Highway 34;
- Poorly designed or operated septic tanks, leachfields, or other means of sewage disposal along the river;
- Disposal of washing and laundry wastes into the river;
- Unapproved sanitation practices near the river by bathers and campers who stop along the scenic route.

TABLE III-1 WATER QUALITY DATA FOR THE BIG THOMPSON RIVER [s]

WATER QUALITY PARAMETERS SAMPLED \ SAMPLING POINT	7-11 Above Estes Park Sewage Disposal and Lake Estes [a]	Above UTSD Below Olympus Dam of Lake Estes [b]	Stations, 1, 2, 3 Below Estes Park Yearly Average [c]	Whispering Pines [d]	Glen Comfort [e]	Waltonia [f]	Drake [g]	Sylvan Dale Ranch [h]	Devils Backbone Station [i]	Taft Road, Loveland [j]	West Creek Above Glen Haven [k]	North Fork Above Glen Haven [l]	Painted Rock Below Glen Haven [m]	North Fork at North Fork Picnic Grounds [n]	Big Pine [o]	Rearing Pond Inlet [p]	Rearing Pond Effluent [q]	North Fork at Drake Confluence [r]
Temperature (°C)	12	16	7	14	17	18	18	11 18	14	14 22	12	13	13	14 13	16 14	17 12	17 13	17 15
Dissolved Oxygen (mg/l)	8.8	8.3	10.1	7.8	7.5	7.7	7.8	9.5	10.1	9.5	8.5	8.4	8.5	8.4	8.3	8.5	8.0	7.9
pH	7.5	7.7	7.2	7.5	7.6	7.2	7.3	7.1 8.1	8.2	8.0 8.2	7.4	7.5	7.5	7.1 7.3	7.6 7.0	7.3 6.9	7.1 6.8	7.1 7.1
Total Alkalinity (mg/l as C_aCO_3)	4	6	21	8	8		10	16 12	32	32 60	8	4	4	12 8	12 8	8 8	12 4	8 8
Nitrate as Nitrogen (mg/l)			0.1					6.0		4.0	4.0	6.0	8.0	8.0	4.0			6.0
Nitrite as Nitrogen (mg/l)			$<$0.01					0.0		0.0	0.0	0.0	0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
Ammonia as Nitrogen (mg/l)	0.3	0.3	0.4	0.5	0.3	0.4	0.3	0.4		0.4	0.18	0.1	0.12	0.34 0.16	0.24 0.16	0.16 0.3	0.46 0.5	0.3 0.2

TABLE III-1 WATER QUALITY DATA FOR THE BIG THOMPSON RIVER (Cont.)

SAMPLING POINT / WATER QUALITY PARAMETERS SAMPLED	7-11 Above Estes Park Sewage Disposal and Lake Estes [a]	Above UTSD Below Olympus Dam of Lake Estes [b]	Stations, 1, 2, 3 Below Estes Park Yearly Average [c]	Whispering Pines [d]	Glen Comfort [e]	Waltonia [f]	Drake [g]	Sylvan Dale Ranch [h]	Devils Backbone Station [i]	Taft Road, Loveland [j]	West Creek Above Glen Haven [k]	North Fork Above Glen Haven [l]	Painted Rock Below Glen Haven [m]	North Fork at North Fork Picnic Grounds [n]	Big Pine [o]	Rearing Pond Inlet [p]	Rearing Pond Effluent [q]	North Fork at Drake Confluence [r]
Total Phosphate as Phosphorus (mg/l)	1.8	0.0	< 0.2	0.0	0.0	0.0	0.6	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
														0.0	0.0	0.0	0.0	0.0
Total Hardness (mg/l as C_aCO_3)	16	8		8	8	8	10	16	40	100	8	8	8	12	12	12	16	8
								16		140				12	8	8	8	8
Fecal Coliforms (Colonies/100 ml)	35	4	8	79	7	260	390				3	4	3	300	230			280
Total Coliforms (Colonies/100 ml)	1800	670	470	11900	4800	10,900	19,000				200	480	340	350	360			800
											870	830	380	820	1180			1830
Turbidity (FTU)	3.6	2.1	2.1	1.9	1.9	1.7	1.6	2.5		3.0	0.82	0.5	0.64	0.9	0.9	0.9	2.5	1.2
														0.65	0.84	37	2.0	1.0
Magnesium (mg/l)	3	1		1	1	1	1	1	4	6	1	1	1	1	2	1	2	1
								2		9				2	1	1	1	1

TABLE III-1. WATER QUALITY DATA FOR THE BIG THOMPSON RIVER (Cont.)

WATER QUALITY PARAMETERS SAMPLED \ SAMPLING POINT	7-11 Above Estes Park Sewage Disposal and Lake Estes [a]	Above UTSD Below Olympus Dam of Lake Estes [b]	Stations, 1, 2, 3 Below Estes Park Yearly Average [c]	Whispering Pines [d]	Glen Comfort [e]	Waltonia [f]	Drake [g]	Sylvan Dale Ranch [h]	Devils Backbone Station [i]
Total Dissolved Solids (mg/l)	88	37		36	34	36	35	63 32	
Suspended Solids (mg/l)	6	3	2.3	4	5	6	4	11 406	
Conductivity (umhos/cm)	95	23	38	25	23	25	25	43 26	85
Chlorides (mg/l)	4.2	4	0.9	3	3	3	4	4 3	8
Sulfates (mg/l as SO_4)	12	9.8	1.3	7.5	11.2	7.5	9.8	9.8	
Copper (mg/l)	0.003	0.0		0.002	0.016	0.0	0.0		
Lead (mg/l)	0.0	0.0		0.0	0.0	0.0	0.0		

WATER QUALITY PARAMETERS SAMPLED \ SAMPLING POINT	Taft Road, Loveland [j]	West Creek Above Glen Haven [k]	North Fork Above Glen Haven [l]	Painted Rock Below Glen Haven [m]	North Fork at North Fork Picnic Grounds [n]	Big Pine [o]	Rearing Pond Inlet [p]	Rearing Pond Effluent [q]	North Fork at Drake Confluence [r]
Total Dissolved Solids (mg/l)	195 115	54	32	24	42 79	38 31	38 37	36 35	25 41
Suspended Solids (mg/l)	12 44	1	1	1	4 4	5 2	3 6	7 6	4 1
Conductivity (umhos/cm)	300 38	54	23	19.5	4.5 19.5	23 20	23 20	25 25	25 20
Chlorides (mg/l)	6 3	11	5	3	5 2	4 3	5 1	3 2	4 3
Sulfates (mg/l as SO_4)	121	7.5	6.2	7.5	4.3 4.3				
Copper (mg/l)		0.002	0.0	0.006	0.0	0.003			0.002
Lead (mg/l)		0.0	0.0	0.0	0.0	0.0			0.0

TABLE III-1. WATER QUALITY DATA FOR THE BIG THOMPSON RIVER (Cont.)

SAMPLING POINT / WATER QUALITY PARAMETERS SAMPLED	7-11 Above Estes Park Sewage Disposal and Lake Estes [a]	Above UTSD Below Olympus Dam of Lake Estes [b]	Stations, 1, 2, 3 Below Estes Park Yearly Average [c]	Whispering Pines [d]	Glen Comfort [e]	Waltonia [f]	Drake [g]	Sylvan Dale Ranch [h]	Devils Backbone Station [i]	Taft Road, Loveland [j]	West Creek Above Glen Haven [k]	North Fork Above Glen Haven [l]	Painted Rock Below Glen Haven [m]	North Fork at North Fork Picnic Grounds [n]	Big Pine [o]	Rearing Pond Inlet [p]	Rearing Pond Effluent [q]	North Fork at Drake Confluence [r]
Zinc (mg/l)	0.03	0.0		0.0	0.0	0.0	0.0				0.0	0.0	0.0	0.0	0.0			0.0
Iron (mg/l)	0.510	0.22		0.22	0.41	0.22	0.22				0.12	0.08	0.12	0.12	0.0			0.16
Sodium (as Na mg/l)	2	2		2	2	3	2	3	8		2	2	2	3	2	2	2	2
								1	8					2	2	2	2	2

[a] Sampling Date 7/13/76 at 9:00 a.m.
[b] Sampling Date 7/13/76 at 10:00 a.m.
[c] Yearly average of data collected by Morrison of CSU.
[d] Sampling Date 7/13/76 at 10:45 a.m.
[e] Sampling Date 7/13/76 at 12:45 p.m.
[f] Sampling Date 7/13/76 at 1:30 p.m.
[g] Sampling Date 7/13/76 at 2:15 p.m.
[h] Sampling Dates 5/25/76 and 7/22/76.
[i] Sampling Date 5/27/76 at 1:10 p.m.
[j] Sampling Dates 5/25/76 at 12:45 p.m. and 7/22/76 at 10:45 a.m.
[k] Sampling Dates 7/6/76 and 7/14/76.
[l] Sampling Dates 7/6/76 and 7/14/76.
[m] Sampling Dates 7/6/76 and 7/14/76.
[n] Sampling Dates 6/28/76 and 7/6/76.
[o] Sampling Dates 6/28/76 at 3:15 p.m. and 7/6/76 at 5:00 p.m.
[p] Sampling Dates 6/28/76 at 3:30 p.m. and 7/8/76 at 10:45 a.m.
[q] Sampling Dates 6/28/76 at 3:45 p.m. and 7/8/76 at 10:30 a.m.
[r] Sampling Dates 6/28/76 at 4:00 p.m. and 7/6/76 at 5:15 p.m.
[s] Data collected by Colorado Department of Health

Water quality of the Big Thompson River within the study area does not exceed the established state standards for that river which classify these waters as non-body-contact waters because they are generally too cold and flow at too high velocities for safe swimming. The water quality standards for the Big Thompson River are presented in Table III-2. The waters of the river, however, are used occasionally for primary contact such as bathing, river floating, and swimming, and when discussing Big Thompson River water quality these activities should be considered.

TABLE III-2. WATER QUALITY REQUIREMENTS FOR CLASS B_1 OR B_2 WATER QUALITY STANDARDS

PARAMETER	USE	COLIFORMS	DISSOLVED OXYGEN	pH	TEMP	TURBIDITY
Acceptable level	All except swimming and water skiing	Less than 10,000 total or 1000 fecal in 100 militer sample	Not less than 6 mg/l [a]	Not greater than 9.0 or less than 6.0	Not greater than 68° F	Less than 10 Jackson units

[a] mg/l = miligrams per liter or parts per million.
Table compiled from material presented by Flack, E.J.

Because of the large amount of erosion caused by the July, 1976, flood, Big Thompson water will take many years to return to a consistent high level of quality. If measures are taken to adequately protect the river from additional impacts of man, this time can be shortened.

Table III-1 shows increased levels of ammonia and fecal coliforms below the Upper Thompson Sanitation District sewage outfall and increased levels of ammonia below the outfall from the fish hatchery on the North Fork. At the time of sampling, the Upper Thompson wastewater plant was undergoing start-up procedures, and the nitrification tower, which converts ammonia to nitrate, was not operating. Another possible explanation for the 0.5 mg/l ammonia concentration noted at Whispering Pines Motel is due to Lake Estes water releases. Anaerobic (without oxygen) conditions in the bottom of Lake Estes would cause sediment decomposition of organic nitrogen to be in the ammonia form. With anaerobic conditions, releases from the bottom of the lake at Olympus Dam could cause considerable ammonia to be released to the Big Thompson River. Only a detailed sampling program and limnological survey could verify that such a situation occasionally exists. Ammonia levels of 0.5 mg/l are not toxic to aquatic life and should be of little concern.

Prior to the flood a number of diseased rainbow and brown trout were seen along the main fork of the Big Thompson River above Drake. Upon investigation by officials of the Wildlife Department it was determined that the disease was a secondary effect resulting from a weakened condition of the fish. The factor responsible for weakening the fish resistance to disease was not determined. Poor water quality may have been a factor.

The areas from Glen Comfort to below Drake on the Big Thompson River and downstream from the U.S. Forest Service picnic grounds on the North Fork were found to have increased levels of ammonia and fecal coliforms. These constituents are characteristic of human wastes.

The Department of Health survey also shows that degraded water quality is noticeable along the other stretches of the river. This is indicative of contamination from the septic tanks and leachfields, broken vaults, and pit privies located along the two rivers. Practically all residential and commercial development between the city of Loveland and the town of Estes Park was served by individual wastewater systems prior to the flood. Toups' analysis of the records of the Larimer County Health Department and the Colorado Water Quality Control Division shows that pollution of streamwaters and associated subsurface waters has been a continuing problem in the Big Thompson Canyon, particularly during summer periods when septic tank loads were increased by tourism and recreational activities. Due to exceptionally high coliform counts, leaching from septic tank systems was suspected as the principal cause of water quality degradation in the Big Thompson River. A discussion later in this volume explains why such septic systems may be the cause of higher than expected concentrations of coliforms and ammonia.

The data available within the Big Thompson Canyon study area does not establish that the water is polluted beyond state standards. However, if untreated, this water will not pass the requirements of the Federal Safe Drinking Water Act. Because of the Act, this water cannot be used to serve more than twenty-five people from one supply for over sixty days. The Safe Drinking Water Act is discussed more fully later in this volume.

MAINTENANCE OF HIGH WATER QUALITY

The following section describes what is necessary to maintain high river water quality and some of the impacts the 1976 flood is having and will have on water quality management.

INTERRELATIONSHIP OF WATER QUALITY, WATER AND WASTEWATER SYSTEMS

High water quality can be restored and maintained in the Big Thompson River Canyon. Human contamination of the river can be effectively curtailed by the use of a good quality wastewater management scheme as outlined later in this document. To protect the river from sediment runoff from Highway 34, additional water quality protection may be necessary. Engineering of a new road along the stream with proper sediment control features can solve some of the sediment problems caused by the canyon roadway. The careful design and use of high quality water systems can alleviate health concerns of area water users. The various options available for water systems will be discussed more fully later in this volume.

FLOOD DAMAGE TO WATER AND WASTEWATER SYSTEMS

In October, 1976, the Larimer County Health Department (LCHD) surveyed all water and wastewater systems in the canyon area affected by the flood. A total of 773 water systems were reviewed. This review included many structures outside the limits of the study area. Table III-3 shows the results of the sanitary survey. This data helps in determining the number of water and wastewater systems damaged as well as the general nature of the canyon's facilities.

Of the 716 residential establishments surveyed, 98 were given notice that their water systems represented immediate health hazards. Such notice was given if the water supply had:

1. Obviously damaged well;
2. Well apparently flooded but not back in operation;
3. Apparently missing well due to washout.

TABLE III-3. WATER SUPPLY AND WASTEWATER SYSTEMS SURVEYED BY THE LARIMER COUNTY HEALTH DEPARTMENT, OCTOBER, 1976

WATER SYSTEMS		NUMBER	% OF TOTAL
Number of shallow or river supplied wells	RESIDENTIAL	257	36
	COMMERCIAL	21	37
Number of modern, drilled and cased wells	RESIDENTIAL	174	24
	COMMERCIAL	12	21
Number of water supplies unknown	RESIDENTIAL	285	40
	COMMERCIAL	24	42
Number of water supplies obviously damaged by flood	RESIDENTIAL	150	21
	COMMERCIAL	17	30
WASTEWATER SYSTEMS		NUMBER	% OF TOTAL
Number of septic tanks and leachfields	RESIDENTIAL	130	18
	COMMERCIAL	26	46
Number of sealed vaults	RESIDENTIAL	127	18
	COMMERCIAL	3	5
Number of privies	RESIDENTIAL	266	37
	COMMERCIAL	7	12
Number of systems unknown	RESIDENTIAL	193	27
	COMMERCIAL	21	37
Number damaged	RESIDENTIAL	68	10
	COMMERCIAL	9	16

During the course of the survey, 285 water supply systems were found to be of an unknown nature. These systems include cabins where water is carried from a town or the river for short term use and residences with wells or supply systems located under the house or other undetermined locations.

Water quality records for these water systems are sparce and scattered. Many residents do not have their water supply periodically tested for bacteriological contamination and some wells have never been tested. Those bacteriological tests that have been taken are not cataloged by address at the LCHD and hence it is very time consuming to determine if the sample was taken in the Big Thompson Canyon. However, many well water samples from the Big Thompson Canyon were found to be bacteriologically contaminated in 1976 and 1977. Neither the state nor the county requires testing of private wells.

From Table III-3, eighteen percent of the wastewater systems surveyed utilized septic tanks with leachfields. Another eighteen percent used sealed concrete vaults for sewage containment. The most common residential wastewater disposal method in the canyon is the use of unsealed privies. Such "outhouses" provide insufficient means of treating or containing fecal material on site and therefore constitute a serious health hazard as well as pollute the nearby river and groundwater. In speaking with canyon residents it was found that a large number of these privies are no longer operated or only operated at times when an installed vault is overloaded. Such sites should be pumped and backfilled so use is permanently discontinued.

The LCHD served placards or closure notices on sewage disposal systems that represented "an apparent immediate health hazard". Systems were placarded when there existed:

1. Open septic tanks or vaults;
2. Exposed or partially exposed adsorption fields;
3. Missing systems apparently washed out;
4. Systems which were not found but could be so located as to pollute a water course.

Thus, many privy systems were not served notice of hazard because they failed to represent an "apparent immediate health hazard". According to the LCHD, operational privies will be served notice to upgrade their sewage disposal practices [Wigle, 1977]. A result of the LCHD survey was that 98 residential establishments and 10 commercial structures were given notice to discontinue operation until adequate sewer and water was available. Thus, more notices were issued for inferior wastewater systems than for water supply inadequacies.

In spite of LCHD records, the Fall, 1976 sanitary survey and other sanitary assessments in the Big Thompson Canyon, the exact nature of sewage disposal practices is not known. Many sewage containment and treatment systems were located close to the streambed prior to the flood, and were destroyed or damaged by the flood waters or rehabilitation crews working in the floodway.

These systems, especially leachfields, may have been damaged by the flood but not detected by the LCHD survey. The erosional forces of the flood and the heavy equipment brought in after the flood may have damaged leachfields. Distribution pipes may have been broken and leachfield soils may have been displaced enough to alter their adsorption capabilities. Vaults located within the floodplain may have been subject to enough force to cause cracks and present a new health risk. Seasonal freezing also can break the seal in vaults.

Unnoticed damages may still exist in many canyon locations and may continue to impact the quality of the river waters for many years unless tests are conducted on all systems or new wastewater facilities are incorporated into the canyon study area.

Table III-4 illustrates a maximized estimate of the extent of damage to water and wastewater systems imposed by the flood and possible future damage that could occur to these systems if another natural disaster would occur. Column one is the number of sewer and water systems that are within the one hundred year floodway. This number does not include sewer and water systems that were destroyed by the flood and will not be permitted to be reconstructed. It does include all systems within the floodway that experienced some damage as a result of the floodway but that will be allowed to rebuild. Many of the sewer and water systems placarded by the LCHD were destroyed to such an extent that reconstruction will not be allowed and are not counted in column one. The extent of damage to these 77 sewer and water systems is not known. Some may have experienced broken pipes, destroyed leachfields, cracked vaults or other major types of damage. Others may have experienced only minor flooding.

The second column in Table III-4 consists of those properties outside of the floodway but within the borders of the floodfringe. The thirty-four sewer and/or water systems within this boundary may also have damage ranging from pipe breaking to simply water filled vaults. These systems may be required to install some type of floodproofing for future use.

Systems outside the 100-year floodfringe area that were encroached upon by the flood of 1976 are counted in column 3 and are considered to be within the 1976 "floodzone" area.

The floodzone area is defined for the purposes of this water and wastewater study as the limit of the summer, 1976, flood. Thus, column 3 represents the number of sewer and/or water systems that may have been damaged by the flood of 1976. Because these systems are outside of the floodfringe area, they may not be required to install floodproofing measures.

By analysis of detailed canyon maps, it was determined that a large number of properties may have residences located above the flood level of 1976 but may have sewer or water facilities that were impacted by the flood of 1976. Houses and commercial structures located adjacent to the floodzone boundary may have had septic tanks, pipes, vaults, and leachfields damaged by the flood. The 110 properties listed in column 4 include all such properties. The total of the first four columns in Table III-4 represents the sewer systems adjacent to the river that may be causing pollution and health hazards.

TABLE III-4. NUMBER OF WATER AND WASTEWATER SYSTEMS DAMAGED OR POSSIBLY DAMAGED IN THE BIG THOMPSON CANYON

COMMUNITY	WATER AND WASTEWATER SYSTEMS POSSIBLY DAMAGED BY THE FLOOD OF 1976 BUT NOT DESTROYED				COLUMN 5 PROPERTIES LOCATED IN FLOODWAY THAT MAY REBUILD OUT OF FLOODWAY	COLUMN 6 PROPERTIES LOCATED IN GEOLOGIC HAZARD AREAS NOT DAMAGED BY FLOOD	TOTAL
	COLUMN 1 IN FLOODWAY	COLUMN 2 IN FLOODFRINGE	COLUMN 3 IN FLOODZONE [a]	COLUMN 4 OUTSIDE FLOODZONE			
Glen Haven and North Fork	34	11	12	22	3	10	92
Loveland Heights and Glen Comfort	15	3	45	32	2	31	131
Waltonia	0	1	5	3	6	20	35
Drake/Midway	4	3	32	17	14	4	74
Cedar Cove [b]	12	4	3	12	5	6	42
Sylvan Dale [c]	1	4	4	4	3	0	16
Big Thompson Valley East [c]	11	5	13	20	0	0	49
Subtotal	77	34	114	110	33	71	
TOTAL				335			439

[a] Floodzone is the areal extent of the 1976 flood.
[b] In many places floodway boundary is above the floodzone boundary.
[c] Big Thompson Valley East and the east end of Sylvan Dale are served by the Loveland Water Treatment Plant; therefore, the numbers in these two rows reflect only wastewater systems.

Analysis of canyon maps shows that there are 33 houses, and therefore sewage and water systems, that were destroyed by the flood that may be rebuild on the portions of property outside the floodplain. Owners of these properties will be prohibited from rebuilding on their previous sites but because they own sufficient land above the floodplain, they may select to rebuild above the floodplain. Column 5 of Table III-4 shows the number of such properties that exist in each of the canyon communities. These properties are important as they will need to rebuild water and sewage facilities if they construct a new house and therefore may help provide a core group for community water and wastewater development.

The sixth column is the number of properties that are outside of the floodzone area but that are located upon geologic hazard areas. These hazards include debris fans, rockfalls, landslides, downcut stream channels, and sheet erosion. Properties located on these areas may have had unnoticeable water or sewer damage as a result of the 1976 flood or may experience damage in the future. Movement of debris fans, occurrance of rockfalls and slow moving landslides can crack vaults, break pipes, and allow contamination of water supplies and surface waters. Areas with downcut stream channels or that are subject to sheet erosion are a public health concern because these areas may not be able to properly contain a leachfield or may expose other contaminant or treatment devices.

The 439 properties listed in Table III-4 represent the properties that are expected to have inferior systems. A detailed health survey of properties located out of the floodfringe area and of properties located upon geologic hazard areas would be necessary to determine the full number of potentially hazardous systems. It should be emphasized that the preceeding analysis includes the entire Big Thompson Canyon area. When the water and wastewater alternative projects are discussed in Chapters V and VII, the number of service connections differs from the numbers presented in this overview because of possible service difficulties and the limited extent of the study area.

CHAPTER IV

INFORMATION NECESSARY FOR DEVELOPMENT OF ALTERNATIVE WATER AND WASTEWATER PLANS

Prior to discussion of the alternatives for water and wastewater systems within the flood impacted area it is necessary to outline the basic premises on which these alternatives will be discussed. These premises include population, water, and wastewater characteristics.

POPULATION

As discussed in Volume 1, the population levels and characteristics of the communities within the study area are complex due to the impact of part-time residents and tourists. Due to these problems only rough estimates of existing population had been developed and these estimates were not separated according to the communities within the study area. To evaluate the water demands and wasteloads it was necessary to estimate the existing population levels within each of the communities and then develop population projections for each community. The following discussion outlines the assumptions made in estimating existing community population levels and projections.

By analysis of maps included in Volume 2, the existing structures were analyzed for full and part time occupancy. The results of this analysis are summarized in Table IV-1. Those structures that are occupied for the entire year west of the Narrows are often occupied by retired couples, widows, widowers, and small families. Hence, the average number of people in each full time household in this area was assumed to be two people. Conversations with canyon residents seems to establish this to be a reasonable estimate. The communities of Sylvan Dale and Big Thompson Valley East have larger families and a figure of three people per household was used as an average. The number of part time residents was more difficult to determine. Those that spend only a part of the year in the study area vary from out of state people who visit only a couple of weekends per year up to people who spend a half a year in their canyon cabins. Cabins may be occupied by a retired couple or may be used by large families and relatives for a mountain haven. To arrive at existing population characteristics of the planning communities, it was assumed that part time residents spent one-fourth of the year in the canyon on the average and each house had four people in it for the 3-month period. These assumptions were used to estimate the non-seasonal (full time) and seasonal (full time and part time) residential population of each community. These numbers were then combined with estimates of population related to commercial activities to determine the total seasonal and non-seasonal population levels.

TABLE IV-1. POPULATION CHARACTERISTICS OF THE BIG THOMPSON CANYON COMMUNITIES

COMMUNITY	FULL TIME (Units)		PART TIME (Units)		NON-SEASONAL POPULATION [1]		SEASONAL POPULATION [2]	
	RESIDENTIAL	COMMERCIAL	RESIDENTIAL	COMMERCIAL	1977	2000	1977	2000
Loveland Heights Glen Comfort	58	5	134	9	285	600	895	1350
Waltonia	3	0	26	1	33	50	112	175
Drake/Midway	34	5	36	1	131	200	267	400
Cedar Cove	38	4	21	4	125	200	262	450
Sylvan Dale	24	2	4	4	108	250	186	250
Big Thompson Valley East	136	10	15	5	454	1100	541	650
Glen Haven	24	3	115	5	179	300	610	650
TOTAL	317	29	351	29	1315	2700	2873	3925

[1] Assumes 2 people per full time unit and one person per part time unit (4 people per unit with 1/4 occupancy). Full time hotels were assumed 40 percent full at 14 units each. In Sylvan Dale and Big Thompson Valley East it was assumed 3 people per house full time.

[2] Assumes 2 people per full time unit and 4 people in each part time unit. Hotels were assumed 80 percent occupied, or 45 people per complex. Other commercial, 2 people per unit.

Deciding on the number of people involved with commercial establishments is even more difficult. Only one person may operate a small dry goods store while nearly 100 people may occupy a motel complex at any any one time. Population estimates for commercial establishments attempts to handle the variability by assuming two people in most commercial buildings and assuming fourteen units in motels each with four people at eighty percent occupancy or forty-five people per hotel complex for seasonal periods. Non-seasonal population in the canyon communities assumes only forth percent occupancy in those hotels that remain open.

Table IV-1 shows the assumed present and future population of each of the communities in the study area. These population estimates were used as a basis for plan development. The future population levels of this area are based on analysis of the population projections for the unincorporated areas of Larimer County and the cities of Loveland and Estes Park, and the projections of visitor use in Rocky Mountain National Park. This analysis indicated [redacted] was anticipated in the unincorporated sections of the county and the cities adjacent to the study area which, coupled with growth projections in visitor use, would influence and stimulate growth of both seasonal and non-seasonal residents. The population projections reflected in Table IV-1 further assume that development beyond existing levels will be allowed to occur within the study area. More revised population estimates were later developed after public hearings established the land use character of the canyon. The implications of these changes are discussed in Chapters VI and VIII of this volume.

WATER SUPPLY CHARACTERISTICS AND REQUIREMENTS

Rural community water demand has been analyzed by a number of authors [Bennett, 1975; Kreissl, 1971; and Metcalf and Eddy, 1972]. Water use analysis varies from 33 gallons per capita per day (gpcd) up to 125 gpcd. Small lots may use little water while large lots with many people may have a large demand that includes lawn maintenance. Since many canyon landowners, especially the part time residents, are on small lots that have only a minimal yard area, 75 gpcd is a reasonable average water demand figure for canyon study area consideration. Table IV-2 shows how demand can vary and the different criteria that must be considered when developing alternative plans. For the purpose of this study, maximum water demand was assumed to be 200 percent of average, or 150 gpcd.

Actual water demand may vary considerably. Low, nighttime water use may be zero while early morning and the dinner hour may require over 14 gallons per household per minute. Pulse loads of 60 gallons within six to thirty minutes may also be expected at each home. For calculating pipeline pressure it was assumed that 10 gpm per household would be the peak instant demand by residents in the study area.

TABLE IV-2. WATER USE CHARACTERISTICS FOR RURAL AREAS

Demand Value	33 to 125 gpcd [a]	75 gpcd	150 gpcd	10 gpm [b]
Engineering Use	Average range of daily per person water use in rural areas	Daily average per person water use rate for Big Thompson Canyon study area	[redacted] per person water use rate, [redacted] for pipe [redacted] no	The maximum instant water use rate in the study area. [redacted] must be able to carry this much water to each household

[a] gpcd = gallons per capita per day.
[b] gpm = gallons per minute.

WASTEWATER CHARACTERISTICS

In analyzing wastewater characteristics, it is necessary to investigate components affecting both the amount of wastewater and its strength and composition.

FLOW

The per capita water usage in the study area is not as great, on the average, as the corresponding per capita usage in a city. Consequently, the per capita wastewater flowrate is less than the average rate in a city.

A unit average flow of 75 gpcd is a realistic value for design purposes and will be utilized in this report. This value represents typical domestic waste, including residential and commercial contributions, together with infiltration/inflow (I/I) expected even from well-designed and constructed sewerage systems. Peak flow will be calculated based upon 200 percent of the average flow.

Their "peak flow" is actually the maximum daily flow I believe

COMPOSITION

Wastewater strength is generally measured in terms of biochemical oxygen demand (BOD_5) and suspended solids (SS). Evaluation of other constituents such as chemical oxygen demand (COD), ammonia (NH_3), temperature, and pH are necessary in particular situations.

Although wastewater flowrates are less than flowrates in large cities, the pounds of pollutants per capita would not significantly decrease. The unit strength of wastewater is 0.18 pounds per capita per day (pcd) BOD_5 and 0.18 pcd SS. These values correspond to a concentration of 270 milligrams per liter (mg/l) BOD_5 and 270 mg/l SS.

DESIGN FACTORS

A summary of unit design factors for sizing various components of the wastewater system is presented in Table IV-3.

TABLE IV-3. UNIT DESIGN FACTORS

ITEM	FACTOR
Wastewater Flow	
Average flow (gpcd)	75 [a]
Peak flow (gpcd)	150
Wastewater Composition	
BOD_5 (pcd)	0.18
SS (pcd)	0.18
Ammonia (mg/l)	15

gpcd = gallons per capita per day.
pcd = pounds per capita per day.
[a] Includes minimum I/I contributions.

WASTELOAD PROJECTIONS

Wasteload projections have been developed [redacted] Resulting wasteload projections are summarized in Table IV-4.

TABLE IV-4. WASTELOAD PROJECTIONS FOR YEAR 2000

COMMUNITY	CONSTITUENT AVERAGE FLOW (gpd)	BOD$_5$ (lbs/day)	SS (lbs/day)
Glen Haven/ North Fork	49,000	117	117
Loveland Heights/ Glen Comfort	100,000	243	243
Waltonia	13,125	32	32
Drake/Midway	30,000	72	72
Cedar Cove	34,000	81	81
Sylvan Dale	19,000	45	45
Big Thompson Valley East	49,000	117	117

gpd = gallons per day.

RECREATIONAL VEHICLES

Many recreational vehicles travel through the canyon annually. These vehicles have self-contained units which must be dumped fairly frequently. The wastewater from these vehicles is difficult to treat due to its high strength. It is recommended that these vehicles not be allowed to dump at any site within the canyon.

CHAPTER V

DESCRIPTION OF WATER SUPPLY

The following section outlines the present water system in the study area and some of the advantages and disadvantages of the current operation. The basis for development of the various water supply options is presented followed by a selection of the optimal supply system.

SUITABILITY OF PRE-FLOOD WATER SUPPLIES

The following section describes the general study area water supply and the acceptability of such a system.

SHALLOW RIVER WELLS

In the past the use of shallow wells in the Big Thompson Canyon was a common means used to acquire potable water from the river. Such wells consisted of a deep riverside depression with a pump that delivered the water to the resident. These systems were used mostly by summer residents who would take proper precautions against freezing by sheltering the pipe and pump for winter months. By covering the pump intake pipe with gravel and sand, the homeowner was able to obtain filtered water. However, the bacteriological counts of the water were often quite high. This type of system is rarely discussed as a potable water alternative because of the lack of control over bacteriological quality and hence the inability to protect human health.

There are four problems associated with this approach. Two of them are legal, one geological and one biological/chemical. The first legal question is one of rights. According to Colorado Water Law a person is not entitled to use water unless a right to the water has been acquired. Rights to surface waters of the Big Thompson River are entirely appropriated and therefore canyon residents may not be allowed to use shallow wells. Rights to the water may be acquired because "when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall have the preference over those claiming for any other purpose...". Currently the State Engineer's Office is allowing some reissuance of permits for shallow wells providing they exist in a subdivision that was platted prior to May, 1972.

The second legal question is the county ordinance concerning construction within the floodway. Installation of pumps, piping, and pump houses would probably be allowed by the county commissioners because they are not designed for human habitation.

The geological problem associated with shallow well construction in the Big Thompson Canyon is mainly a result of the 1976 flood. Scouring caused by the flood exposed the bedrock in many places on the river bottom making it difficult to re-establish a shallow well.

The biological/chemical problem associated with shallow well construction in the canyon is actually a sanitary reason for not utilizing such a system. The sand and gravel that would filter the river water as it is pumped from the river cannot adequately remove bacteria. Outbreaks of Giardiasis have been recorded in the drainage. Even with the control obtained by utilization of a wastewater containment technique, as outlined later in this report, to prevent water contamination, the residents of the canyon cannot be protected from accidents and inappropriate use of the river waters. The use of individual chlorine disinfection within the pumphouse is an alternative to such dangers but these systems are generally not developed to the extent that they are universally accepted by individual water supply system users. They often are not given the attention and care needed to sustain good operational characteristics.

DRILLED AND CASED WELLS

A number of the water supplies in the canyon come from drilled and cased wells. To protect water rights, well drillers are required to drill at least fifty feet from the stream and the top twenty feet of the well must be cased and sealed with an impermeable material. This seal helps also to protect the well from surface water contamination.

In conversations with well drillers who have often drilled wells in the canyon, it was found that they have had good luck obtaining water in the canyon. Wells range from 125 to 550 feet deep. Minimum depth is usually 250 feet deep and the wells seldom exceed 450 feet. These six-inch diameter wells can supply from one gallon per minute (gpm) up to ten gpm with an average supply capacity of less than two gpm.

The necessity of having to drill a well this deep can be an asset. The deep well can generate a static head (water level) within ten feet of the surface. Thus, a 400 foot well that supplies only one gallon per minute may have a water column within the well of over 380 feet. This column provides water storage of over 550 gallons. Such storage capacity makes granite wells excellent for household wells but incapable of supplying constant water at a high rate such as for irrigation or large housing complexes.

It has been observed that some wells within the canyon contain considerable iron. Although the iron can damage clothing and other property, it is not considered a health hazard. Excessive iron in some wells will encourage some homeowners to redrill their water supply.

CRITERIA FOR LAYOUT OF WATER SYSTEMS

This section and the following section entitled "Evaluation of Alternative Water Supply Systems" contain detailed introductory material needed to assess the feasibility of each water supply option. The section entitled "Screening of Alternative Water Supply Systems" assesses the optimal water supply options for each community.

Prior to the development of alternative plans for water supply systems within the damaged areas of the Big Thompson study area, specific criteria must be established to insure the proper comparison of plans and resultant optimum plan selection. Information required includes design criteria for facilities and cost estimates for facility construction and operation.

The following discussion describes design criteria that were used for water supply system schemes, including pipelines, pumping stations, storage reservoirs, water acquisition, pressure release systems, and other facilities necessary for adequate delivery of clean water.

Treatment of community or canyonwide water supplies is included as a requisite for all systems developed. The water quality of the Big Thompson as outlined previously is not of sufficient quality for drinking water purposes without treatment.

SAFE DRINKING WATER ACT

No water supply review is complete without a discussion of the Safe Drinking Water Act. The Act requires all community water systems to periodically monitor their waters for the constituents in Table V-1. The water supply must also keep good records detailing the:

1. Date of analysis;
2. Name of laboratory conducting analysis;
3. Name of person responsible for analysis;
4. Analytical method used;
5. Result of analysis.

The general water supply operation will also need to report routinely to the state or the EPA to comply with the Act. The Act requires community water suppliers to report to its customers if the drinking water is found to contain a biological or chemical constituent that may be dangerous to public health.

TABLE V-1. NATIONAL PRIMARY DRINKING WATER STANDARDS

A. MAXIMUM CONTAMINANT LEVELS FOR INORGANIC CHEMICALS

Contaminant	Level (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate	10.0
Silver	0.05

Fluorides

When the annual average of the maximum daily air temperatures for the location in which the community water system is situated is the following, the corresponding concentration of fluoride shall not be exceeded:

Temperature

Degrees F	Degrees C	Level (mg/l)
53.7 and below	12.0 and below	2.4
53.8-58.3	21.1-14.6	2.2
58.4-63.8	14.7-17.6	2.0
63.9-70.6	17.7-21.4	1.8
70.7-79.2	21.5-26.2	1.6
79.3-90.5	26.3-32.5	1.4

B. MAXIMUM CONTAMINANT LEVELS FOR ORGANIC PESTICIDES

Chlorinated Hydrocarbons	Level (mg/l)
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.01
Toxaphene	0.005
Chlorophenoxys	
2,4-D	0.01
2,4,5-TP Silvex	0.01

As defined by the Act, public water systems include systems that serve at least twenty-five individuals at least 60 days out of the year. All public water systems must comply with the requirements of the Act. Private water systems do not have to comply with the Act. This definition is subdivided into two types of water supply systems. Community systems are systems which serve at least 15 service connections used by year-around residents or serves at least 25 year-around residents. A canyonwide water supply would be such a system. Non-community systems are those systems that usually serve transients. They are operational 60 days a year or more and have at least 15 service connections or serve water daily to at least 25 people. Most hotels, restaurants, and other public facilities in the Big Thompson Canyon are classed as non-community systems. Generally the monitoring requirements are not as stringent for non-community water systems as for community water systems.

DESIGN FACTORS

Design and cost data presented in this report apply to preliminary design and layout of facilities. In layouts of this type, it is necessary to make a reasonably close approximation of the size, location, type of construction, route, and cost of the various facilities to be developed. In addition, this information must be given in sufficient detail to permit comparison of alternative plans. Some relocation and resizing of a portion of the facilities will be required at a later date as a result of the detailed engineering studies which are made during the preparation of construction drawings and specifications. Conveyance facilities include distribution lines, pumping facilities, storage, and pressure release systems. Pipes were designed as forcemains based on the Hazen-Williams formula for pressure conduit flow ("C" = 120).

Distribution facilities have been sized to handle peak hourly demand without undue pressure loss. Minimum forcemain size was assumed to be four inches in diameter which allows for very little future expansion in some areas but will adequately serve projected year 2000 population. Cluster well systems were usually sized using two-inch supply pipe unless such size would be insufficient. One-inch pipes were sufficient for individual well systems. Occasionally when designing community and canyonwide water distribution systems, a two-inch diameter pipe was used to serve small housing clusters away from the main supply line. A minimum of 30 psi residual pressure is supplied at each distribution point.

Pumping capability was designed to serve maximum hourly demand in conjunction with storage supplies. Storage facilities are designed to handle maximum hourly demand for over two hours. Maximum hourly demand rarely continues for more than thirty minutes. Smaller than normal storage facilities are utilized because of the low level of irrigation that occurs within the canyon. More water is available from the river for large irrigated parcels. Fire storage is not provided.

Treatment facility design for water supply facilities is based on the type of treatment and volume of water to be treated. For this study, it is assumed that units of Colorado-Big Thompson water would be available to the canyon water systems. Softening of surface water and well water would not be required.

CHLORINE ADDITION

Commercial establishments in the canyon study area must chlorinate their water to prevent disease transmission to travelers. Chlorination can help guarantee the bacteriological quality of the supply. Private residents often do not chlorinate their drinking water because of the increased level of effort required to maintain the system and the inability to control concentrations from small chlorinators. For all cluster, community and areawide systems, the cost of chlorination facilities was included.

PIPELINES

Unit construction costs for forcemains are based upon the use of cast iron, lined and coated steel, or concrete cylindrical pipe. Costs include pipe, excavation, laying, valves and fittings, select bedding and backfill, testing, and clean-up. Figure V-1 indicates the pipe construction cost per lineal foot used in this report for cost estimates. An added incremental cost is not included to account for cost of floodproofing any major distribution lines that would be located in the floodway. Most of this supply would be located along Highway 34 which would have floodproofing measures as a part of the highway design and would also adequately protect the water main. River crossings would usually be made on new bridges and would have the floodproofing equivalent of these structures.

BASIS OF COST ESTIMATES

The cost of constructing and maintaining a water supply system includes the capital outlay necessary for initial funding plus continued expenditures for operation throughout the lifetime of the project. The data presented in the following sections will provide sufficient information for comparison of alternative plans developed in this report plus an approximate total cost of each proposed water supply project.

Project and Construction Costs

Project costs include all capital outlays necessary for construction of a project. These costs include expenditures for construction, engineering services, contingencies, and overhead items such as legal and administrative fees.

Because costs of construction undergo significant changes in accordance with corresponding changes in the national economy, a cost index is usually presented to reflect the conditions for which the estimates are made. A widely used index is the Engineering-News-Record (ENR) Construction Cost Index, which is computed from prices of construction materials and labor and based on a value of 100 in the year 1913. Based on recent conditions for Larimer County, cost data in this report are based on an ENR Construction Cost Index of 2300. Although this value will not reflect future conditions, costs of future construction can be related to cost data presented herein by applying the ratio of the then-current ENR Construction Cost Index to 2300. This index will be used for evaluation of wastewater systems as well as water systems.

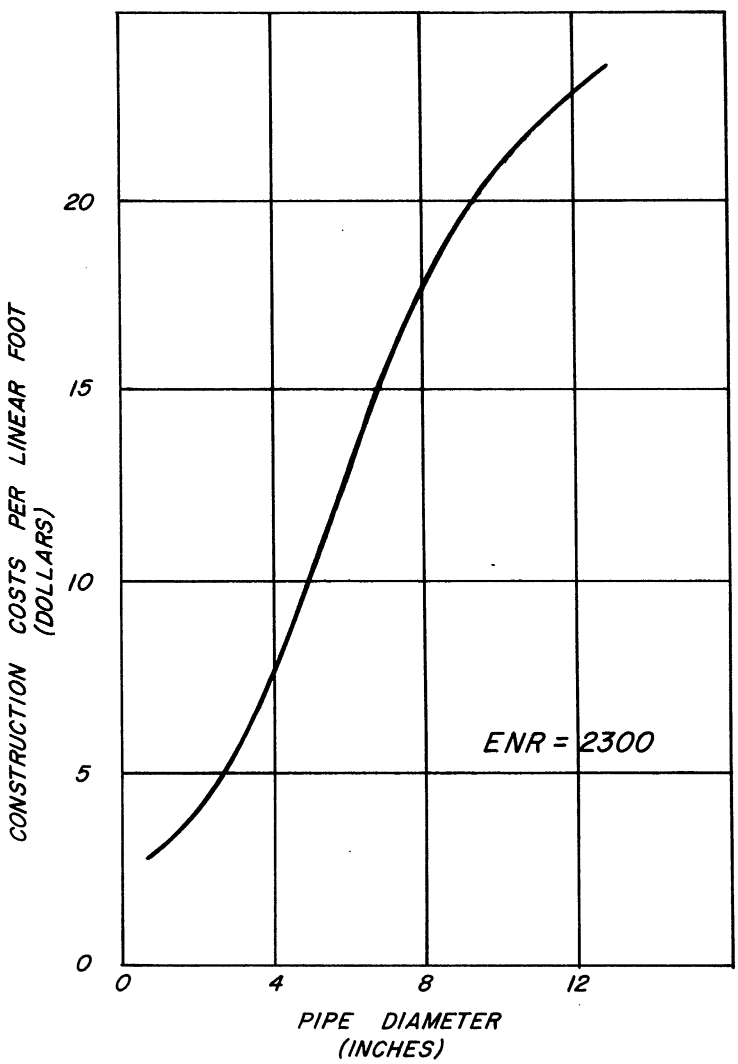


FIG. V-1. INSTALLED CONSTRUCTION COSTS OF WATER SUPPLY LINE

Unit construction cost prices given in this report include contractor's overhead and profit, but do not include engineering, construction contingencies, right-of-way acquisition, or legal costs. An additional 30 percent is added to the construction cost to cover such expenses to arrive at estimated project cost. Because these unit prices represent average bidding conditions for many projects, actual construction bids for a given project may not correspond to the unit prices used herein.

Special additive items are applied for river crossings and other special designs where believed necessary to cover special conditions. These preliminary estimates are not presumed to be as accurate as those prepared for final design. They are, however, adequate for screening purposes.

INTEREST RATES

Interest rates, generally applied as a compounded percentage per year, are an expression of the time value of money. Interest rates must be assumed for purposes of computing the annual cost of capital, for estimating the total cost of prospective bond issues, and for discounting the value of deferred works in present worth comparisons.

Many studies for public works programs have used very low interest rates, based on the apparent interest costs of highgrade, tax-exempt bonds. This practice ignores the fact that public projects are financially supported by consumers and corporations for whom the time value of money is much higher than public-bond interest rates. In addition, interest rates for public financing are now at relatively high levels and are continually rising. This report used a rate of 7.0 percent for calculating possible public works financing and a loan period of 30 years for water supply systems and 20 years for wastewater systems.

Annual Costs

Economic evaluation of alternative projects requires consideration of annual as well as project costs. Annual costs include expenditures for capital recovery plus operation and maintenance (O&M). O&M costs include expenditures for labor, repairs, power, chemicals, supplies, administration, and additional costs which vary from project to project. Operating costs presented herein are based on an ENR Construction Cost Index of 2300.

To assist the canyon residents in deciding which water service alternative may be the most acceptable, annual costs are expressed in terms of an annual cost per connection for each homeowner.

Present Worth

Another means of comparing the cost of various alternatives is the present worth method. Present worth is the amount of capital needed now to secure payment of all obligations over the life of the project. Thus, the present worth of a water system alternative represents the sum of money needed now to pay all project costs and operation and maintenance costs for the next thirty years.

Depreciation and Amortization

Most bonds sold for water supply projects have redemption periods of about 25 years. However, an estimate of the average economic life of each project is used in computing the annual cost of capital. The annual fixed cost is computed by applying a capital recovery factor to the project's capital cost.

The economic life of projects and facilities will vary. For this report water facilities were assumed to have a 30-year life. Generally, pipelines and other in-ground facilities have longer lifetimes but the geologic conditions of the canyon prevent justification of a longer life.

OPERATION AND MAINTENANCE

Pipelines

The annual operation and maintenance for pipelines has been assumed to be 0.5 percent of construction cost. This figure is for average yearly conditions and can be expected to vary widely from year to year.

Pumping Facilities

Total operation and maintenance costs for pumping facilities consist of power costs for the various flows and pumping heads, and other normal operating costs. The costs used in this report for both of these categories are based on rates for total dynamic heads ranging from 250 to 500 feet in wells. A total dynamic head of 100 feet was used to calculate power requirements for pumping-storage facilities. A rate of six cents per kilowatt-hour was used for electrical pumping costs.

Other Facilities

Annual O&M requirements such as labor, chemical requirements, and treatment facility costs were developed by extrapolation of curves for larger plants into the range of size utilized within the Big Thompson Canyon. Where smaller facility cost estimates were available, they were utilized.

Individual Wells

Cost of individual wells was based upon discussions with local drilling contractors. Design of facilities was based upon scaled down estimates from larger systems.

EVALUATION OF ALTERNATIVE WATER SUPPLY SYSTEMS

The variety of viable water system services for the Big Thompson Canyon were subdivided into four general categories:

- Individual wells for each study area resident and commercial establishment;
- Installation of wells that supply water to a group of households - a cluster alternative;
- Design and development of a community water system for each study area community;
- Design and development of a canyonwide water supply system extending from Loveland Heights to Cedar Cove. The other communities would be served by one of the three alternatives listed above.

The approximate cost of each of these alternatives will be presented and analyzed for its acceptability and functional capabilities. Normally when designing water facilities for communities, the design engineer will incorporate a necessary factor into the design to account for fire supply demand. However, in developing and reviewing water supply alternatives for the Big Thompson Canyon study area the fire demand was not provided for because of the high additional cost which could not be justified when river water is available and can be pumped for such emergency action. Pumper trucks are capable of supplying sufficient water from the river to adequately control house fires. Fire protection throughout the canyon is discussed more fully in Volume 3. Forest firest are a danger, but county, state, and federal assistance is available if it is needed.

Any water supply alternative must be able to provide adequate water and pressure for all service connections during hours of peak flow. At morning and dinner times, the water requirements may be four or more times the average supply needs. Thus water systems must be able to provide four times the average flow to meet a peak demand. Such peak demand is usually provided by storage, releasing water at higher rates than pumping would supply.

INDIVIDUAL WELLS

Installation of wells on each canyon property may be the easiest means of supplying water to the canyon residents. The use of such wells means each landowner is responsible for securing his own safe water supply. Individual wells require personal indebtedness and not community monies or development of water user associations. Finally, most wells when supplying personal residents would not need to comply with the Safe Drinking Water Act and therefore money would not need to be spent on monitoring, recordkeeping and reporting.

Individual wells are the easiest system to initiate. Co-ops and other types of homeowner associations need not be developed to guarantee a constant supply. Operation and maintenance responsibilities are clearly defined and the effects of system failure are placed upon the one responsible. Both deep drilled and cased wells and shallow wells are discussed.

The following analysis assumes that adequate wells are drilled at each developed property. Adequate wells are deep drilled and cased wells that do not allow surface water infiltration.

The cost of six-inch properly cased wells is $10.00 per foot, resulting in an initial cost for drilling of about $2,500, depending greatly upon the ease of acquiring water. In addition to the $2,500 drilling cost, additional capital is needed for purchase of a pump, installation and protection. These fixtures will add another $1,800 to the initial cost. Ammortizing this cost for a 30-year life would cost $346 per year (4300 x .08059). Additional operational and maintenance cost for the Big Thompson Canyon residents are approximately $180 per year for the full time resident. Thus, the full time resident pays nearly $520 a year for his water supply, providing it is from a deep secure well. Such a well system for the part-time resident may cost $420 per year because of reduced pumping cost.

The cost of installing an individual shallow well system would average about $1800. The unit costs are listed below:

Digging and setting the materials	$ 500
Pump	200
Shelter	250
Pipe and installation	300
Hydropneumatic tank, gages and fittings	450
Electrical hookup	100
Total	$1800

Electrical operation would be approximately $80 annually and about $20 for maintenance of the pump and fittings. Generally such systems would be located within the floodway and all parts of the system except for the house service pipe may have to be replaced every ten years.

The present worth of such a water supply is $4,190 compared with $6,530 for a deep drilled and cased well. Thus, installation of a shallow well system will cost about two-thirds of a properly drilled and cased system. These systems, however, are not recommended due to public health concerns and will not be discussed further.

The alternative of using deep drilled and cased wells will be discussed for each community individually.

Glen Haven and North Fork

In the steep canyon area of Glen Haven a total of 57 properties were located within the floodzone. An additional 3 households may rebuild their structures out of the floodway on their property. Only four of the 57 properties that may have to rebuild water systems had deep drilled and cased wells. The remaining 53 wells would cost $228,000 to re-install.

Loveland Heights/Glen Comfort

There are approximately 206 developed properties in the Loveland Heights/Glen Comfort area. Sixty-three of these are utilized year-around while the remaining 143 are occupied only seasonally. As discussed previously, 131 of these properties may have experienced water or sewer system damage. Using data developed by the Larimer County Health Department, it was found that 28 of the properties near the river presently have properly drilled and cased wells. A larger number may exist away from the river. For the purpose of water supply analysis only those properties that are within the floodzone will be considered for cost analysis (Columns 1-3 of Table III-4). For the purposes of this study, the floodzone is that area affected by the summer of 1976 flood. All the properties within the floodzone area which do not have drilled and cased wells were assumed for this study to have water system needs of some sort. Of the 63 properties that may have experienced damage within the floodzone, 7 have drilled and cased wells and are assumed to be operational. Thus, 56 properties located near the river may need water supply improvement. Average cost for canyon wells is $4,300 per homeowner. Total cost for the 56 properties to install individual wells would be $240,000. The present worth, which includes annual O&M costs, of such an alternative is $366,000.

Waltonia

Of the 35 developed properties in Waltonia that may have system damage, only 6 are within the floodzone and therefore considered for analysis of individual wells. The type of systems these 6 properties have is not known. Like most canyon residents, they presently may have shallow river wells. Cost for construction of six wells in the Waltonia area would be $25,800. Another six properties may select to rebuild out of the floodway.

Drake/Midway

Thirty-nine properties in the Drake area within the floodzone were not destroyed by the flood but may have experienced water system damage. Ten of these property owners had drilled and cased wells prior to the flood and it is assumed these water supplies were not severely damaged. The remaining 29 wells would cost residents of Drake/Midway $124,000 to install. An additional 14 families may rebuild out of the floodway and cost for these 14 wells would be $60,200.

Cedar Cove

Cedar Cove has 14 properties within the floodzone area that may need upgraded water supply systems. Five properties within this area already have drilled wells. An additional five properties may elect to rebuild above the floodway. Cost for individual well installation in the Cedar Cove area would be $38,700 for the 9 residents needing wells and $21,500 for the 5 residents that may rebuild.

Sylvan Dale

The eastern end of Sylvan Dale is supplied with water by the Loveland water system. Households located west of the plant near the Sylvan Dale Ranch had water supply systems damaged by the flood. A total of 5 residents may need new water supplies following the flood. Cost of replacing these 5 systems with modern drilled and cased wells would be approximately $21,500. At a cost of $4,300, one other homeowner may choose to rebuild a water system out of the floodway.

Summary

Of the total 181 water systems inundated by the flood, only 23 had drilled and cased wells. Thus, replacement cost for the entire canyon would be approximately $679,000. An additional 31 may rebuild on their properties above the floodway at a cost of $133,000. Ammortizing this cost at 7 percent for thirty years results in an annual per pump cost of $346. Additional cost of maintenance, repairs, and electricity use can cost $180 per year for the full time resident down to $30 per year for the seasonal resident. Later in this report these costs will be compared to other alternatives.

CLUSTER WELLS

The concept of sharing well systems in remote areas is not new. Within the Big Thompson Canyon there are a few known shared water systems ranging from two houses per well up to four houses per well. Cluster wells can vary considerably in cost. Table V-2 shows the cost of cluster wells designed to serve from two to ten houses. The costs shown in Table V-2 reflect a generalized analysis of piping, well and distribution systems assuming about 200 feet of supply pipe per household. Systems actually built may reflect as much as a 20 percent change from these costs. Factors that may reduce the cost presented in Table V-2 include:

1. Acquiring adequate water before a full 250 foot well is drilled, reducing well and pump costs;
2. Higher density house clusters that use less than the assumed 200 feet of supply pipe per household;
3. Clusters serving only seasonal residents would reduce the estimated operational and maintenance expense for individual wells by as much as 70 percent.

Increased homeowner cost would result if:

1. Extra well depth or additional wells were necessary to provide adequate water;
2. Additional piping was necessary to supply outlying houses;
3. The cluster served more than 25 people for more than 60 days, resulting in additional cost of monitoring and reporting required by the Safe Drinking Water Act;
4. The terrain or geology is such that installation costs for piping are increased;
5. A considerable amount of iron is present in the well and it must be redrilled.

Table V-2 also shows the peak daily demand experienced by a cluster system. Most wells in the Big Thompson Canyon are only capable of supplying 2 gallons per minute. Thus, the cluster well system that serves only five houses may exceed the capacity of the well. Consultation with a well driller familiar with the canyon geohydrology can help determine what the capacity of the well may be. Cost would be increased by about 12 percent if two wells were needed to provide adequate capacity for a cluster well of more than five houses or excessive iron concentrations make the well unacceptable. Table V-2 also shows the per connection annual cost for cluster wells.

The following discussion shows the results of a community-by-community analysis for effective utilization of cluster well systems by structures that are within the floodzone area. Each community was analyzed to determine the size of cluster well systems needed. Individual cost could be substantially reduced if those in the community without damaged systems would choose to upgrade their water supply systems by connecting into a cluster system. The clusters shown in the following figures do not account for people out of the floodzone that may choose to connect into a reliable system.

North Fork and Glen Haven

A cluster well supply system to serve the 53 properties near Glen Haven located within the floodzone would include four wells serving two properties each, four wells serving three households each, one well serving a group of seven houses, one well supplying a group of nine houses, and a large system serving ten houses. Another twelve wells would serve individual residents. Total installed cost for the water supply system would be $193,700 which would cost over $7,700 annually for operating and maintenance expenses. This is $30 per tap per year less than individual well cost.

TABLE V-2. DESIGN CRITERIA FOR DEVELOPMENT OF CLUSTER WELL SYSTEMS

DESIGN CRITERIA	NUMBER OF HOUSES SERVED BY WELL SYSTEM								
	2	3	4	5	6	7	8	9	10
Maximum daily demand (gpd) with seasonal occupancy of 4 people/structure at 150 gpcd	1,200	1,800	2,400	3,000	3,600	4,200	4,800	5,400	6,000
Well recharge rate necessary to supply maximum daily demand (gpm)	0.8	1.3	1.7	2.1	2.5	2.9	3.3	3.8	4.2
Depth of well needed for storage of maximum hourly rate (feet). Minimum depth assumes 250 ft.	250	250	250	380	410	500	575	650	730
Cost of well ($)	2,500	2,500	2,500	3,800	4,100	5,000	5,750	6,500	7,300
Cost of pump, piping, hydropneumatic and distribution system	3,400	4,600	5,900	7,900	10,000	11,800	13,700	15,500	17,400
Total Cost ($)	5,900	7,100	8,400	11,700	14,100	16,800	19,450	22,000	24,700
Construction Contingencies & Engineering (30%)	1,700	2,100	2,500	3,500	4,200	5,000	5,800	6,600	7,400
Total Capital Cost ($)	7,600	9,200	10,900	15,200	18,300	21,800	25,250	28,600	32,100
Annual O&M Cost ($)	350	400	460	540	610	660	710	870	1,000
Amortization 30-Year Life at 7 Percent ($)	610	740	880	1,220	1,470	1,760	2,030	2,300	2,590
Average Installed Cost Per Connection ($/Year)	480	380	335	350	350	345	340	350	360

Operation and maintenance expenditures would cost each person on the system about $146 per year. Table V-3 shows the cost of a cluster system for this area. Damaged systems located too far from cluster locations would need private drilled and cased wells.

Loveland Heights/Glen Comfort

From analysis of maps showing the extent of the 1976 flood, there are ten cluster well systems that could serve this area. Two wells serving two houses each; three wells serving three houses each; three wells serving four houses each; and three wells serving eight, nine, and ten houses for a total of 52 houses within the floodzone area served by cluster well systems. The remaining four structures within the floodzone area would be best served by individual wells. Table V-3 shows that the total cost for a cluster well system in Loveland Heights/Glen Comfort would be $188,800. The average cost per connection is $390 per year, about three-fourths of the annual cost of individual well ownership. $6,580 would be needed for annual operational and maintenance expenses; $117 per connection would be needed annually for adequate operation and maintenance.

Waltonia

The optimal cluster well system for the six houses within the floodzone at Waltonia is to serve three houses by one well and distribution system and three residences with individual wells. Table V-3 shows the total cost of such a system at $22,100 and an annual cost of $1,280 for operation and maintenance. This cost is not significantly less than the cost of individual wells, reflecting the scattered nature of damaged properties around Waltonia. The per connection annual cost is $510 of which $213 would be for operation and maintenance.

Drake/Midway

A total of fourteen households would best be served by cluster well systems in the Drake/Midway area. Eight structures could be served by cluster wells serving two properties each; two systems serving three properties each would serve six other structures. The remaining fifteen houses within the floodzone area would be served by individual wells because these are widely spaced. This system would cost $113,000 and require $4,900 annually for adequate operation and maintenance expenses. The annual cost per connection would be about fifteen percent less than the cost of individual wells. Total per connection cost would be $483 annually, of which $169 is for operation and maintenance.

Cedar Cove

Optimal cluster well system layout for the nine damaged properties within the floodzone area of Cedar Cove would include four wells. One well would serve two households; a second and third well would serve six households; and a fourth well would be an individual household well.

Total cost for the system would be $30,300 and an annual cost of $1,330 for operation and maintenance would be required. Table V-3 shows the various costs.

Sylvan Dale

There are only five properties in the Sylvan Dale area that would use a cluster well system. Such a system would involve three wells. One well would serve three houses and the two other wells would serve one house each. Total cost for the three water systems would be $17,800, or $438 per house per year. Operational and maintenance costs would be $152 per year per connection, or a total of $590.

COMMUNITY-WIDE SYSTEMS

To adequately design a community surface water supply system for the residents of the Big Thompson Canyon, it was assumed that all properties who did not have drilled and cased wells at present would utilize the community supply. A preliminary layout was developed for each of the canyon communities except Big Thompson Valley East. Most of the Big Thompson Valley East area presently uses water from the Loveland water treatment plant located near Sylvan Dale. Analysis for community-wide water systems was made assuming that a water treatment facility was constructed for each community. A brief review of the cost of drilling sufficient wells to supply each community was made. However, preliminary analysis showed that costs were about 10 percent higher if wells were drilled for community water distribution.

TABLE V-3. TOTAL COST BY COMMUNITY OF CLUSTER SYSTEMS [1]

	NORTH FORK/ GLEN HAVEN	LOVELAND HEIGHTS/ GLEN COMFORT	WALTONIA	DRAKE/ MIDWAY	CEDAR COVE	SYLVAN DALE
Capital Cost	$193,700	$188,800	$22,100	$113,300	$30,300	$17,800
Total Annual O&M	$ 7,740	$ 6,580	$ 1,280	$ 4,900	$ 1,330	$ 760
Amortization at 7% - 30-Years ($/Yr)	$ 15,600	$ 15,200	$ 1,780	$ 9,130	$ 2,440	$ 1,430
Total Annual Cost - Amortization + O&M	$ 23,340	$ 21,780	$ 3,060	$ 14,030	$ 3,770	$ 2,190
Cost/ Connection To Support Debt Service + Annual O&M Cost	$ 440	$ 390	$ 510	$ 483	$ 418	$ 438

[1] Damaged properties only.

Glen Haven/North Fork

The community-wide system for Glen Haven would serve all properties on West Creek, Fox Creek, and the North Fork of the Big Thompson River below 7,400 feet elevation. The layout for the water supply utilizes a maximum demand of 290 gallons per minute. This demand is generated by 112 connections in the area requiring $28,000 worth of service pipe. The main distribution pipe would consist of 7,200 feet of six-inch diameter pipe, 10,000 feet of four-inch diameter pipe, and nearly a mile of two-inch diameter pipe. Total cost of pipe is $230,800. Table V-4 shows the cost of other facilities that would be needed to supply potable water to the North Fork Community.

Annual operation and maintenance costs include $750 for chlorination facilities, $1,000 for pipeline maintenance, $4,000 for groundskeeping and general overseeing, $400 for electricity and pump maintenance, and $250 to comply with monitoring requirements of the Safe Drinking Water Act. The total capital cost of a community water system for Glen Haven/North Fork would be $491,700.

Loveland Heights/Glen Comfort

There are 206 possible connections for a community water system in the Loveland Heights/Glen Comfort area. The layout of this community system includes the cluster of homes on the west end of Glen Comfort but does not

TABLE V-4. COST OF COMMUNITY WATER SYSTEMS

COMMUNITY / WATER TREATMENT FACILITY	GLEN HAVEN/ NORTH FORK		LOVELAND HEIGHTS/ GLEN COMFORT		WALTONIA		DRAKE/ MIDWAY		CEDAR COVE	
	Cost ($)	Units (#)	Cost ($)	Units (#)	Cost ($)	Units (#)	Cost ($)	Units (#)	Cost ($)	Units ($)
Pipe [a]	220,800	33,200 ft.	381,400	48,400 ft.	30,450	5,230 ft.	114,000	19,250 ft.	105,800	16,800 ft.
River Crossings	4,800	8	16,000	8	-	-	10,000	5	6,000	2
Pressure Release Valves	9,000	3	12,000	4	3,000	1	3,000	1	3,000	1
Pumping Station Treatment & Storage [b]	113,600	1	137,800	1	19,600	1	53,000	1	53,000	1
Site Acquisition & Preparation	10,000	1	12,000	1	8,000	1	9,000	1	9,000	1
Chlorination	2,000	1	2,500	1	1,200	1	1,800	1	1,800	1
Purchase of Water	18,000	18	40,000	40	-	-	14,000	14	14,000	14
Total Construction Cost	378,200		601,700		62,150		205,500		192,600	
Contingencies & Engineering (30%)	113,500		180,500		18,600		61,650		57,800	
Total Capital Cost	491,700		782,200		80,750		267,150		250,400	
Annual O&M	6,400		7,450		3,200		4,850		4,500	
Annual Debt Payment [c]	39,600		63,100		6,510		21,550		20,200	
Total Annual Cost	46,000		70,550		9,710		26,400		24,700	

[a] Includes service pipe. [b] Includes diversion structures as needed.

[redacted]] [redacted] in[redacted]est[redacted] 30[redacted]ars[redacted] distribute water to the eastern properties that are in more remote locations down the canyon. It was assumed that 24 percent of the canyon properties presently have drilled and cased wells that supply water of high quality and that these people would not choose to connect to a public water system. Therefore for calculations of per connection cost of the system, it was assumed that 157 properties would need good quality water.

Design of distribution lines in the community includes 2,000 feet of eight-inch diameter supply pipe, 15,000 feet of six-inch diameter supply line, and over 2 miles of four-inch diameter supply pipe. One hundred twenty-five feet of service pipe was used as an average length of pipe needed per house connection in the area. A total of 19,600 feet of one-inch diameter service pipe would be necessary.

Table V-4 shows the cost of the facilities needed to adequately serve this west-canyon community. Total capital cost for the project would be about $782,200. Annual operation and maintenance costs would include $800 for chlorination facilities, $4,400 for personnel to watch the operation and take care of the equipment and structures, $400 for pump electricity, and an additional $250 to comply with the monitoring requirements of the Safe Drinking Water Act.

Included in the cost is $40,000 for the purchase of Colorado-Big Thompson (C-BT) water shares to guarantee sufficient water supply. Purchase of such a supply would be in excess of the community's needs but would provide sufficient water when C-BT project water had low allocations. Water might be rented when excess water was known to be available. Arrangements would have to be made to trade C-BT water for other water sources during the non-irrigating season.

Waltonia

For the design of a water supply system to serve the 23 service connections lacking drilled and cased wells in Waltonia, it was determined that a groundwater supply would be sufficient. These 23 service connections include all households that were assumed to not have drilled and cased wells. Two wells at 500 foot depth each would adequately supply water and storage. The $10,000 cost for these wells could be substantially reduced if only one well was drilled and sufficient water was available (about 8 gpm). Additional capital cost would be saved because only one pump and less pipe would be necessary. Table V-4 shows the total capital cost for a Waltonia water system to be $81,000. This includes 3,000 feet of four-inch diameter pipe and 500 feet of two-inch supply pipe. Each service connection would require 75 feet of distribution pipe for a total of 1,725 feet.

The wells would be located in Waltonia Gulch with the necessary pumps, chlorination, pressure, and housing facilities. The steep assent down the gulch would require one pressure release valve.

Annual costs for operation and maintenance would include $250 for monitoring, $300 for chlorination, $1,200 for general equipment watch and facility upkeep, $150 for pipeline work, and $1,300 for pump maintenance and electrical usage.

Drake/Midway

The layout of a Drake/Midway community water system incorporates a small water treatment plant located above the North Fork of the Big Thompson River. An alternative site may be on the southwest end of Drake above the Big Thompson River. Because the cost of extra piping to serve the east end was prohibitive, that end of the community was served by a cluster well system. The water supply system includes 3,000 feet of six-inch diameter pipe, 7,000 feet of four-inch diameter pipe, 1,000 feet of two-inch feeder pipe and over 6,000 feet of service supply pipe one-inch in diameter. River crossings, pressure release valves, storage, site preparation, design, treatment plant, and purchase of 16 acre-feet of water add to a total construction cost of $205,500.

The community of Drake could be served by a four-inch diameter pipe which would result in a capital savings of about $15,000. This small supply line, however, may not serve future development in the Drake area with sufficient volume and pressure.

Cedar Cove

A water supply system for the community of Cedar Cove involves many small connections to outlying houses. Because this area may also experience a period of growth, the supply pipes were sized at four-inch diameter where in some places a two-inch diameter pipe would presently be sufficient. A total of 9,300 feet of four-inch diameter line is needed and 1,400 feet of two-inch diameter line. Total cost for pipe installation, including one-inch diameter service pipe, is $105,800. Table V-4 shows the nature of other expenses that result in a total capital cost of $250,400. Annual operation and maintenance cost would be $4,500. Cedar Cove would find it necessary to purchase 14 units of C-BT water to guarantee a consistent supply.

Sylvan Dale

The ten residents on the west end of Sylvan Dale would experience the costs of a ten cluster well system as outlined. The possibility of these people pumping treated water from the Loveland water treatment plant is discussed under the canyonwide alternative.

CANYONWIDE SYSTEM

To estimate the approximate construction cost of a canyonwide water supply system, it is estimated that a treatment plant capable of treating 0.3 million gallons per day would be constructed above Loveland Heights. The plant and supply lines would serve projected Big Thompson populations to the year 2000. The layout for such a canyon-wide system must be able to serve future populations because of the prohibitive cost of reinstalling larger pipes and storage facilities. This treatment plant and distribution pipe would supply water for Loveland Heights/ Glen Comfort, Waltonia, Drake/Midway, and Cedar Cove. Glen Haven and Sylvan Dale would be served by cheaper, alternate systems because of the high cost of pipe for water carriage.

Minimum pipe diameters were used because the large elevation drop within the canyon would offset pipe pressure losses. Such a system would help reduce annual operation and maintenance costs and may become a viable alternative if sewer and water systems were constructed simultaneously, reducing construction cost.

Almost four miles of eight-inch diameter supply pipe, eight miles of six-inch diameter pipe, and another four miles of four-inch diameter pipe would be required. The estimated cost for this supply pipe is $982,000. An additional $118,900 would provide service connections for the 289 structures with inadequate systems. Another $1,159,000 would provide the needed treatment works, pumping facilities, storage tanks, diversion structures, pressure release valves, and shares of C-BT.

Sylvan Dale

The large distance and difficult terrain of the Big Thompson Canyon below Cedar Cove makes it prohibitive to install a water supply pipe to serve the residents of Sylvan Dale from a canyon treatment plant. A possibility not outlined previously, however, should be addressed. This is the option of pumping treated water from the Loveland treatment plant up to the people in the Sylvan Dale area.

This option would require $6,600 for service supply pipe to the ten connections and $45,000 for pipe to transport the water from the treatment plant to the homes. Pump, pressure system, and housing for the system would add another $6,000. Total cost for such a project is discussed in a later section of this report.

Glen Haven/North Fork

This community was not included in the development of a canyonwide service alternative because of its remote location. The high cost of supply pipeline up the North Fork Canyon would make such an alternative economically prohibitive. The optimum system for Glen Haven/North Fork is presented in the next section of this report.

SCREENING OF ALTERNATIVE WATER SUPPLY SYSTEMS

This section summarizes the costs of the various alternative water supply systems of the Big Thompson study area and other significant factors needed to arrive at an optimal water supply alternative. Economic, environmental, and operational factors should be analyzed and combined into an overall evaluation from which the best alternative plan can be selected.

Economic evaluation should include analysis of capital cost and total annual cost presented as present worth. It is re-emphasized that in this report economic evaluations are based on preliminary design and layout for facilities only. These costs were developed based upon the extent of information available and the resource and time constraints imposed. Actual design costs and estimates will vary but these costs are sufficient for screening and economic evaluation purposes.

ENVIRONMENTAL AND FUNCTIONAL FACTORS

Environmental evaluation will include hydrologic factors, geology, biology, land use and population, and aesthetics. These factors have been considered in each community and canyonwide for all of the proposed alternatives. The general environmental setting of the canyon study area was described in the first volume of this report.

Functional evaluation of alternatives includes effectiveness, reliability, flexibility, program acceptability, implementation capability, and water acquisition. These factors are all given a weight factor in Table V-5 from one to three. A rating of one is a low evaluation while a rating of three makes that factor highly acceptable.

Effectiveness

To evaluate effectiveness of the four alternative water supply systems each system was evaluated on its capability to serve canyon residents with water. All alternatives discussed are capable of providing potable water to canyon residents. The more technical alternatives of community-wide and canyonwide water supply systems are rated slightly more effective because of the higher level of operation and maintenance and associated capability for maintaining a high quality product.

Reliability

In considering water system reliability the more technical alternatives were again considered superior. However, as the length of service line increased so did the probability of system failure due to geologic hazards and other mishaps.

Program Acceptability

Because many canyon residents currently own and operate personal wells and because the responsibility for maintaining personal water systems is clearly defined, individual wells are the most functionally acceptable canyon water program. Canyon residents are generally willing to accept the idea of cluster and community-wide water systems but feel that a canyonwide water system would be a very difficult project. These canyon residents' feelings are depicted in Table V-5 so individual wells are given a rating of three for acceptability.

TABLE V-5. FUNCTIONAL FACTORS AND THEIR RELATIVE ACCEPTABILITY IN VARIOUS CANYON AREAS

FUNCTIONAL FACTOR [a] / ALTERNATIVE	EFFECTIVENESS	RELIABILITY	PROGRAM ACCEPTABILITY	IMPLEMENTATION CAPABILITY	WATER ACQUISITION	TOTAL
Individual Wells	1	1	3	3	3	11
Cluster Wells	2	2	2	2	3	11
Community-Wide Water System	3	2	2	1	1	9
Canyonwide Water System	3	2	1	1	1	8

[a] A rating of 1, 2, or 3 was given each functional factor, where 1 constitutes low functionality and 3 constitutes a high functionality.

Implementation Capability

Individual wells are considered to be the easiest alternative to implement because of their general canyonwide acceptability. However, community organization would make the other alternatives much more implementable as legal and cooperative problems could be more easily solved by such groups.

Water Acquisition

Colorado water law allows the use of Colorado waters to the first individual or organization to put that water to beneficial use. Deep drilled and cased wells are generally an acceptable way of acquiring water according to the State Engineer's Office. Community-wide and canyonwide water systems would use surface water supplies and negotiations would be necessary to acquire water rights by purchase.

Summary

Table V-5 shows the total of the weight factors for functional consideration. Individual wells and cluster wells received the highest total. Community-wide water treatment was seen as slightly more functional than a canyonwide alternative.

ECONOMIC EVALUATION

Screening of the various water supply alternatives on the basis of cost has been presented in two ways--annual per connection cost and present worth. Per connection cost is the annual cost per homeowner who must pay for debt service on all facilities and maintain the necessary operation expenses for the 30 years of the water supply system's life. The second means of presenting annual per connection cost and shown in Table V-6 reflects the amount of money needed for operation and maintenance expenses alone. This dollar amount becomes important if assistance is provided by a grant or other monies to pay for 100 percent of capital cost and study area residents are required to pay only for upkeep of the water supply system. If 75 percent project aid were available, then the per connection cost would be the annual operation and maintenance cost plus 25 percent of the difference of the total annual per connection cost and the annual operation and maintenance cost. A detailed financial analysis is presented in a later chapter of this report.

TABLE V-6. ANNUAL PER CONNECTION COST OF VARIOUS WATER SERVICE ALTERNATIVES

COMMUNITY	NUMBER OF SUPPLIES DAMAGED	TOTAL ANNUAL PER CONNECTION COST				ANNUAL O&M COST			
		PRIVATE WELLS	CLUSTER WELLS	COMMUNITY-WIDE [d]	CANYONWIDE [d]	PRIVATE WELLS	CLUSTER WELLS	COMMUNITY-WIDE [d]	CANYONWIDE [d]
Glen Haven/North Fork [a]	53	526	440	410	-	180	146	58	-
Loveland Heights/ Glen Comfort	56	526	390	449	882	180	117	48	63
Waltonia	6	526	510	422	882	180	213	139	63
Drake/Midway	29	526	483	528	882	180	169	97	63
Cedar Cove	9	526	418	484	882	180	148	89	63
Sylvan Dale	5	526	466	360	886	180	152	100	83

The easiest way to compare the costs of the various water supply alternatives is by use of Table V-7 which lists the present worth of the alternatives. In this table all expenses for the thirty years of project life are prorated back to the amount of money needed in 1977. This makes the least overall project cost easy to determine. Alternatives can be evaluated either to serve the properties within the floodzone or the entire community.

Tables V-6 and V-7 do not show the cost of community and canyonwide water service alternatives assuming that such alternatives were implemented to serve damaged systems only. These costs were developed and were found to be extraordinarily expensive. Implementation of a communitywide or canyonwide water service alternative because of its high cost is not feasible for damaged systems only. These more technical alternatives would require the formation of some type of debt payment organization. The specifics of such an organization are outlined in a following chapter.

SELECTION OF OPTIMAL COMMUNITY WATER SYSTEM

The selection of the optimal water supply system for study area communities is largely dependent on community goals and objectives. For all communities the cost data presented in Tables V-6 and V-7 indicate that individual wells and a canyonwide water system are not optimal solutions to water supply.

TABLE V-7. PRESENT WORTH OF ALTERNATIVE WATER SUPPLIES BY COMMUNITY ($1000's)

COMMUNITY	INDIVIDUAL WELLS TO SERVE DAMAGED PROPERTIES (1)	INDIVIDUAL WELLS TO SERVE ENTIRE COMMUNITY (2)	CLUSTER WELLS TO SERVE DAMAGED PROPERTIES (3)	CLUSTER WELLS TO SERVE ENTIRE COMMUNITY [a] (4)	COMMUNITY WIDE WATER SYSTEM (5)	CANYONWIDE WATER SYSTEM (6)
Glen Haven/ North Fork	346	732	290	531	571	571
Loveland Heights/ Glen Comfort	366	1026	270	743	875	1714
Waltonia	39.2	150	38	112	120	251
Drake/Midway	189	379	174	275	327	633
Cedar Cove	58.8	333	46.8	241	306	557
Sylvan Dale	32.7	65.3	27.2	49	45	63
Total	1032	2685	846	1951	2244	3694

[a] This number represents an extrapolation of cost from cluster wells to serve damaged systems only. It represents the maximum amount of a cluster well implementation.

A community-by-community analysis is presented below for selection of optimal water system.

Glen Haven/North Fork

Fox Creek, West Creek, and the North Fork of the Big Thompson River all have many homes along the streams. This strip development substantially increases piping cost for water supply systems. Thus, a cluster well system is about 10 percent cheaper than a community-wide water treatment plant and supply system. The lower operation and maintenance cost for a community system (see Table V-6) fails to make such a system the optimal selection when phased through 30 years. Service to damaged systems only would also be more economical and functionally feasible with cluster wells.

Loveland Heights/Glen Comfort

Functionally and economically service to the Loveland Heights/Glen Comfort area would best be provided by a cluster well system. A community system has a present worth almost 18 percent higher than a cluster well system even though operation and maintenance expenses of a community water supply system are less than one-half that of a cluster well system. Damaged properties are also best served with a cluster system.

Waltonia

The most economical and functional alternative for all of the Waltonia residents may be a community installed and operated supply. Although this alternative has a present worth of about $8,000 more than a cluster well system, its ease of operation and significantly lower operation and maintenance expense should make this alternative attractive to Waltonia residents, especially if a grant or other assistance was made available. Service to damaged systems near Waltonia would best be provided by a cluster well system.

Drake/Midway

A cluster well alternative is shown in Table V-7 as the lowest present worth for both damaged system service only and for service connecting the entire community. Annual operation and maintenance expenses are lowest when using a community-wide water supply.

Cedar Cove

Both from an operation and maintenance standpoint and a present worth standpoint the community of Cedar Cove would best serve the damaged water supplies by incorporating a cluster well system. Service to the entire community is also provided most economically with a cluster well system.

Sylvan Dale

There is no significant difference in cost if Sylvan Dale potable water is provided by a cluster well or community system. Because the area is geologically separated by the river and canyon, the cluster well system is encouraged because of its environmental acceptability.

Summary

For all of the Big Thompson Canyon study area communities, the best alternative for water supply should be selected from a cluster well or community water option. Functional and environmental considerations tend to encourage the use of a cluster well system as a canyon resident water supply. Other important considerations for water supply selection are availability of grants and loans and resident acceptance of a community owned and operated water system. It is emphasized at this point that cost estimates developed for the total present worth of the cluster well system can be quite variable. These cost estimates are a result of a changing number of taps incorporated, cost of purchasing existing wells and the average cluster well system size. Total present worth estimates range from $1.3 million to $2.1 million; however, the per resident cost continues to remain approximately the same, independent of the size of the complex. The different types of aid available and the responsibilities and committments of the community resident are described in Chapter X of this volume.

CHAPTER VI

OVERVIEW OF SELECTED WATER SERVICE ALTERNATIVE

The concept of using one well or a series of wells to serve water to a housing cluster was selected as the optimal system for damaged well systems and/or the entire study area. Only in Waltonia was a community-wide system recommended and the nature of this community is such that the community well system could be operated much like a cluster system. For this reason a separate discussion is not included for Waltonia Gulch.

This information was presented to canyon residents, the Larimer County Planning Commission, and the County Commissioners. Input, discussion and policy developed from such public meetings is reflected in the following discussion concerning cluster wells and water supply. An outgrowth of these meetings was development of population projections that more accurately reflect the development of the canyon communities reflecting the recommended land use plan. This change in population estimates could have significantly altered design and cost of community-wide and canyonwide water service alternatives. Use of cluster wells, however, allows a phased implementation of water supply and cost estimates will not be altered to any significant extent.

DESCRIPTION OF CLUSTER WELL SYSTEM

A cluster well system actually involves a cooperative use of a well and associated supply system by two or more property owners.

PHYSICAL DESCRIPTION

Wells supplying more than one property owner need to be drilled to a sufficient depth that will provide within the well shaft water storage for peak demand. The amount of such storage is shown in Table V-2 and avoids the added cost of buying, operating, and maintaining a storage tank.

Necessary equipment for each cluster well system includes:

- Pump capable of drawing water from the bottom of the well at a rate equal to the maximum demand generated by the well users;
- Foundation over the well to support the pump, motor and other equipment;
- A hydropneumatic or other satisfactory pressure system that provides adequate water pressure at all points of the supply network;
- A well and equipment house that can protect motors and water from freezing and allows sufficient space and shelter for maintaining equipment in superior working order;
- Supply pipe network that prevents excessive head loss and is buried deep enough to prevent freezing during long periods of non-use;

- Sufficient gauges, fittings, and tools to allow flexibility of operation and provide capability for on-site maintenance.

For large cluster systems serving many full time residents additional equipment may be considered necessary. Such extras include:

- Standby engine to pump when standard engine is non-operatable;
- Auxiliary well or storage tank to provide water during periods of excessively high demand.

OPERATION AND MAINTENANCE

Chapter V in presenting the various water service alternatives for the Big Thompson study area communities emphasized that high standards of operation and maintenance (O&M) would be required. Such a high standard of O&M for a cluster well system involves daily attention to equipment and periodic servicing of that equipment. Table VI-1 lists the general daily, semi-annual, and annual maintenance requirements of a typical cluster well system. The O&M requirements listed in Table VI-1 gives a general idea of the level of O&M needed. Each cluster well complex will vary from this basic schedule depending on manufacturer's suggestions.

NEW WELLS

Since the development of the data presented in Chapter V, the Department of Housing and Urban Development (HUD) administration has offered rehabilitation money to canyon residents. Many canyon residents are using this money to drill wells for private use. Of the 35 residents that have shown an interest in this funding source, only 1 has actually started work on a well. Another six property owners are presently (October 5, 1977) seeking bids from contractors on new wells with HUD money. Another eleven wells are considered by the Big Thompson Recovery Planning Office to have a very high probability of getting funding for well construction. The remaining 17 possible water supplies are awaiting verification of application acceptance or have not yet filed a preliminary application to HUD.

Seven of the applications for HUD assistance are not for complete well systems. Two applications have been filed asking for rehabilitation money to install pumps. Another three applications request assistance for the purchase of a chlorinator. Money is requested for a water supply line at two remaining properties. Thus, if all applicants receive HUD funds for property rehabilitation, 28 wells will be drilled and seven water supplies will be upgraded. These systems could provide a core group for further cluster well development.

ORGANIZATION

Although not necessary, the best way to implement and manage a potable water supply system is with some type of formal organization. There are three types of organizations that can be used for control and operation of a cluster well system. These are: a homeowners association; a corporation; and a water district. Each type of organization has particular advantages which are discussed below.

TABLE VI-1. CLUSTER WELL SYSTEM MAINTENANCE REQUIREMENTS AND SCHEDULE [a]

DAILY -	Check and record pressure gauge readings, flow and power consumption. Observe and record any irregularities in pump operation. Inspect area for leaks of water, oil or grease. Check and respond to service inquiries and complaints.
SEMI-ANNUAL -	Clean and oil gland bolts. Inspect for free movement of stuffing box glands. Inspect bearing packing and replace if required. Check and repair alignment. Drain and refill all oil-lubricated parts. Check consistency of grease at all grease lubricated points.
ANNUAL -	Remove bearings and check for flaws. Clean bearing housing. Packing should be removed and examined for wear. Check vertical movement of pump - make sure it is within manufacturer's specifications. Check and flush auxiliary piping, drains, and cooling water piping. Recalibrate instruments. Test pump to see if proper performance is being maintained. Check wiring.
OVERHAUL -	Only as needed, preferably delayed until winter season.

[a] These are general requirements. Different manufacturers and pumps will require modifications from this basic schedule.

Adopted from Karassik, I.J., Krutzsch, W. C. et. al. Pump Handbook. McGraw-Hill Book Company, New York, New York. 1976 .

Homeowners Association

Homeowners associations are usually implemented by a developer of a housing development. As people purchase lots or building units from the land developer, they join a homeowners association which pays for common property (i.e., open space). In the context of a cluster well, a group of homeowners could form an association that obtains fees for purchase and O&M of the potable water supply. The homeowners association acts as a formal organization that agrees to pay for and operate the well. Purchasers of property that is within the jurisdiction of the association requires joining of the association and payment of fees. A homeowners association may be a contractural arrangement having a water and sanitation district oversee the operation of their well system.

Corporation

A second option for cluster well organization is the use of a corporation. This formal arrangement is not discussed as a viable alternative because of the cost of incorporating and the added accounting burden of incorporation. Generally, the formal nature of a corporation is beyond that needed to effectively operate and manage a cluster well potable water supply.

Water District

The formation of a water district is the recommended operation and management scheme to be used in the Big Thompson study area. A water district is organized by filing a petition with the local district court. The petition will then be filed with the Secretary of State. Final formation of the district requires an election on approval of property owners and residents of the district. A board of directors with corporate powers acts as the administrative component of the district. The board has the power to levy and collect taxes within the district which are used to support O&M as well as pay for capital expenditures. The details of incorporation of a water district with a sanitation district are discussed in the implementation chapter of this report (Chapter X).

It is the taxing power of a water district that makes it a more acceptable service alternative. Homeowners associations and corporations can not apply for federal or state assistance. The final chapter of this report illustrates how this assistance can effect the individual users' monthly fee.

Existing wells that are utilized by a canyon resident but that are capable of supplying additional homeowners could be purchased by a water district and additional water supply obtained at a relatively low cost. In addition, the owner of the well would be relieved of operation and maintenance expenses. A particularly affordable means of purchasing these wells may be by not charging the well owner for water service until the agreed price is paid in full.

SUMMARY

The use of one well to serve multiple housing units was shown to be the most cost effective of the four water alternatives discussed. This, like all water service alternatives, requires a high level of operation and maintenance to be a dependable water supply. It is [redacted] within the canyon to operate cluster well systems within the canyon and seek federal and state assistance for providing water to the canyon residents.

CHAPTER VII

ALTERNATIVE WASTEWATER COLLECTION SYSTEMS CONSIDERED

Several collection alternatives have been considered and evaluated including gravity sewers, pressure sewers, vacuum sewers, vaults and pump trucks, and various combinations of these alternatives. These collection methods were evaluated assuming various numbers of units served and using various sites as the final destination. This section describes the alternatives considered, explains the selection process, and recommends basic collection methods.

GRAVITY SEWERS

Gravity sewers are constructed with a slope of at least 0.4 feet per 100 feet so sewage can flow by gravity at sufficient velocity to avoid solids deposition and odor production. As the name implies, sewage flows by gravity to its destination. This collection alternative requires the least amount of operation and maintenance of any of the alternatives.

PRESSURE SEWERS

Pressure sewers, as contrasted with gravity sewers, convey waterborne wastes through relatively small pipelines. Pumping is used as necessary, making the system less sensitive to extremes of topography than gravity sewers. Due to the relatively small diameter of the pipes, large solids must be removed from the wastewater flow before it enters the system to prevent pipeline clogging. This is accomplished by use of an individual grinder pump installed in a package unit wetwell or by the use of a pump following a vault which removes the solids. Existing undamaged septic tank vaults can be incorporated in this alternative.

VACUUM SEWERS

Vacuum sewers operate by pulling air through sewer lines at a rate of about 30 cfs. Sewage is transported by the moving air. Each connection is equipped with a valve which allows wastes into the line. Capital expenditures can reflect up to a 50 percent savings over a gravity system through reduced cost of materials, smaller lines, and reduced excavation costs in certain locations [Cooper and Rezek, 1976]. Operating costs of vacuum sewers are significantly higher than those of gravity sewers. Water conservation techniques can greatly reduce operating costs. Cooper and Rezek report that vacuum systems appear to be cost-effective on relatively flat topographic sites with shallow soil mantle.

In the Big Thompson Canyon, the installation cost of a vacuum system is about the same as the cost of the pressure system. Operating costs are much greater because of high power costs. It was concluded that vacuum systems offer no benefits over the pressure alternative. For this reason, they were not further considered.

COLLECTION WITH TANK TRUCKS

An alternative to wastewater collection via sewers is storage in vaults and the transportation by truck to a treatment site or interceptor sewer. Existing septic tanks could be used as vaults by sealing off the leach fields. This would be similar in concept to garbage collection. Capital costs are very low as compared with sewer lines, but operating costs are high especially where the distance to the discharge point is great. Water conservation would reduce operating costs. this alternate would definitely encourage water conservation

Although hauling wastewater with tank trucks is a collection alternative, the cost should actually be compared with treatment alternatives. One of the collection methods described above would be required to transport wastewater to one or more common vaults in each community. From the common vault the alternatives are to haul wastewater out of the canyon to be treated elsewhere, or to treat the wastes in the canyon.

CORRIDOR SYSTEM

A system called the "corridor system" is being used in the Glacier View Meadows development near Red Feather Lake, Colo. An insulated corridor is buried just deep enough so its top is even with the ground surface. Water distribution and wastewater collection lines are placed inside the corridor. Wastewater lines are pressure sewers, as described above. Heat tape is used inside the corridor to prevent freezing.

This system is too expensive to be used for either water distribution or sewage collection alone. Since both lines are laid in the same corridor, the only way to compare the corridor system is to evaluate it with the sum of the least expensive water distribution and wastewater collection systems. The water distribution methods and cost estimate are presented in a previous section.

The total present worth (capital plus operation and maintenance) of providing water and wastewater utilities to canyon residents using the corridor system is in excess of $4 million. The present worth of providing the same service using more conventional distribution and collection lines is near $3.5 million.

EVALUATION PROCEDURES

As with the potable water systems analysis, the various alternatives and combinations were compared by using the present worth method. The present worth technique is a method of engineering analysis which allows payments made in the future comparable with payments made today. The interest rate used was 7 percent over a 20-year period. Because the material carried by wastewater systems is corrosive, they do not have the 30-year life used for water system costs.

SCREENING OF COLLECTION ALTERNATIVES

A cost estimate has been prepared for each of the alternatives discussed above. Two costs were developed for each; one is the initial construction cost and the other is the annual operation and maintenance expense. All costs presented are at an ENR of 2300 (i.e., 1977 prices).

For simplicity, only the canyonwide wastewater collection costs are presented in this chapter. The present worth value of a gravity sewer system is about $1,600,000. This compares with a cost of $1,615,000 for the pressure sewer estimate. These costs are very similar, so based on costs alone neither system is a superior alternative.

The gravity sewer is by far the simplest collection system to operate. Periodic flushing of the lines is the only routine maintenance required. Its reliability makes it the most attractive system. There may be some areas in the canyon where a gravity system physically cannot work, mainly because some residences are still in the floodplain. In these areas pressure sewers should be used.

INDIVIDUAL WASTEWATER TREATMENT SYSTEMS

There are many types of individual wastewater treatment and disposal methods available in the United States. The application of many of these methods is very site-specific. The types of systems and their advantages and disadvantages will be described individually below and in Table VII-1.

SEPTIC TANK/LEACHFIELDS

The septic tank/leachfield method of wastewater treatment is the most common method of individual wastewater treatment. Primary treatment, or settling of solids, is achieved within the septic tank. The leachfield utilizes adsorption characteristics and filtering ability of the soil for further treatment. Unfortunately, there are very few sites in the canyon suitable for septic tank/leachfield systems. [Rold, 1977]. The soil mantle is either too thin, the ground water table is too shallow, or the percolation rate of water through certain soils is too high [ibid].

It is believed that the degraded water quality in the Big Thompson River previously discussed is largely attributable to the use of inadequate septic tank/leachfield systems. For this reason the Larimer County Health Department has greatly limited their use in the canyon.

MOUND SYSTEMS

Where soils are inadequate for adequate septic tank/ leachfield systems, a mound system may be employed. Essentially soils adequate for efficient wastewater treatment are carried to the site and built up to provide a sufficient leachfield. Mounds are somewhat costly because of the expense of hauling soils and because of the relatively large land areas required. Within the canyon there is not much land available for mound treatment systems.

EVAPOTRANSPIRATION SYSTEMS

A third possible wastewater treatment is evapotranspiration (E-T) systems. With E-T systems, a sealed mound is constructed instead of a leachfield. Evaporation and water drawn from the mound by plants pulls the water from the mound as it is added from a septic tank. E-T systems are extremely inefficient during winter months. E-T systems may be illegal in Colorado unless the user of such a wastewater system has an established right to the water he uses. Even if a right is established, the consumptive nature of the system may encourage the State Engineer and the courts to define such use as illegal.

VAULT SYSTEMS

A more traditional method of wastewater disposal utilized extensively in the Big Thompson Canyon is vaults. Sealed vaults provide total containment and therefore control of wastewater. They require frequent pumping of accumulated waste and unnoticeable leaks may develop. Two health problems are commonly assiciated with vaults. First, owners often puncture a hole in the vault so they don't require pumping as frequently. This practice can cause devastating health problems at a much later date. Further, to keep the vaults from filling too fast, the owners pour grey waters on the ground or directly into the stream. Such activity cannot help maintain high quality water in the Big Thompson River.

AEROBIC SYSTEMS

Individual aerobic systems can provide a high degree of treatment. These systems are scaled-down attempts to duplicate the biological units used in larger wastewater treatment plants. Their high efficiency can be severely limited by shock wastewater loads, operator-owner misunderstanding, and adverse climatic conditions. Like septic tanks, sludge deposits must be periodically removed from the units. If the discharge from these units is into a stream, a discharge permit (NPDES) is necessary.

SEPTIC TANK/SAND FILTER

Intermittent sand filtration of septic tank and aerobic system effluent can adequately protect human health and relatively inexpensively upgrade effluent to a high quality. These systems are capable of oxidizing the effluent but fail to adequately remove coliforms. Chlorination is necessary. This system is also adaptable to community systems.

COMPOSTING

On-site composting toilets are another possibility for waste containment. These systems, when properly operated and managed, can provide total waste containment and treatment on site. They are odor-free but require considerable operation and maintenance time and expense. This high degree of operation and maintenance makes these systems unfeasible for most people.

PRIVIES

Privies do not provide treatment and are not an acceptable disposal method. As no treatment is provided, groundwater and surface water contamination precludes these systems from being considered. Existing privies should be filled with soil and use discontinued.

AREA SUITABILITY FOR WASTEWATER DISPOSAL SYSTEMS

Aerobic systems, composters and sand filtration systems can be used throughout the canyon as these units are generally not site limited. Use of vaults is generally not limited in the Big Thompson Canyon, except in geologic hazard areas, such as areas prone to earth movement. These geologic hazards can damage and destroy vault systems. The slow ground movement characteristic of such geologic occurrances prevents observation of damage by the vault user.

Only detailed site soil evaluations can determine if individual properties are suitable for a septic tank and leachfield. However, the general suitability of the Big Thompson Canyon soils for septic tank effluent was determined by examination of a soil association map and by questioning the State Geologist. The maps developed by Heil, Moreland, Cipra, Phillips and the U.S. Soil Conservation Service were predominantly used for this analysis. These maps provide only an overview of the general soil qualities, the extent of the soils and the approximate distribution of soils and are useful for general planning purposes to prevent costly misuse of the land.

Nearly all of the land in the Big Thompson Canyon is in either soil association five or six. The soils within these two associations are described in Table VII-2. Only one of the minor soils (Breece) is rated as good for septic tanks and leachfields, but often the Breece soil is located on ground too steep for septic tank construction and effective effluent treatment. Other soils are not acceptable for septic tanks because the soil is not of sufficient depth to adequately treat human wastes, a large percentage of the soil is comprised of stones of sufficient size to inhibit sewage treatment, and/or some of the soils lack a sufficient percolation rate and subject leachfields in these soils to a high failure rate.

Soils on slopes greater than 12 percent are generally considered too steep for septic tank/leachfield construction [Tyler, 1977]. However, some sites with steeper slopes may be adaptable to mound treatment systems if adequate soil is available.

TABLE VII-1. ADVANTAGES, DISADVANTAGES AND CONSTRUCTION COST OF VARIOUS INDIVIDUAL WASTE TREATMENT SYSTEMS

TYPE OF SYSTEM	ADVANTAGE	DISADVANTAGE	COST
Septic Tank/ Leachfield	Superior treatment; Does not require daily attendance	Severely limited by soil type and proximity to groundwater and surface water; Construction must be fully supervised.	[a]
Mound System	Superior treatment; Does not require daily attendance	Excessive land required; Construction must be carefully managed; Requires 5' high mound on property	$2,500-4,000
Evapotranspiration	Superior treatment; Does not require daily attendance; Superior protection of groundwater	Water rights restrictive; Many canyon locations would be unsuitable; Requires large area	$3,000-5,000
Vault	Superior water quality protection; Low initial cost	Must be pumped often; Difficult to determine if leak has developed	See subsequent section
Aerobic System	High quality effluent, especially with chlorination; Can be installed at most sites	High cost; Operational and maintenance requirements high; Must be occasionally pumped; Unable to handle shock loads	$1,400-2,100

TABLE VII-1. ADVANTAGES, DISADVANTAGES AND CONSTRUCTION COST OF VARIOUS INDIVIDUAL WASTE TREATMENT SYSTEMS (Cont.)

TYPE OF SYSTEM	ADVANTAGE	DISADVANTAGE	COST
Intermittent Sand Filtration	May be used with existing system whether septic tank or aerobic; Very high quality effluent; Nitrification	Fails to adequately remove coliforms; Requires periodic cleaning Cost is above cost for anaerobic or aerobic system.	$2,000
Composting Toilets	Complete containment and treatment; Odor free when operating properly	High cost; High operational and maintenance requirements; Inability to handle shock loads	$750- $1,800/
Privies	Can be self-installed	Illegal; Inconvenient; Does not protect waters; Health hazard; Odors; Insects	[b]

[a] Use is extremely limited due to conditions in the canyon. Therefore, the cost of an adequate system cannot be determined.

[b] Cost is not included as this alternative is illegal.

TABLE VII-2. SOIL ASSOCIATION DESCRIPTION AND OPPORTUNITIES FOR USE

SOIL ASSOCIATION 5

General Description: This association is located in the north central and south central part of the county. It is comprised mostly of shallow, nearly level and very steep, well-drained, materials weathered from granite. Minor soils included in this association are Breece, Moen, Elbeth, Ratake, Trag soils, and extremely variable stony soils on steep mountainsides. Breece soils are deep, sandy loam soils on alluvial fans and valley fills. Moen soils are moderately deep loamy soils on mountainsides and valley side-slopes. Ratake soils are shallow channery or gravelly soils on mountainsides. Bare granite outcrops occur on the steeper parts of the association. The range in average annual precipitation is about 14 to 18 inches. Elevations range from 6,500 to 8,000 feet. The soils in this association are used mainly for livestock grazing, forestry purposes, recreation and wildlife habitats.

PERCENTAGE	LARIMER COUNTY SOILS	SEPTIC TANKS SUITABILITY
35	Wetmore	poor - 1, 2
20	Boyle	poor - 1, 2
20	Rock outcrop	unsuitable
25	Minor Soils	
	Breece	good-poor - 1
	Moen	poor - 1, 2
	Elbeth	poor - 1
	Ratake	poor - 1, 2
	Trag	poor - 1

SOIL ASSOCIATION 6

General Description: This association lies mainly east of Association 5 in the north central part of the county and in scattered areas in the south central part. It consists largely of shallow to deep, steep to very steep, stony soils on mountain slopes and shallow, nearly level to steep, gravelly soils on upland hills and mountainsides Haploborolls represent a Great Group in the classification system, consisting of extremely variable soils on strongly sloping to steep slopes. The major soils are formed in materials weathered from granite, gneiss, and schist. Minor soils included in this association are Breece, Farnuf, Moen, Elbeth, and Trag soils and rock outcrops. Breece soils are deep, sandy loam soils on alluvial fans and valley fills. Moen soils are moderately deep, loamy soils on uplands and valley sideslopes. The range in average annual precipitation is about 14 to 20 inches. Elevation ranges from about 6,000 to 8,000 feet. The soils in this association are used primarily for livestock grazing. Some areas are used for recreation and for wildlife habitat.

PERCENTAGE	LARIMER COUNTY SOILS	SEPTIC TAN SUITABILIT
25	Haploborolls	poor - 1,
20	Boyle	poor - 1,
10	Ratake	poor - 1,
45	Minor Soils	
	Breece	good-poor
	Farnuf	fair-poor
	Moen	poor - 1,
	Elbeth	poor - 1
	Trag	poor -1

Reasons for poor suitability:

1. Slope greater than 15%.
2. Soil depth less than four feet.
3. More than 35% of soil comprised of large stones (greater than 3 inches).
4. Slow percolation rate.

Evapotranspiration systems may be used in parts of the canyon. However, the E-T fields must be very large to offset the greatly reduced wintertime evaporation and transpiration rates. The only major area in the study area where E-T systems would be acceptable is in the Big Thompson Valley East area.

CONCLUSIONS REGARDING ON-SITE SYSTEMS

The two systems with widespread practicality for use within the canyon are ~~the intermittent sand filtrat~~ion ~~system and the vault syste~~m. Both of these systems must be properly operated and maintained in order to obtain the desired degree of treatment. Use of these two systems will be further explored in the analysis of community-wide systems.

ALTERNATIVE COMMUNITY-WIDE WASTEWATER TREATMENT PROCESSES AND SITES

This section includes a discussion of process selection criteria and a discussion of alternative community-wide treatment processes. On-site disposal systems have been described in previous sections of this chapter.

PROCESS SELECTION CRITERIA

The selection of the optimum process for an individual community or area should not be based exclusively on the economics of the individual processes capable of satisfying discharge requirements. Many technical, environmental, and social factors should be considered in evaluation of viable alternatives. Community characteristics such as growth rate, land cost and availability, proximity of treatment facilities to residential or commercial areas, [redacted] and treatment facility aesthetics (visual and odor) all have a bearing on the treatment facilities best suited for a given community.

There are a great number of alternative treatment processes capable of satisfying BOD_5 and suspended solids (SS) discharge requirements. The alternatives discussed in the following sections are those which have been found suitable for small communities. Processes requiring extremely sophisticated operator capabilities generally unavailable in small communities, such as continuous operator monitoring, are not considered in this report.

There are two major treatment plant classifications: biological and physical/chemical. Both types of processes remove dissolved and particulate organic material. Biological treatment processes, some of which have been used since the turn of the century, depend on micro-organisms to convert putrescible substances to less noxious chemical forms which are compatible with the environment. Controlled biological processes are those such as activated sludge or biofilters in which the biological growth conditions are artificially controlled; stabilization ponds or aerated lagoons are considered uncontrolled biological processes. Physical/chemical treatment consists of the addition of various chemicals to aggregate and settle particulate matter and to oxidize organic substances. Depending on the particular effluent quality goals, physical/chemical plants may employ multi-media filtration, activated carbon adsorption, ozonation or any one of several other processes.

ALTERNATE TREATMENT PROCESSES

The treatment processes that will be considered as alternatives in this report are listed in Table VII-3. Each of these processes will be evaluated in terms of satisfying the existing discharge requirements.

TABLE VII-3. ALTERNATIVE TREATMENT PROCESSES

DESIGNATION	PROCESS
	Pond Systems
1	Unaerated Stabilization Ponds
2	Aerated Stabilization Ponds
3	Evaporation Systems
	Mechanical Systems
4	Extended Aeration
5	Conventional Activated Sludge
6	Oxidation Ditch
7	Biofiltration
8	Rotating Biological Contactor (RBC)
9	Physical/Chemical
10	Clarifier/Recirculating Filter
11	Land Application

Pond Systems

According to the EPA, 25 percent of the wastewater treatment plants in this country are lagoons. Nearly 90 percent of these wastewater treatment ponds serve communities of 5,000 population or less. Ponds are popular with small communities because operation and maintenance costs are relatively low and the fairly long detention times cause them to be less susceptible to shock loads or breakdown than a mechanical plant.

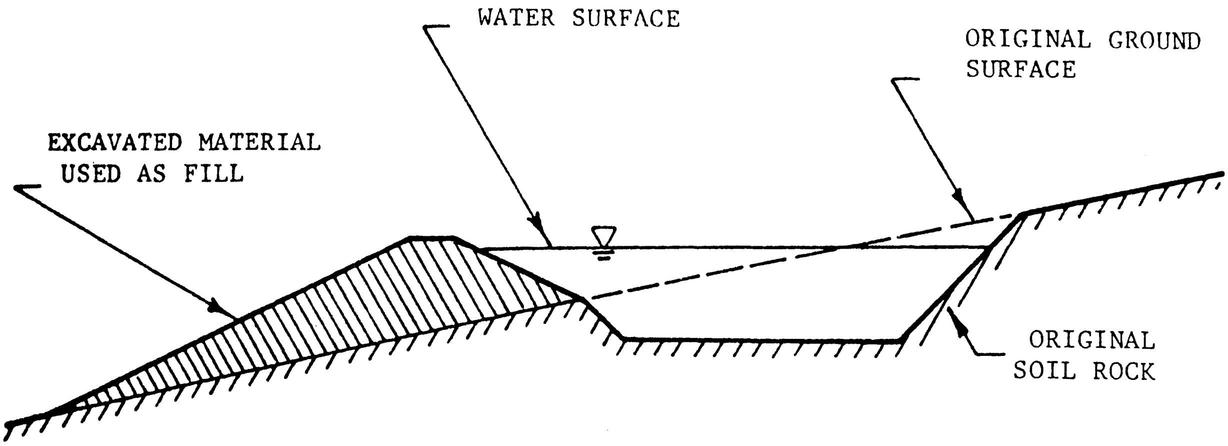
Normally, installation costs for pond treatment or storage systems are relatively low. However, the steep slopes in the canyon greatly complicate construction of ponds as illustrated in Figure VII-1. Also, blasting may be required for excavation into the granite which is common in some areas. For these reasons, construction costs of ponds are approximately three times the construction costs in the plains.

1. Unaerated Stabilization Ponds

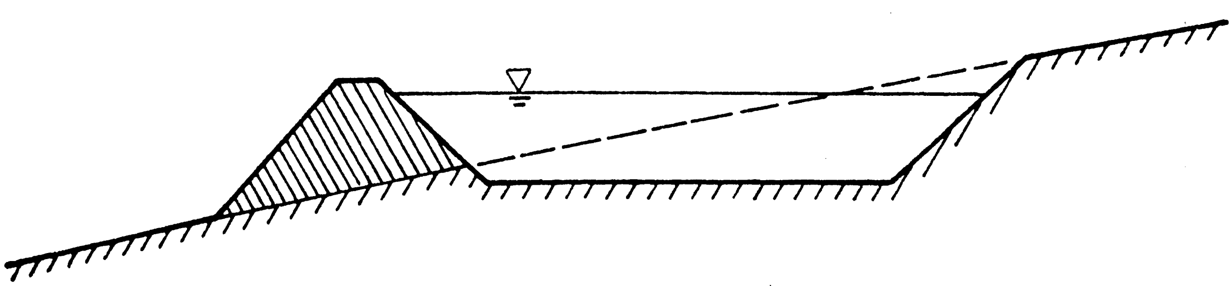
Domestic wastewater may be effectively stabilized by natural biological processes involving symbosis between bacteria and algae when stored in shallow pools. Bacteria degrade the organic substances in wastewater and produce carbon dioxide; algae utilize the carbon dioxide and produce oxygen which is required by the bacteria. This symbiotic relationship requires the presence of a healthy growth of algae which occurs when pond depths are less than 6 to 10 feet. The algae which supply oxygen for the bio-degradation of the wastewater do not completely settle and are present as suspended solids in the pond effluent.

A stabilization pond is basically a shallow pond (3 to 10 feet deep) in which wastewater is stored for 30 to 120 days. In some cold climate areas where freezing of the receiving stream occurs, it has been practice to provide for pond storage of all wastewater through the winter until the spring thaw when adequate dilution water is available in the receiving stream. The maximum BOD loading per unit volume of pond is limited by the amount of available oxygen produced by the algae and supplied by surface reaeration. Both of these oxygen sources are directly related to the pond surface area since algae growth only occurs near the surface where light is available.

FIGURE VII-1. TYPICAL POND CROSS-SECTIONS ON HIGHLY SLOPED LAND.



A. Typical Pond with 2:1 Fill Embankments and 1:1 Cut Embankments. Slope of Original Ground Surface = 20%.



B. Typical Pond with 1:1 Embankments. Slope of Original Ground Surface = 20%.

A stabilization pond is considered an uncontrolled biological treatment process since the amount of active biomass in the system cannot be adjusted or regulated.

In cold climates where lagoon water approaches freezing, maximum BOD loading rates are approximately 15 to 20 pounds BOD per acre per day. This is equivalent to approximately 100 people per acre.

Operation and maintenance (O&M) requirements for stabilization ponds are the lowest of any secondary treatment process. It is this O&M factor combined with low capital costs that cause the wide use of stabilization ponds by small communities, particularly in the plains.

Stabilization ponds do, however, have several disadvantages including:

1. Large land requirements;
2. Odor problems two or three times a year when temperature inversions occur and cause the ponds to "turn over" bringing up septic odorous liquid from the lower depths;
3. The effluent is usually laden with algae and may be unsuitable for certain reuses.

A significant advantage of waste stabilization pond systems is that no sludge is produced and all sludge handling and disposal problems are eliminated. The power and chemical requirements are also minimal.

It is doubtful that a constantly discharging pond could meet the BOD discharge requirement during the winter months when an ice cover would develop on the pond and decrease the available oxygen supply. Based on this probability of non-compliance with the discharge standards and the relatively large land requirements, an unaerated stabilization pond system cannot be recommended.

2. Aerated Stabilization Ponds

Increased BOD loading rates and, therefore, smaller land requirements are possible if a pond system with a supplemental supply of oxygen can be provided. Such systems, commonly referred to as aerated lagoons, aerated ponds, aerated oxidation ponds, etc., are generally provided with supplemental oxygen by either mechanical surface aerators or a diffused aeration system. Supplemental oxygen can increase maximum BOD loading rates into the range of 100 to 200 pounds BOD_5 per acre per day depending on the temperature of the lagoon water. Even with the supplemental oxygen supply, aerated lagoons, like stabilization ponds, are considered uncontrolled biological processes.

Aerated lagoons have several advantages over stabilization ponds, including:

1. Smaller land requirements due to the greater maximum BOD loading rate;
2. Lower probability of odor problems since supplemental oxygen is supplied and the pond liquid is completely mixed;
3. Production of better quality effluent during the winter months when an ice layer may develop.

Aerated lagoons do have slightly greater O&M requirements than stabilization ponds due to the energy requirements and maintenance associated with the aeration equipment. Aerated lagoon effluents, like those of stabilization ponds, contain large amounts of algae which cause the effluents to exceed the suspended solids discharge requirements of 30 mg/l.

3. Evaporation Systems

In this area, the average annual evaporation exceeds the average annual precipitation. This phenomena can be utilized to design wastewater holding ponds large enough to achieve total evaporation of wastewater so that no discharge occurs. The large surface area required, however, does not make them a viable alternative in the canyon area.

Mechanical Systems

4. Extended Aeration

Extended aeration is a modified activated sludge process suitable for use by small communities. Basically, raw wastewater is aerated for 24 hours in a tank containing a high concentration of activated sludge microorganisms which break down the waste substances. The mixture of water and sludge then flows to a clarifier or settling tank where the activated sludge organisms are separated from the liquid phase. The settled sludge is returned to the aeration tank and the clear wastewater is discharged. Disinfection of the final outflow is required. The major mechanical equipment required for an extended aeration plant are aerators (diffused or mechanical) and sludge return pumps. Internal sludge digestion occurs and eliminates or reduces the requirements for external sludge digestion facilities. Depending on sludge disposal facilities, it may be cost-effective to provide for external sludge digestion.

The primary advantage of extended aeration over conventional activated sludge is that extended aeration is biologically more stable and thus requires less operation and maintenanace. Proper operation will require the services of a relatively highly trained operator for several hours each day. It has generally been found that a well-operated plant does not result in any odor problem. Additional characteristics of the extended aeration process are presented in Table VII-3.

5. Conventional Activated Sludge

Conventional activated sludge is very similar to extended aeration. The main differences are that only a 6-hour aeration time of wastewater is used, as opposed to a 24-hour detention time for extended aeration and that primary clarifiers are required. The sludge from the primary clarifiers is odorous if not treated properly. The short aeration time applied to the wastewater causes this treatment method to be susceptible to shock loads and, therefore, poorly suited for use by small communities.

Conventional activated sludge is not considered a viable process since continuous biological stability would be difficult, if not impossible, to maintain for the fluctuating flowrates of the Big Thompson Canyon study area.

6. Oxidation Ditch

The oxidation ditch is a modification of the extended aeration-activated sludge process which utilizes a closed loop channel as an aeration chamber. The process was originally intended to be a low cost system requiring non-sophisticated construction methods and mechanical equipment. The process flow scheme consists of aeration of raw wastewater in the loop channel followed by the sedimentation of the activated sludge in a clarifier. The activated sludge (active micro-organisms) is returned from the clarifier back to the aeration tank. Brush aerators are used to supply oxygen and to retain solids in suspension in the aeration channel.

The biological stability of the oxidation ditch process causes it to have one of the lowest operation and maintenance requirements of any of the controlled biological treatment processes such as activated sludge or biofilters. This is a significant advantage for small communities where highly trained operators might not be readily available.

Oxidation ditches suffer from two disadvantages where considered for application in the Big Thompson Canyon:

- Not available as package plants - this causes a significant increased cost for oxidation ditches when compared to package extended aeration plants which would be sufficient for small communities.
- Satisfactory operation in cold climates is difficult--the shallow, relatively large surface area ditch would be difficult to protect from the snow and freezing temperatures common in the canyon.

Design Q's gpd
23,000
24,600
71,000
111,000
205,000
307,000
not too small

7. Biofiltration

Biofiltration plants, commonly called trickling filters, have a distribution system which spreads wastewater over a filter media. The filter media may be rocks with a diameter of 2-4 inches, or a synthetic media such as plastic. This unit is the biological portion of the treatment plant. Biofilters are preceeded and followed by clarifiers which are used to remove settleable solids. Sludge removed from the first clarifier called primary sludge is especially putrescible and must be treated separately.

Low temperatures affect biofilters more than the activated sludge processes because biofilters provide a large surface area which increases heat losses. It would be necessary to house the biofilters to prevent their freezing in winter.

Although biofilters are simpler to operate and are biologically more stable than activated sludge processes, they will not be considered further for application in view of their primary clarification requirements and their difficulty of operation in cold weather.

8. Rotating Biological Contactor

A rotating biological contactor (RBC) is similar in operation to a trickling filter. The RBC consists of a rotating axis on which many plastic discs are mounted. The discs are submerged approximately 40 percent so that rotation causes repeated exposure of the biological growth attached to the discs to the atmosphere. The RBC must be preceeded and followed by a clarifier although no sludge or effluent is circulated through the compartment containing the RBC. The RBC is available as a package plant and is therefore less expensive than a trickling filter for a small community.

The RBC is more compact than the trickling filter (biofilter) and therefore has less heat loss. Cold weather operation is possible by enclosing the RBC or installing the unit in a building. The RBC is biologically very stable and would be relatively resistant to the shock loads occurring on weekends. The process does suffer the disadvantage of requiring a primary clarifier which produces a putrescible sludge.

9. Physical/Chemical

There are various schemes which employ physical and chemical processes to remove organics in both the dissolved and solid phases from wastewaters. Through the controlled addition of iron or aluminum salts or lime to raw wastewaters inorganic and organic suspended solids can be aggregated and settled in clarifiers. The settled sludge requires proper treatment before it can be disposed of in the environment. Soluble organics are then removed from the liquid phase by adsorption to activated carbon.

It is necessary to periodically replace or regenerate the activated carbon which has a finite adsorption capacity for the organics in wastewaters.

There are only a limited number of physical/chemical plants currently in operation in the United States. The physical/chemical processes require significantly more operator attention and maintenance than biological processes such as extended aeration. For this reason, physical/chemical processes are not recommended for use in the canyon.

10. Clarifier/Recirculating Filter

In an effort to achieve high quality effluent without requiring excessive operation and maintenance, a system particularly adaptable to small communities has been investigated. The system would consist of a settling tank, a recirculating tank, a sand filter, and a chlorinator.

The first unit would be a primary settling tank. An identical tank would follow the first unit. This would be the recirculating tank and the chlorine feed tank. Effluent from these tanks would be polished by a sand filter prior to discharge to the Big Thompson River. Approximately 80 percent of the filter effluent would be recirculated through the recirculating tank.

Cite references

[redacted] that the effluent from this system is very high quality, with BOD5 and total suspended solids values less than 10 mg/l. Conversion of ammonia to nitrate can be achieved by using a low application rate on the sand filter, particularly during warm weather.

11. Land Application

Percolation of wastewater through the soil provides treatment of the applied wastewater. Suspended solids, bacteria, BOD and phosphorous are all effectively removed by filtering and straining action of the soil. Nitrogen removal, however, is poor. EPA requirements for secondary treatment do not apply to this alternative since no discharge is produced. However, to control phenomena such as odors, [redacted] that, as a minimum, [redacted] as defined by EPA be achieved prior to land disposal.

The factors which affect the cost of such a system most directly is the area of land required for the design flowrate of the communities. Both the size of the application equipment and the land capital costs are directly related to the required area which is determined by the maximum allowable hydraulic loading rate. The allowable hydraulic loading rate for a high-rate irrigation process is dependent only upon the soils' capacity for transmitting water and not on the moisture requirements of the vegetation. The maximum hydraulic loading rate is the sum of soil moisture depletion plus the quantity which can be transmitted through the root zone. The soil moisture depletion for the climatic conditions in the canyon is approximately 12 inches for the season while the soil transmission rate can range between 10 and 600 inches per year depending on soil type, depth of soil and surficial geology. Total hydraulic loading rates can therefore range between 22 and 612 inches per year which correspond to area requirements of 610 acres/million gallons per day and 20 acres/million gallons per day, respectively.

In view of the limited thickness of the topsoil, the steepness of the areas and the close proximity of bedrock which could cause almost immediate surfacing of percolated water, a maximum application rate of 2 inches per week (104 inches/year) is recommended for the sites available. The required land areas should be based on an assumed overall land utilization factor of 70 percent and application of 2.0 times the average flowrate since all effluent must be stored for several months during the winter.

The basic components of a land application system would include:

1. Storage adequate for 90 days;

2. Pumping and transmission facilities between the storage ponds and the application site;
3. A distribution or spray system for application of the liquid to the land.

The Big Thompson Canyon does not have good sites for land application because of the steep slopes and because of the amount of land area required for large wastewater storage ponds. Therefore, land application will not be considered further.

ALTERNATIVE TREATMENT SITES

There are eight communities within the study area. Each community has its own physical characteristics which must be considered while evaluating wastewater treatment sites. In certain instances the physical characteristics of a community, such as its location or topography, dictates which site should or should not be used.

The western communities on the main stem of the Big Thompson River have certain characteristics which enable them to be described jointly. These communities are Loveland Heights/ Glen Comfort, Waltonia, Drake, Midway, and Cedar Cove. Two major alternatives were considered. One was a site located below Cedar Cove which would be used to serve all the above-mentioned communities. The other possibility was to have four small systems serving the communities. One would serve Loveland Heights and Glen Comfort; one would serve the Drake/Midway area; and Waltonia and Cedar Cove would each be served by its own system.

Glen Haven is approximately seven miles above Drake. Although it is physically possible to connect Glen Haven with a regional system, the distance involves makes this possibility economically unfeasible. Wastewater generated in Glen Haven must be treated locally.

The possibility of serving Sylvan Dale and the homes in the Big Thompson Valley East area at a common site was considered. Also evaluated was the possibility of having Loveland serve these areas. One or more treatment plants serving each of the two areas individually was also considered.

The alternative of serving the entire Big Thompson Canyon and providing treatment at Loveland was considered but rejected as being too costly.

SCREENING OF ALTERNATIVE PLANS

The alternatives discussed above are presented in large part to give the reader a better understanding of the decisions involved in choosing a best alternative. An effort was made to recommend the least costly alternative to each community in an effort to make the least expensive canyonwide system.

The use of on-site disposal systems was rejected in all areas except the homes in Big Thompson Valley East area and a few homes in the Sylvan Dale area. The State Geologist has indicated that in the upper canyon areas the suitable soils for leachfields have been washed away. In addition, many cannot meet the county requirement of having septic tanks placed no closer than 100 feet from the stream.

Table VII-4 presents the canyonwide costs of the most promising alternatives. These costs are based on providing a wastewater treatment facility at each community in the canyon. This table is particularly valuable to compare the relative cost of each method. The least costly alternative is the clarifier/recirculating filter system.

This system will be fully evaluated. Other systems which may be viable in a given area in the canyon will be compared with the clarifier/recirculating filter system.

CONCLUSION REGARDING WASTEWATER COLLECTION AND TREATMENT

After comparing all the wastewater collection and treatment alternatives available for the various communities in the canyon, two areas were established. One is the Big Thompson Valley East area and the other consists of all the other communities in the study area. The optimum treatment alternatives are discussed below.

Big Thompson Valley East

One of the unique characteristics of this area is that there is more topsoil in this area now than there was before the flood. This soil is adequate for leachfield material.

The county requires that no septic tank/leachfield system be installed within 100 feet of a stream. Many residences in this area are within the flood plain, so technically they cannot be more than 100 feet from the stream. When the river is within its banks, the county regulations are generally met.

TABLE VII-4. CANYON-WIDE TREATMENT SYSTEMS COST

PRESENT WORTH ($)	TYPE OF SYSTEM				
	LAGOON	EXTENDED AERATION	CLARIFIER/ FILTER	ROTATING BIOLOGICAL CONTACTOR	HAUL BY TRUCK
Capital Cost ($)	973,000	1,817,000	316,000	3,230,000	-
O&M ($)	547,000	1,129,000	775,000	1,310,000	2,977,000
Total ($)	1,520,000	2,946,000	1,090,000	4,540,000	2,977,000

In 1976, before the flood, the populace in this area voted not to form the Lower Thompson Sanitation District. Had the district been formed, the wastewater would have been treated at the new Loveland wastewater treatment facility.

Loveland has received funds to help construct a collection line to serve the Namaqua Hills Subdivision. This line is sized so it can serve the residents of the Big Thompson Valley East area also.

In consideration of all of these factors, it is felt that the best long-term solution for wastewater treatment in this area is to provide service at Loveland. The residents should be encouraged to pursue this. In the meantime, the septic tanks presently being used are adequate to serve the residents.

Remainder of Canyon

The communities in this area are Glen Haven, Loveland Heights, Glen Comfort, Waltonia, Drake, Midway, Cedar Cove, and Sylvan Dale. The optimum treatment method to be used in this area is the clarifier/recirculating filter system. Gravity sewers can be used in most areas with a few homes in each community served by a lift station.

Two options concerning treatment plant sites were considered. One option is to have six separate treatment plants to serve the communities. Wastewater flows from Loveland Heights and Glen Comfort would be combined and treated at one site; the same is true of flows from Drake and

Midway. The other option is to treat the wastewater from all the communities on the main stem of the river at a site east of Cedar Cove. Glen Haven and Sylvan Dale would have their own wastewater treatment systems.

Normally, consolidation of small wastewater treatment plants is beneficial. However, the larger the system used, the more land required. This land must be fairly flat, and cannot be in the flood plain. Suitable undeveloped land areas in the canyon are generally quite small, making large wastewater systems impractical. Therefore, the optimum solution is the option of installing separate clarifier/sand filter treatment facilities at each of the communities.

The land requirement for facility treatment does not change that much for sizes listed

Glen Haven	205,000 gpd
Sylvan Dale	24,600
Loveland Hts/Glen Comf.	307,000
Drake/Midway	71,000
Waltonia	23,000
Cedar Cove	111,000
	512,000

i.e. land requirement for 111,000 gpd @ Cedar Cove vs. [illegible] gpd @ Cedar Cove not a [illegible] reason to throw out. Probably [illegible] between is.

Approx "equipment" land required
Assume 12' deep units circular

	First	Second	Filter	Total
111,000 gpd	50' φ	50' φ	6' φ	60 × 100
512,000	100' φ	100' φ	12' φ	100 × 200

CHAPTER VIII

OVERVIEW OF SELECTED TREATMENT ALTERNATIVE

Following the development of the alternatives described in the preceeding chapters, public hearings were held. The Planning Commission received comments from canyon residents and the County Commissioners. With this input, a land use policy was adopted which will be reflected in the optimum treatment scheme.

COORDINATION WITH LAND USE PLAN

One of the policies of the adopted land use plan was that no growth should be allowed in the canyon unless adequate wastewater treatment is provided. If these facilities are provided, growth can be allowed to occur. Therefore, the population projections utilized in this study will vary from those used in Volume 3 because it will be assumed that growth will occur.

Using the data developed, the projected population levels were modified from those used earlier in this report. These population levels more accurately reflect the policies of the Land Use Commission. These population levels are shown in Table VIII-1.

Although the projected population has varied from that previously used, the earlier estimates were sufficiently accurate for alternative development and screening purposes.

This is because the relative cost of each alternative will not change with the magnitude of the change in population. The absolute costs of the collection lines and treatment plants will vary as a result of the modified population projection.

TABLE VIII-1. EXISTING AND PROJECTED POPULATION

COMMUNITY	NUMBER OF TAPS (1977)		SUMMER POPULATION	
	RESIDENTIAL	COMMERCIAL	1977	2000
Glen Haven	139	8	610	1370
Loveland Heights/ Glen Comfort	192	14	895	2050
Waltonia	29	1	112	153
Drake/Midway	70	6	267	470
Lower Midway	8	9	52	75
Cedar Cove	58	8	262	740
Sylvan Dale	14	13 [1]	92	164 [2]

[1] Nine of these are associated with Sylvan Dale Ranch.
[2] No commercial growth was anticipated at Sylvan Dale.

Big Thompson Valley East? = Narrows

2290 5022

Another change that resulted from the public hearings was that the area below the Narrows was excluded from the planning area. Despite this fact, there is a small part of Sylvan Dale which has wastewater problems that are very similar to the canyon areas above the Narrows. This is the area along the river between the Big Thompson Siphon and the Loveland water treatment plant.

Following the adoption of the final study area, intensive field checking was conducted. As a result, an area east of Midway was added to the wastewater service area. This area shall be called "Lower Midway".

TREATMENT AND DISPOSAL FACILITIES

The optimum treatment process has been only briefly described prior to screening of alternatives. To give the reader a better understanding of this process, it will now be described in greater depth. The basic components of this treatment plant consist of a settling tank, a recirculating tank, a sand filter, and a chlorinator.

The first unit, the settling tank, would act as a primary clarifier. Its function would be to remove solids, both settleable and floating solids, such as grease. The bottom should be filleted to facilitate solids removal. Quick couple devices for [redacted] should be installed to make the solids removal operation clean and fast. The hydraulic detention time of this unit should be at least [redacted].

I agree this is needed

The recirculation tank is a duplicate of the primary settling tanks. Piping should be arranged between these two tanks so that either can be used as the first tank. It should also be possible to completely bypass either tank so one tank can be temporarily taken out of service for cleaning or repair.

Following these tanks are the sand filters. Two should be installed of equal size, although only one is to be used at any one time. This will allow the vacated filter to regenerate itself between filter runs. The design hydraulic loading rate should be 3 gallons per minute per square foot (3 gpm/ft^2). These filters should be covered with a removable cover so the sand can be changed periodically. A recirculation pump is placed after the filters and piped to the recirculating tank.

The final process is chlorination. The chlorine contact basin should be designed in accordance with the Colorado Department of Health's design criteria.

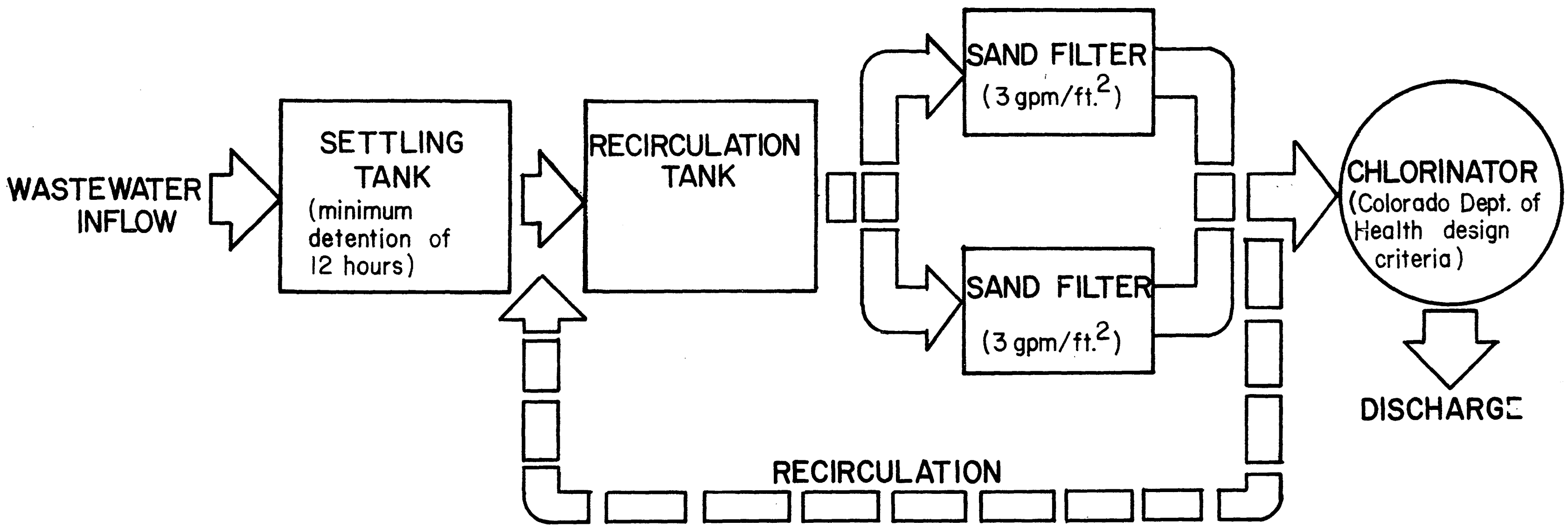
The following table illustrates the effluent quality from this system [redacted] This data is average effluent quality data. Peak values will be higher than these numbers. State effluent standards will be met. A flow diagram is shown in Figure VIII-1.

TABLE VIII-2. SETTLING TANK/SAND FILTER EFFLUENT QUALITY DATA

	SETTLING TANK EFFLUENT	SAND FILTER EFFLUENT	CHLORINATED EFFLUENT
BOD (mg/l)	123 (55% rem)	9	3
TSS (mg/l)	48 (82% rem)	6	6
Total Nitrogen-N (mg/l)	23.9	24.5	19.9
Ammonia-N (mg/l)	19.2	1.0	1.6
Nitrate-N (mg/l)	0.3	20.0	18.9
Total Phosphorus-P (mg/l)	10.2	9.0	8.4
Orthophosphate-P (mg/l)	8.7	7.0	7.9
Fecal Coliforms (#/100 ml)	5.9×10^5	6.5×10^3	2
Total Coliforms (#/100 ml)	9.0×10^5	1.3×10^3	3

Reference: Otis, Richard J., et. al.

two years operational data on single household resulted in annual costs of $400-700/yr sand remains aerobic?



Otis, et al mention Qrecirc/Qin = 4:1

FIG. VIII - I. FLOW DIAGRAM FOR CLARIFIER / RECIRCULATING FILTER WASTEWATER TREATMENT FACILITY

OPERATION AND MAINTENANCE

One of the reasons that this is the optimum alternative is that operation and maintenance (O&M) is fairly simple.

The primary settling tank must be pumped by truck as required 4 to 6 times a year. ~~Septage should be hauled to the Larimer County designated disposal site at the landfill.~~ When the primary settling tank is pumped, it should be thoroughly cleaned and the flow reversed so it is used as the recirculating tank.

A sand filter can be expected to run for about [redacted]s before becoming clogged. At this time, the second sand filter should be placed in operation. The clogged filter should have the top three to four inches of sand removed. ~~The wasted sand has a high organic content which is very good for plants.~~ ~~It can be spread on the ground.~~ The filter should then be allowed to "rest".

An operator with at least a Class "C" license would be required to operate this plant.

TIME PHASING

The revised population projections indicate significantly more growth than previously anticipated in the communities of Glen Haven, Loveland Heights/Glen Comfort, and Cedar Cove. One of the benefits of the recommended type of treatment facility is that the plan can be easily expanded. It is cost-effective in these three communities to phase the construction of the treatment plants.

With a phased construction program, the initial cost is kept to a minimum. Should growth not occur as rapidly as anticipated, an excessive amount of money would not have been spent.

DETAILED COST ESTIMATES

The greatest expense involved in this project is associated with the collection facilities. The serviceable buildings tend to be constructed in strips along waterways. Density is low, so taps are widely spaced and collection lines are long. Additionally, the construction cost of the lines in this area is almost double the cost of the same length of lines in the plains.

The terrain is such that most areas can be served by gravity flow. However, several major river crossings are needed which will require lift stations.

Tap lines will cost as much per foot as do the sewer lines. Normally the cost of tap lines is less than sewer lines because smaller pipe is used. In this case, the cost of the line is negligible compared to the cost of excavation. In the Big Thompson Canyon, most of the tap lines will be constructed through virgin earth, much of which is rock. A great deal of the sewer line can be built through soil that has been previously disturbed by road construction. Excavation in the disturbed soil should be easier, and thus less expensive, than through virgin soil. The cost of the tap line is estimated to be approximately $825. This will vary depending on the distance to the sewer line.

The treatment facilities recommended to be used are fairly inexpensive to construct and to operate. Additionally, the complexity of operation is minimized. This will reduce the degree of skill required to properly maintain and operate the treatment facilities.

The capital cost of the construction of the collection and treatment facilities is shown in Table VIII-3. These numbers are based on assumed 1978 construction costs (ENR-2300). These estimates are sufficient for this level of study--they may vary depending on equipment selected during design, year of construction, annual inflation rate, and other unforeseen difficulties.

TABLE VIII-3. CONSTRUCTION COST OF RECOMMENDED FACILITIES

COMMUNITY	WWTP [1]	COLLECTION FACILITIES	TOTAL CONSTRUCTION COST
Glen Haven	$ 52,000	$ 388,200	$ 440,200
Loveland Heights/ Glen Comfort	76,000	492,000	568,000
Waltonia	23,000	60,000	83,000
Drake/Midway	43,000	182,800	225,800
Lower Midway	20,000	21,300	41,300
Cedar Cove	42,000	216,000	258,000
Sylvan Dale	20,000	56,700	76,700
Canyonwide	$276,000	$1,417,000	$1,693,000

[1] WWTP = wastewater treatment plant.

total capacity 7 plants ≈ 275,000 gpd

but they show summer pop (7,000) as 7050

193,750 gpd

307,000 gpd "peak flow" i.e. max. daily or is this peak rate

CHAPTER IX

WATER AND WASTEWATER FLOW REDUCTION THROUGH HOUSEHOLD WATER CONSERVATION

This chapter presents the various water saving devices and systems, general costs of achieving specific per capita wastewater production rates, and the feasibility of initiating and maintaining a water conservation program. Water conservation devices can result in savings in water supply and treatment costs, wastewater treatment costs, and energy costs. The term "grey water" refers to the wastewaters produced by all water appliances/functions except toilets which produce "black water".

DESCRIPTION OF WATER SAVING DEVICES

The impact of a specific water saving device is greatest when the device is applied to an appliance or function which uses large quantities of water. Table IX-1 describes the water consumption for the various household functions typical of the average family of three. It is apparent that almost 70 percent of the total water consumed in a household is used for toilet flushing and bathing. There are two basic levels of water saving devices/appliances which currently are available. The first level which involves modification of existing fixtures can achieve a 30 percent to 50 percent reduction while the second level achieves a 50 percent to 70 percent water use reduction by replacing fixtures with completely new fixtures.

MODIFICATION OF EXISTING FIXTURES

Orifice type flow controllers, pressure reduction valves, displacement or low volume flushing device for toilets, and low water use appliances (suds saver washing machines) can be employed at a minimum cost to reduce water consumption by 30 percent to 50 percent.

TABLE IX-1 DAILY WATER USAGE OF VARIOUS HOUSEHOLD FUNCTIONS/APPLIANCES FOR AVERAGE THREE MEMBER HOUSEHOLD IN U.S. [a]

Function/Appliance	U.S. Average
Toilet	75 [b]
Bathing	60
Laundry	25
Kitchen/Utility	15
Lavatory	8
Drinking/Cooking	12
Total	195
Per Capita	65

[a] U.S. average values obtained from Linaweaver, 1967.
[b] All values in gallons.

Bathing

Reduction in bathing water usage can be achieved for showers through flow restrictors in shower heads. Conventional shower flow rates of 5 to 10 gpm can be reduced to 2.5 to 3.5 gpm. When flows have been reduced to values less than 2.5 gpm with conventional shower heads longer times are required to achieve acceptable degrees of cleanliness. This tends to increase overall water consumption. Approximate installed costs of modification devices along with reduced water usage for the various function/appliances are presented in Table IX-2.

A reduction in bathing water usage also results in a substantial savings in energy costs due to hot water conservation. A study conducted by the California Department of Water Resources indicates that the average energy savings per household is $5.90 per year.

Toilets

Various reduced flow types are currently available including several which use no water. Under the modification alternatives being considered in the first level of water conservation, reduction of 20 percent to 50 percent is possible for modifying siphon design, tank capacity, and flushing mechanism. Several schemes are as simple as installation of bricks or sand-filled plastic bottles to modify tank capacity. Another scheme involves conversion of the tank/flushing valves to achieve two flushing volumes, a low volume for urine and a large volume for fecal matter.

For new or replacement installations conventional toilets are now available which use a maximum of 3 gallons per flush which is significantly less than the conventional 5 to 7 gallons per flush. Several municipalities and some states have adopted building codes which require installation of low volume toilets in all new applications. The installed costs of modification/conventional low use toilets are presented in Table IX-2.

Clothes Washing Machines

Front loading washing machines use approximately 22 to 33 gallons per load while top loading machines require 35 to 50 gallons per load. Sud-saving devices on top loading machines can reduce water consumption by 10 gallons per load.

TABLE IX-2 INSTALLED COSTS FOR WATER SAVING DEVICES

	Conventional Water Usage (gpd)	Percent Savings [a]	Reduced Water Usage (gpd)	Cost $
Bathing	45	50-70	14-22	5-30
Toilets	58	20-55	25-47	2-300
Laundry	20	20-30	14-16	50-400[b]
Kitchen/Utility	12	10-20	10-11	5-30
Lavatory	6	20-50	3-5	5-30
Drinking/Cooking	9	0	9	0
Total Per Household	150	---	75-110	$70-700
Total Per Capita	50	---	25-37	

[a] Modification of existing fixtures.
[b] Represents a range of costs from the additional cost of suds-saver to a complete unit.

Others

Flow restricting devices can be installed on all faucets thereby reducing usage for both kitchen/utility and lavatory applications. Approximate information is presented in Table IX-3.

Overall modification of existing fixtures or replacement of appliances with conventional low water use appliances can reduce water consumption (wastewater production) to 75-110 gpd for a family of three at a cost of $70 to $700. This is equivalent to per capita wastewater flow rates of 25-37 gpd, with an average rate of 30 gpcd.

REPLACEMENT WITH MINIMUM USE FIXTURES/APPLIANCES

Various low water use systems are available which can greatly reduce overall water consumption. In general, these systems cost from several hundred to several thousand dollars. Currently available are minimum water use systems for bathing and toilet functions.

TABLE IX-3. COST AND SUITABILITY OF ALTERNATIVES [a]

Description	Capital Cost	Estimated O&M (Yearly)	Manufacturer	Comments	Public Acceptance	Environmental Impact
Chemical Toilet	$330	$50	Monogram Industries Redondo Beach, CA	2% of normal toilet water consumption Must use special tissue Must be emptied approximately each 10 days.	Negative: Odors Maint. Aesthetic	Negative: Chemicals Strong Effluent
Pressurized Flush	700	10	Micropore Willets, CA	10% of normal toilet Water consumption	Positive: Aesthetic	Positive: Low Energy Low Water Use
Oil Flush	2000-5000	175 (Elec., Chemical, Maint.)	Monogram Industries Monterey Park, CA	No water use. Requires storage and annual pumpout.	Positive: Aesthetic	Negative: Scarce Resource
Incinerator	550	150 (Elec. Propane)	La Mere Industries Walworth, Wisc.	No water use.	Negative: OP. Cost Cleaning	Negative: Energy Use

[a] References: "Residential Water Conservation", Murray Milne, et.al., California Resources Center, University of California, Davis, Report #35, March, 1976.

Personal contact with manufacturers.

Toilets

There are three general classes of water conservation toilets currently available: 1) devices which use less than 0.5 gallons per flush; 2) systems or devices which use no water but require disposal of a sludge or other material stored in a vault; 3) systems producing no waste but an ash. The costs and overall suitability of several available facilities are described in Table IX-3.

The first category includes vacuum, compressed air, trap door or any of several other type toilets. Total water usage for flushing can be reduced to less than 7 gpd for a typical family of three.

In the second category are toilet systems which produce compost or recycle oil which acts as the flushing agent. Such systems completely segregate human wastes from the grey water.

No liquid wastes are produced by the incinerator toilets which use electrical or natural gas/propane to completely evaporate water and oxidize organics. These systems also permit complete segregation of grey waters from human wastes.

The minimum installed cost of a toilet utilizing 7 gpd or less for an average family of three ranges between $1,500 and $4,000.

Bathing

Showers have been developed which use less than 0.5 gpm of water in a dual fluid nozzle. The other fluid, air, is supplied by a small compressor. This system can reduce the bathing water requirements for a family of three to less than 10 gpd while at the same time achieving significant energy conservation. Installation of the shower system involves considerable modification of existing plumbing since an electrical in-line water heater is required if the shower is not located directly adjacent to a conventional water heater. At a flow rate of 0.5 gpm, the water will never get hot at distance greater than 25 feet from the water heater due to heat losses in the piping.

The total installed cost of the dual fluid, low water use shower system ranges between $750 and $1,500 depending on the extent of modifications required.

From the above discussion it can be concluded that water consumption for bathing and toilets can be reduced to less than 10 to 20 gpd for a family of three for $2,250 to $5,500. This can reduce the total household water consumption of 45 gpd or 15 gpcd.

WATER CONSERVATION IMPACT AND IMPLEMENTATION FEASIBILITY

The overall impact of water conservation on potable water and on wastewater systems is dependent on the nature of the facilities employed. Earlier sections of this chapter described the facilities analyzed and screened the various alternatives.

To analyze the feasibility of implementing water conservation, the least costly water and wastewater alternatives were evaluated with and without water conservation techniques. The following table presents the amount of money saved on a present worth basis if water reduction devices were installed.

TABLE IX-4 DOLLARS SAVED THROUGH WATER CONSERVATION

System	Dollars Saved
Water	$181,000
Wastewater	31,000
Energy	42,000
TOTAL	$254,000

This chapter has described several in-house devices which are capable of achieving varying degrees of water reduction. The cost of these devices has ranged from $70 to $5,500. For the final analysis, it has been assumed that each house can be retrofitted for $700. The per capita water consumption would be reduced by 50 percent.

The total cost of installing these devices in all the homes in the canyon is approximately $510,000. The table above indicates that the amount of money saved is $254,000. Because the cost of water conservation in the study area is in excess of the amount saved, it is not feasible.

CHAPTER X

IMPLEMENTATION OF RECOMMENDED PROJECT

The previous chapters have described, analyzed, and screened the various wastewater treatment options available. This chapter will describe the institutional and financial arrangements which will be necessary prior to the implementation of an adequate wastewater treatment program. It is important to note that the cost of the construction of these facilities is prohibitive without significant government grants; and that government grants cannot be obtained until an institutional structure is developed.

MANAGEMENT AGENCIES

To obtain the funds to construct water and sanitation facilities, a management agency must be formed. Without the formation of a management structure, the existing health and pollution problems will not be solved, even if a no-growth policy is enforced. The organization should have bonding authority and be qualified to be a grant recipient. It also must be able to provide the required operation and maintenance on the facilities constructed.

CANYONWIDE VS. INDIVIDUAL COMMUNITY AGENCIES

The management agency could be structured either on a canyonwide basis or as seven separate agencies, one managed by each community. If a canyonwide agency were formed, significant economies of scale would result as shown in Table X-1. This table shows that the average tap cost if O&M were conducted individually is $279 per year. The annual per tap O&M costs for a canyonwide agency is $153.

TABLE X-1. COMMUNITY VS. CANYONWIDE O&M COSTS

	INDIVIDUAL AGENCIES		
COMMUNITY	NUMBER OF TAPS	ANNUAL COST	COST/TAP
Glen Haven	147	$ 21,540	$147
Loveland Heights/ Glen Comfort	206	30,440	148
Waltonia	30	19,120	637
Drake/Midway	76	24,780	326
Lower Midway	17	18,900	111
Cedar Cove	66	25,010	379
Sylvan Dale	27	19,150	709
Total	569	$158,900	$279 (Average)
	CANYONWIDE SYSTEM		
	569	$ 87,000	$153

Only two communities have per tap O&M costs that are less than a canyonwide system would be, but the annual estimated savings is only $5 per tap at Loveland Heights/Glen Comfort and $4 per tap at Glen Haven.

There are several reasons why costs are substantially greater for the individual communities. The biggest reason is that overall operator salaries would be greater because each community would need a certified operator. This is true even if the operator were a part-time employee. Two operators could run the facilities for a canyonwide agency and only one would have to be certified.

Trucking costs are also much higher. Trucks are used to pump the settling basin and to haul sand for the filters. A canyonwide system would make efficient use of trucks, but the individual communities could not. Benefits could also be derived by sharing other inventories besides trucks, such as spare parts for motors, pumps, etc.

The fact that the per tap O&M cost is as much as $1,100 for one community does not necessarily mean that this community could not be economically served on a canyonwide basis. A community which has only 20 taps cannot afford to hire a certified operator by itself. However, the amount of time required to run a system of that size is very small compared to the larger systems, such as at Loveland Heights. This illustrates the advantages of a canyonwide system.

INSTITUTIONAL ALTERNATIVES

There are seven possible institutional alternatives available. The seven legal alternatives include:

- Special purpose districts (water and/or sanitation);
- Metropolitan districts (utility plus other services);
- Water authority;
- Towns;

- Larimer County;
- Special purpose district with Larimer County supervision;
- Private companies.

Of the seven possible alternatives, only three appear to have any practical significance. These three include the special purpose district, a county established and operated district, or a combination of these two. These will be briefly described.

Special Purpose District

A variety of special purpose districts exist in Colorado. They have been established to deal with specific purposes, such as to provide irrigation water, flood control, stormwater drainage, water treatment, wastewater treatment, etc. In the Big Thompson Canyon the special purpose district would probably be a water and sanitation district. Approval by a majority of the voters within the proposed district is necessary for the formation of the district. Once the district is formed it has very much the same powers and responsibilities of a municipality in the area of its concern. It has bonding authority, can be a grant recipient, and has the responsibility for the overall management of the water and wastewater systems under its control.

Larimer County

The County Commissioners, without an election, have the power to construct, operate and maintain water and sewerage facilities. They may also authorize revenue bond issues, accept grants, charge fees, and purchase property. The right of eminent domain may be used. In short, the Board of County Commissioners has the authority to provide all the services that a special district can provide.

Special Purpose District with County Supervision

Another possibility is to combine the rights, duties, and responsibilities of the two managerial possibilities described above. With this arrangement, the optimum combination would probably be to establish a water and sanitation district which would operate and maintain all facilities. Larimer County would be responsible for the management of this district.

Coordination with 208 Plan

The Larimer-Weld Regional Council of Governments is undertaking a water quality planning study financed in part under the provisions of Section 208 of the Federal Water Pollution Control Act Amendments of 1972. This is commonly called the "208 Plan". One requirement of the Plan is to investigate, evaluate, and recommend institutional alternatives. Any organization formed in the Big Thompson Canyon would have to comply with the findings of the ongoing 208 Plan.

Screening of Alternative Agencies

The Larimer County Commissioners have indicated that they would be willing to help set up a management agency for the canyon residents [Lopez, 1977], but that they do not wish to be in direct charge of the facilities. It is the contention of the Commissioners that this is a local responsibility.

In line with this sentiment, the only alternative available is the establishment of a special purpose district. A water and sanitation district should be formed.

RESPONSIBILITIES OF A WATER AND SANITATION DISTRICT

Because wastewater treatment facilities can do much toward protecting human health within the canyon and help alleviate Big Thompson River water quality problems, the responsibility of the district should initially be oriented predominantly toward the wastewater field. The district must apply for grants, construct the facilities, and maintain and operate the facilities once they are constructed.

It would not be necessary for the district to exercise any powers in the potable water field unless they so desired. If they do decide to become involved in water service, the organization will have been formed. The district could assume the management of existing wells at that time if they comply with the district's specifications. The owners of these wells would have to be reimbursed in some way. These details were described in Chapter VI.

ESTABLISHING A DISTRICT

It is not the intent of this report to encourage the burdening of canyon residents with an intolerable wastewater disposal expense. It is realized that most canyon residents are on fixed incomes. It has also been pointed out that pollution and health hazards do exist. Establishment of a sanitation or water and sanitation district can help avoid economically overburdening the canyon residents.

The County Commissioners have indicated that they may help the canyon residents establish a district by sponsoring an election. It will probably be necessary to have an attorney prepare dialogue detailing exactly the duties and responsibilities of the district. Hopefully the county will authorize its attorneys to prepare this.

To protect the canyon residents, the prepared dialogue should clearly state that no water or wastewater facilities will be constructed unless a substantial grant is obtained. Any grants that are less than 100 percent should be approved by a second vote of canyon residents. This will allow the district to be a grant recipient, but no taxes could be levied for construction without a second vote. It should be noted that even if the project is 100 percent funded through grants, there will be an operating expense. This aspect will be further described in the section on financing.

FINANCIAL PROGRAM

The proposed project will require a major capital expenditure and substantial operating costs. This section will describe the available methods of funding the project. Because the water facilities can be constructed by individuals without forming a district, this chapter will emphasize the wastewater treatment portion of the project with less emphasis placed on the water program.

SOURCES OF FINANCING

Various possibilities of funding from public and private sources exist. Monthly service charges for each resident will vary depending on the availability of grants and on the method of financing the remaining cost of the facility. This section will describe the most promising grant and loan programs as they pertain to water and sewage facilities. Table X-2 shows some of the details of several government grant and loan sources. At this time, there is no financial aid available for annual operating costs.

Community Development Act (HUD)

This is a program administered by HUD which can provide grants for the design and construction of water treatment systems, water distribution lines, wastewater collection lines, and individual taps. Wastewater treatment plants are ineligible. These grants are awarded on the basis of financial need. Larimer County can apply for these funds to be used in the canyon if a canyonwide agency is established.

Private Financing

Many financial institutions handle revenue bonds. Some specialize in this type of financing. Interest rates on revenue bonds are in the neighborhood of 7 to 8 percent. A service charge and repayment schedule is presented which will assume no government grants are obtained. This type

TABLE X-2
SOURCES OF POTENTIAL FINANCIAL AID

	FHA COMMUNITY FACILITY LOANS/GRANTS - FEDERAL	CONSTRUCTION GRANTS FOR SEWERAGE WORKS (STATE OF COLORADO) STATE	FOUR CORNERS REGIONAL COMMISSION, SUPPLEMENTAL GRANT-REGIONAL	COMMUNITY DEVELOPMENT ACT (HUD)-DISCRETIONARY FUNDS FEDERAL	EPA CONSTRUCTION GRANTS - FEDERAL	PREDESIGN ENGINEERING GRANTS (STATE OF COLORADO) STATE	ECONOMIC DEVELOPMENT-ADMINISTRATION (EDA) - FEDERAL
AM DESCRIPTION							
D USAGE	TO CONSTRUCT, ENLARGE, EXTEND, OR IMPROVE SEWERAGE SYSTEMS.	TO CONSTRUCT, EXPAND, OR MODERNIZE SEWAGE TREATMENT FACILITIES	PROGRAM IS GEARED FOR ECONOMIC DEVELOPMENT TYPE PROJECTS. HOWEVER ECONOMIC DEVELOPMENT HAS A VERY BROAD DEFINITION.	TO CONSTRUCT SEWAGE COLLECTION LINES NOT TREATMENT FACILITIES.	TO PLAN, DESIGN, AND CONSTRUCT SEWERAGE COLLECTION AND TREATMENT FACILITIES.	PREDESIGN ENGINEERING FOR THE EXPANSION, CONSTRUCTION, OR MODERNIZATION OF SEWAGE TREATMENT SYSTEMS INCLUDING COLLECTION OF FACILITIES	THE PROGRAM IS CURRENTLY BEING RECONSIDERED BY THE CONGRESS. IT IS ANTICIPATED THAT THE QUALIFICATION REQUIREMENTS WILL NOT CHANGE. THE BASIC REQUIREMENT BEING HIGH UNEMPLOYMENT RATE AND HIGH NUMBER OF UNEMPLOYED.
M OF ASSISTANCE	MAY BE EITHER LOAN OR GRANT. GRANT OR LOAN 50% OF PROJECT. LOAN 40 YEARS AT 5%.	ASSISTANCE IS GIVEN IN THE FORM OF A GRANT. THE AMOUNT VARIES UPON THE FINANCIAL NEED OF THE COMMUNITY	ASSISTANCE IS IN THE FORM OF A GRANT. MAXIMUM SUPPLEMENTAL GRANT IS 60% OF OTHER FEDERAL FUNDING OR $150,000.	GRANT FROM DISCRETIONARY FUNDS FOR ALL PORTION OF PROJECT.	ASSISTANCE IS IN THE FORM OF A 75% GRANT.	NORMAL STATE GRANT OF 80%, APPLICANT MATCHING FUNDS OF 20%. THE APPLICANTS SHARE IS VARIABLE DEPENDING UPON FINANCIAL NEED.	
OUNT OF ASSISTANCE	LOAN/GRANT RANGE: $20,000-$200,000.	AVG. GRANT: $50,000 MAX. GRANT: $500,000	AVG. GRANT: $75,000	AVG. GRANT: $100,000 GRANT RANGE: $50,000-$300,000	AVG. GRANT: N/A GRANT RANGE:	AVG. GRANT: $3,000	
RRENT FISCAL AR APPROPRIATION	$4.8 MIL LOANS, .9 MIL GRANTS	$2.3 MIL	$2.5 MIL	$2.5 MIL FISCAL YEAR 1977 (COLORADO NONMETROPOLITAN)		$200,000	
TICIPATED APPROPRIATION NEXT SCAL YEAR	ABOUT THE SAME AS PRIOR YEAR.	$2.0 MIL	$1.7 MIL	MINOR INCREASE FOR FY 1978		$200,000	
GIBILITY REQUIREMENTS							
IGIBLE ENTITIES	MUNICIPALITIES AND DISTRICTS	ANY MUNICIPALITY OR SPECIAL DISTRICT	ANYONE WHO CAN GET FEDERAL BASIC FUNDING	A FORM OF GENERAL PURPOSE GOVERNMENT, E.G. INCORPORATED MUNICIPALITIES, COUNTIES, THE STATE OR INDIAN TRIBES.	SEE ATTACHED NOTICE OF FINAL ADOPTION OF FEDERAL CONSTRUCTION GRANT PRIORITY SYSTEM, DATED AUG. 20, 1975.	ANY MUNICIPALITY OR SPECIAL DISTRICT.	
IGIBILITY REQUIREMENTS	MUST NOT HAVE THE CAPABILITY TO FINANCE THE PROJECT THROUGH AVAILABLE COMMUNITY RESOURCES. HAVE POP. LESS THAN 10,000 AS OF LAST CENSUS	APPLICANT'S POPULATION MUST BE 5,000 OR LESS, AS OF THE LATEST CENSUS.	MUST HAVE RECEIVED ANOTHER SOURCE OF FEDERAL AID.	N/A	N/A	APPLICANT'S POPULATION MSUT BE 5,000 OR LESS, AS OF THE LATEST CENSUS.	
SCRIMINATING CTORS	FINANCIAL NEED. THE ENTITY MUST BE AT OR NEAR THEIR LIMIT ON BONDING INDEBTEDNESS.	FINANCIAL NEED, BONDED INDEBTEDNESS, ASSESSED VALUATION, MEDIAN INCOME, ETC.	THE PROJECT MUST PROMOTE ECONOMIC DEVELOPMENT.	EXTENT TO WHICH: COMMUNITY HAS POVERTY, SUBSTANDARD HOUSING, BENEFITS LOW-MODERATE INCOME HOUSING, NEEDED FOR HOUSING STOCK, ALLEVIATING HEALTH, SAFETY, & WELFARE PROBLEMS AND GRANTS FROM OTHER AGENCIES.	N/A	FINANCIAL NEED, SERIOUSNESS OF POLLUTION PROBLEM.	
ICATION MECHANICS							
PLICATION PROSS	BEGIN WITH COUNTY FHA REPRESENTATIVE.	A. SUBMIT GRANT APPLICATION TO DIRECTOR OF LOCAL GOVERNMENTS AND APPLY FOR SITE APPROVAL FROM THE COLORADO WATER POLLUTION CONTROL COMMISSION. B. DIVISION OF LOCAL GOVT. THEN ISSUE A CERTIFICATE OF FINANCIAL NEED STATING AMOUNT OF GRANT AND THAT THE APPLICANT MUST OBTAIN SITE APPROVAL. C. SUBMIT SITE APPROVAL, FINAL PLANS AND SPECIFICATIONS TO THE DIVISION OF LOCAL GOVERNMENTS. D. SUBMIT TWO SETS OF FINAL PLANS AND SPECIFICATIONS TO COLORADO DEPARTMENT OF HEALTH.	DETERMINE A SOURCE OF FEDERAL FUNDING OR POSSIBILITY THEREOF. ARRANGE A PRE-APPLICATION CONFERENCE WITH THE FOUR CORNERS REGIONAL COMMISSION REPRESENTATIVE. ARRANGE FOR AN A-95 REVIEW OF PROJECT.	APPLICATION PROCESS WAS PUBLISHED IN THE FEDERAL REGISTER ON OCT. 13, 1976. COMPETITION IS VERY STIFF FOR THESE FUNDS.	THE STATE HEALTH DEPARTMENT WILL CONTACT THE MUNICIPALITY WHEN FUNDING BECOMES AVAILABLE.	A. OBTAIN LETTER FROM LOCAL HEALTH DEPARTMENT OFFICIAL CERTIFYING THAT SYSTEM IS CURRENTLY IN VIOLATION OF STATE STANDARDS. B. OBTAIN ENGINEERS PROPOSAL FOR WORK. C. OBTAIN APPLICATION FORM LG-PS275. SUBMIT ALL OF THE ABOVE TO THE DIVISION OF LOCAL GOVERNMENTS.	
PLICATION ADLINES	FIRST COME, FIRST SERVED UNTIL APPROPRIATION RUNS OUT.	FUNDING IS ON A FIRST COME, FIRST SERVE BASIS.	NO DEADLINES. FUNDING IS ON A FIRST COME, FIRST SERVE BASIS.	TO BE DETERMINED	N/A	FUNDING IS ON A FIRST COME, FIRST SERVE BASIS.	
ME REQUIRED TO ALUATE APPLICAON	3 MONTHS	1-3 MONTHS. THIS INCLUDES TIME REQUIRED FOR HEALTH DEPARTMENT REVIEW OF PLANS AND SPECIFICATIONS.	VERY FAST, AS FUNDING IS TIED TO ALREADY APPROVED FEDERAL FUNDING.	TO BE DETERMINED 5-6 MONTHS, EXCEPT FOR EMERGENCY SITUATIONS	N/A	2 MONTHS	
ELLANEOUS		IF FUNDING IS NOT RECEIVED UPON INITIAL APPLICATION, IT IS REVIEWED MONTHLY UNTIL IS IS FUNDED OR THE APPROPRIATION IS EXHAUSTED. THESE FUNDS MAY BE USED IN CONJUNCTION WITH OTHER LOANS OR GRANTS. THE COMMUNITY MUST BE PREPARED TO USE 1.5% OF ITS MEDIAN FAMILY INCOME PER CUSTOMER PER ANNUM TO OPERATE ITS EXISTING SYSTEM AND/OR PAY FOR ITS SHARE OF THE NEW PROJECT.			CURRENTLY THERE IS A LARGE EMPHASIS ON STEP 1 AND 2 GRANTS. HOWEVER, AS COMMUNITIES BECOME READY FOR STEP 3 GRANTS, THE AMOUNTS AVAILABLE FOR STEP 1 AND 2 GRANTS WILL BE GREATLY DIMINISHED.	THESE FUNDS MAY BE USED IN COMBINATION WITH OTHER LOANS/GRANTS.	
ACTS	JOHN MEIKLE, FHA, 337-4717	BILL PEED, STATE OF COLORADO, DIVISION OF LOCAL GOVERNMENTS 892-2156 JEB LOVE, STATE HEALTH DEPT. 388-6111	IVO ROOSPOLD, DEPT. OF LOCAL AFFAIRS, RURAL DEVELOPMENT 892-2631	ARMAND SEDGELEY, HUD-DENVER 837-4666	RON SCHUYLER, STATE DEPT. OF HEALTH, 388-6111 JERRY BURKE, SAM BERMAN FEDERAL EPA, 837-3961	BILL PEED, STATE OF COLORADO DIVISION OF LOCAL GOVERNMENTS 892-2156	PAUL RENNE, ALL PR GRAMS. JOHN ZENDER LOCAL PUBLIC WORKS ACT, 337-4714

BRISCOE, MAPHIS, MURRAY & LAMONT, INC. MARCH 3, 1976 of financing is available for any type of utility, as long as the community can demonstrate its ability to repay the loan. It is very doubtful that sufficient funds can be obtained from the private sector to finance all of the water and sewerage facilities.

Farmers Home Administration (FmHA)

This is a combination grant and loan program administered by FmHA. All community water and wastewater facilities are eligible. Grants can be for any percentage of the total project costs. Loans are long term, low interest (40-year, 5 percent) loans.

Colorado Department of Local Affairs

This is a grant program available for the design and construction of wastewater collection and treatment facilities for municipalities or districts with a population less than 5,000. The Division of Local Government administers the program. Grants are based on need and legally can be as high as 100 percent of the project cost, although grants over 60 percent of the project cost are rare. As a rule-of-thumb, the wastewater service charge to residents should be at least 1-1/2 percent of income on an annual basis.

U.S. Environmental Protection Agency (EPA)

This is a federal grant program administered by the Colorado Water Quality Control Commission (WQCC). Each year Congress allocates money to each state to be used for waste treatment plants only. Wastewater collection lines and potable water facilities are not eligible. The WQCC prepares a priority system by which municipalities are ranked according to pollution potential. Seventy-five percent of the plant and interceptor sewers is funded for those communities high enough on the priority list to receive a grant. There is great demand for these limited funds. Should some type of district be formed in the canyon, this district would be in competition with all municipalities in the State for these funds. In short, EPA does not appear to be a very promising source of funds.

Four Corners Regional Commission

This is a grant program administered by an agency supported jointly by the governments of Colorado, New Mexico, Arizona and Utah. These grants become available when a federal agency such as FmHA has granted funds.

SERVICE CHARGE DETERMINATION

The annual user fee is dependent on the amount of debt service, the operating costs, and the number of taps on the system. This section will describe the method of determining the annual user fee and provide an estimate of this fee for each resident.

Wastewater Service Charge

The O&M cost of the recommended wastewater treatment works is estimated to be $87,000 annually. This figure will vary only moderately depending on the number of users on the system. The capital cost of the proposed facilities is estimated to be $1,693,000 plus the cost of the taps, or a total of $2,163,000.

There are approximately 569 potential taps within the canyon. A commercial facility, such as a motel, which may have more than one building, constitutes only one tap in the analysis. It should be noted that the county requires that if collection lines are within 400 feet of a serviceable building, that building must hook up to the system. Therefore, it will be assumed that these regulations will be enforced and that everyone in the canyon will participate in this program.

The formula for determining the annual service charge is:

$$\text{Annual Cost Per Unit} = \frac{\text{Annual O\&M} + \text{Annual Debt Service} - \text{Tap Fees}}{\text{Number of Units on System}}$$

For simplicity in this analysis, it will be assumed that no revenues will be collected from tap fees.

If no government grants were obtained to help subsidize this project, the residents would have to pay 100 percent of the capital cost as well as the O&M fee. Assuming the capital was borrowed at 7 percent interest for a period of 20 years, the annual debt service would be $204,000. Coupled with the annual O&M expenses, the total annual payment would be $291,000. This is $511 per year tap, or $43 per month. Thus, with no government assistance, the cost of wastewater service would be exhorbitant.

At the other end of the spectrum is the possibility of obtaining federal and state grant assistance to pay for 100 percent of the capital cost of the facilities. In this case, residents would only have to pay the annual operation and maintenance costs of $87,000. This is $153 per tap per year, or $12.75 per month for wastewater services. Thus the cost for O&M alone is a significant monthly charge for canyon residents.

It is unlikely that grant funding can be obtained to finance 100 percent of the project. Nevertheless, the analysis above indicates that the monthly O&M cost is a significant charge for canyon residents. A very high percentage grant, in the realm of 95 percent or better, is needed to prevent this project from becoming an intolerable economic burden on canyon property owners. Table X-3 illustrates the effect of various percentage grants on the user's charge.

TABLE X-3. EFFECT OF GRANT ON LOCAL SHARE [a]

GRANT %	ANNUAL DEBT SERVICE	ANNUAL O&M	TOTAL ANNUAL	YEARLY SERVICE CHG.
0	$204,000	$87,000	$291,000	$511
70	61,150	87,000	148,150	260
80	40,830	87,000	128,000	225
90	20,420	87,000	107,400	189
95	10,200	87,000	97,200	171
100	0	87,000	87,000	153

[a] Interest at 7 percent, 20 year repayment period.

When a district is formed, it will be necessary to require that every serviceable customer hook-up to the system. This is in accordance with county and state requirements. If less than 100 percent hook-ups are made, the cost per tap increases dramatically. For example, if a 100 percent grant can be obtained, but only 90 percent of the potential customers in the canyon hook-up to the system, the annual service charge increases from $153 to $170. This is an increase of $1.50 per month.

A financial program can never be finalized until all sources of funds are known. Varying grant percentages, interest, and repayment period rates effect the user charges. Also, an initial tap fee would probably be charged before a hook-up is made. The revenue from tap fees is normally applied toward reducing the amount of money borrowed. Thus, tap fee revenues have the same effect on user charges that grants have.

Water System Service Charge

Should the district choose to become actively involved in the water utility business, it would be necessary to determine a user charge for this service. There are already several good wells drilled and some are to be installed in the near future. These wells can be incorporated into the district by reimbursing the owners, either by initial payment or through credit on their water bills.

The cost of this water service will depend greatly upon the availability of grants and the amount of each grant. Because a water and sanitation district can apply for and receive such grants, the cost of potable water service can be greatly reduced when property owners form a district.

The average per connection cost of a cluster well system is about $350. Depending upon the location of the well and the number of taps on the cluster system, this cost can vary about 15 percent. This resulting cost of nearly $30 per month for water service alone can be greatly altered. Table X-4 shows the various grant percentages that may be made and resultant change in monthly service charge for typical cluster well systems.

TABLE X-4. EFFECT OF GRANT ON SERVICE CHARGE

PERCENT GRANT	ANNUAL DEBT SERVICE [1]	ANNUAL O&M	TOTAL ANNUAL	YEARLY SERVICE CHARGE	MONTHLY SERVICE CHARGE
0	$71,006	$31,200	$102,200	$350	$29.17
20	56,600	31,200	87,800	304	25.33
40	42,500	31,200	73,700	255	21.25
60	28,300	31,200	59,500	206	17.17
80	14,200	31,200	43,400	157	13.09
100	0	31,200	31,200	108	9.00

[1] Principal and interest at 7 percent; 30 year repayment schedule.

Total cost of the cluster well system will vary considerably depending upon the number of wells incorporated into the system and the purchase price and availability of present wells. Estimates as discussed earlier vary from $1.3 million to $2.1 million with $1.9 million felt to be a good general representation of the total cost for entire study area implementation. The costs as depicted in Table X-4 however, will remain much the same as they are based upon a generalized cluster well size and associated costs.

Grants are seldom given for more than 80 percent for water service. However, grants in excess of 60 percent are not uncommon and it is strongly recommended that a water district be formed to reduce the monthly cost of water to canyon residents.

As with wastewater service, varying tap fees less than the expected number of hook-up and the grant percentage can greatly affect user fees.

REVENUE COLLECTION METHODS

Revenues can be collected either by directly charging a monthly user fee, through mill levies, or by a combination of these. One of the duties of the district's board of directors is to decide how revenues should be raised. This document will not attempt to usurp the authority of the board, but will discuss some of the advantages and disadvantages of the collection methods. Finally, an example of a revenue program will be presented.

One of the policies which the district should incorporate into its collection strategy is that "he who benefits, pays". This means that the larger producers of wastewater should pay a higher user fee than the smaller ones. Simultaneously, the district will want to keep its operating expense to a minimum. It will probably not want to install a flow meter, which would have to be read at every dwelling or commercial facility. Further, the cost of running a billing department which does not have "flat" rates is high.

An indirect method of collecting more revenues from the larger users would be to charge a mill levy against the assessed valuation of the property within the canyon. Generally commercial establishments, which tend to produce more wastewater than residential habitations, have a higher assessed valuation than do residences.

Conversely, mill levies are not as versatile as are monthly user fees. A mill levy cannot be easily changed by more than 7 percent from one year to the next. Service charges can be fairly easily changed. For these reasons, the district may wish to obtain revenues from both sources.

To illustrate how a combination of a mill levy and a service charge works, an example will be presented. Although the actual assessed valuation within the canyon has never been totalized by the county, a reasonable estimate will be made. For purposes of this example, the following assumptions will be used:

Government grant obtained................	95%
Total number of taps.....................	569
Assessed valuation.................	$5,000,000
Annual revenues required..............	$97,000

The district may decide it wants to bill its customers (a flat rate) of $6.00 per month, which would generate approximately $41,000. The mill levy required to generate the remaining $56,200 would be 11.24 mills ($56,200 ÷ $5,000,000).

These numbers will have to be refined once a district is formed and boundaries are established. The county has the information on the assessed valuation of each property within the canyon which can be made available to the district.

APPENDIX 1

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APPENDIX 2

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