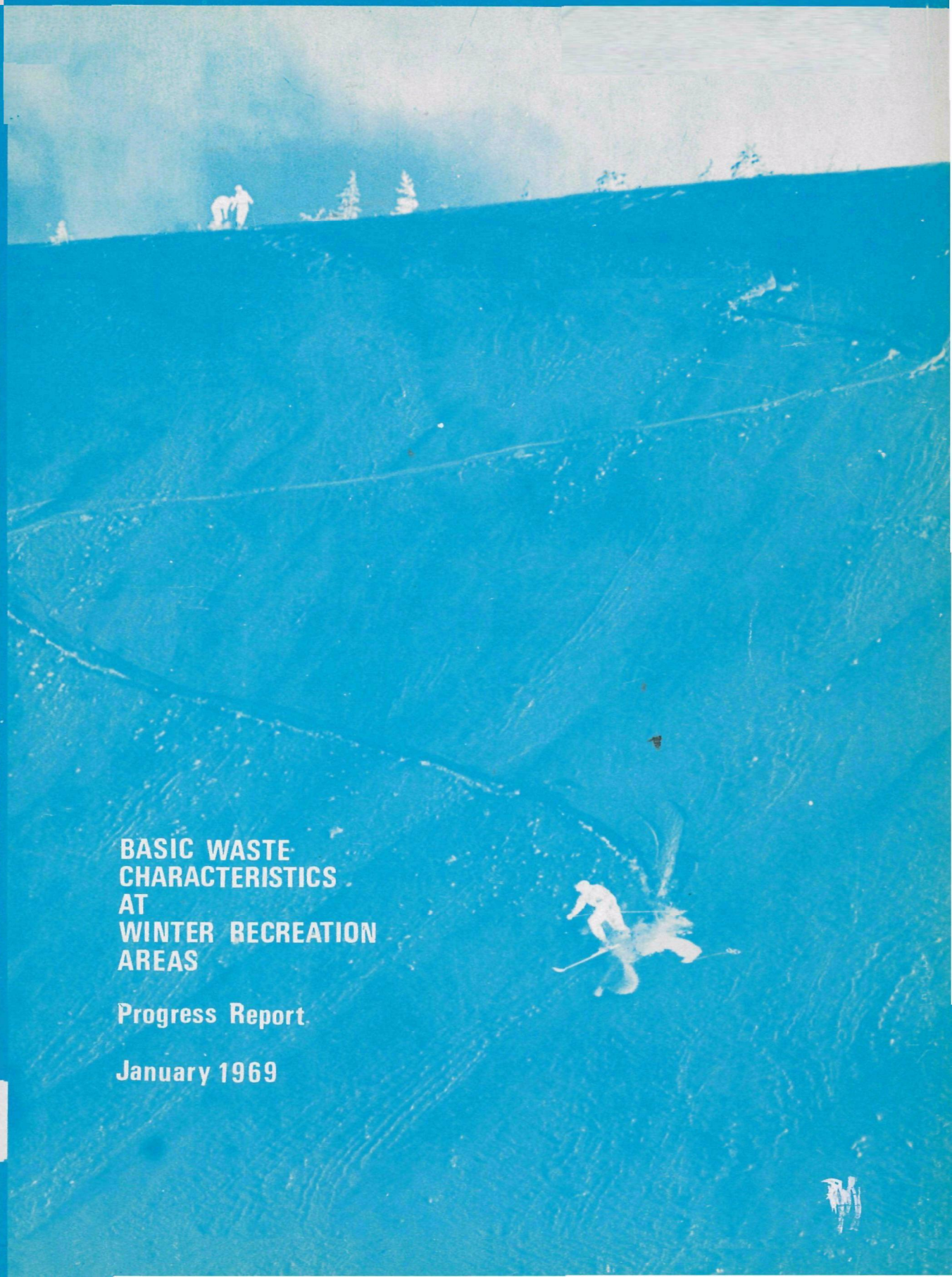
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHWEST REGION, PACIFIC NORTHWEST WATER LABORATORY



BASIC WASTE CHARACTERISTICS AT WINTER RECREATION AREAS

Progress Report

January 1969

CLEAN WATER

BASIC WASTE CHARACTERISTICS
AT
WINTER RECREATION AREAS

Progress Report

A Technical Project Report

Prepared by
B. David Clark
Special Studies Branch

Report No. PR-7

United States Department of the Interior
Federal Water Pollution Control Administration, Northwest Region
Pacific Northwest Water Laboratory
200 South Thirty-fifth Street
Corvallis, Oregon 97330

August 1968

TABLE OF CONTENTS

	Page
INTRODUCTION	1
Purpose and Scope	1
Authority	2
Study Area Descriptions	3
Acknowledgments	10
SUMMARY	15
Findings	15
Conclusions	17
Recommendations	18
STUDY PROCEDURES	21
RESULTS	27
Waste Quantities	27
Waste Quality	33
Correlation Analyses	40
DISCUSSION	43
DESIGN RECOMMENDATIONS	49
APPENDIX	55

LIST OF TABLES

Table		Page
1	Day Lodge Water Use Relationships	27
2	Overnight Lodge Water Use Relationships	31
3	Sewage Flow Variations	34
4	Average Raw Wastewater Quality for Timberline Lodge and Crystal Mountain Ski Areas	35
5	Summary of Correlation Analyses	41

LIST OF FIGURES

Figure		Page
1	Study Area	4
2	Crystal Mountain Ski Area	7
3	Crystal House, Silver Skis Chalet and Alpine Inn Complex	8
4	Crystal Mountain Chapel, Ski Shop, Day Lodge, and Sewage Treatment Plant	9
5	Timberline Lodge Ski Area	11
6	Bachelor Butte Ski Area	12
7	Crystal Mountain Survey Equipment	22
8	Timberline Lodge Raw Sewage Sampler and Location	25
9	Crystal Mountain Waste Flow vs Water Use	28
10	Day Lodge Water Use	30
11	Overnight Lodge Water Use	32
12	Crystal Mountain Air and Sewage Temperatures	36

ABBREVIATIONS

BOD_5	-	Five day biochemical oxygen demand
COD	-	Chemical oxygen demand
TPO_4	-	Total Phosphate
OPO_4	-	Ortho Phosphate
TS	-	Total Solids
TVS	-	Total Volatile Solids
SS	-	Suspended Solids
VSS	-	Volatile Suspended Solids
NH_3	-	Ammonia Nitrogen as Nitrogen
NO_2	-	Nitrite Nitrogen as Nitrogen
NO_3	-	Nitrate Nitrogen as Nitrogen
TKN	-	Total Kjeldahl Nitrogen as Nitrogen
Alk	-	Alkalinity
mg	-	Million Gallons
mgd	-	Million Gallons Per Day
gpd	-	Gallons Per Day
E	-	Full-time Lodge Employees
TV	-	Total Visitors Per Day as Measured by Traffic Counter and Assuming 4 Persons Per Vehicle
G	-	Overnight Guests Per Day as Measured by Actual Head Count
f.u.	-	Fixture-units
Q	-	Daily Water Use, gpd
W	-	Daily Wastewater Discharge

ABBREVIATIONS (CONT.)

Base Use	-	Water Required to Run Establishment Including Use for Employees, Building Maintenance, etc.
pH	-	Analytical Measurement of Hydrogen Ion Concentration Giving an Indication of Acidity or Alkalinity
Mg/l	-	Milligrams per Liter
Cl	-	Chlorides
TH	-	Total Hardness
CaH	-	Calcium Hardness

INTRODUCTION

Purpose and Scope

The disposal of wastewaters from recreation areas has become increasingly of major concern regarding water pollution and public health problems with the rapid growth in recreation use and development of new and more sophisticated areas. Many existing areas, as well as most of the new areas, that use septic tank and drainfield systems have had to look for better methods of disposal due to failure of this type of system to provide adequate treatment and safeguard against water pollution and potential public health hazards. This is also true regarding the use of standard secondary treatment facilities such as package treatment plants. The problem is compounded by the fact that in most situations, wastewater is discharged to a watercourse that is of extremely high quality and must not degrade or lower the existing quality of the waterbody in keeping with State and Federal non-degradation policies. This requires, then, that a very high level of treatment be provided with essentially complete removal of degradable organic matter, suspended solids, nutrients and complete disinfection.

In order to design facilities that will provide this high level of treatment, sound design criteria must be developed on the basic characteristics of wastewater from recreation areas and on

treatment processes that will function under extreme loading and temperature conditions.

The Recreational Sites Wastes Treatment Project was initiated in August 1967 at the request of the Washington State Water Pollution Control Commission and strongly supported by the U. S. Forest Service, National Park Service and the Federal Water Pollution Control Administration. The study is currently planned for completion in September 1969.

The overall objective of the study is to develop a waste treatment guide for the planning and design of wastewater treatment facilities at various recreation areas. It will be conducted in essentially three phases as follows:

Phase I: Winter Recreation Area Surveys

Phase II: Summer Recreation Area Surveys

Phase III: Pilot Plant Studies

This report summarizes the findings of surveys at three winter sports areas to determine basic wastewater characteristics and recommend criteria for use in the design of treatment facilities. The study was conducted over the 1967-68 recreation season from approximately December 1967 to May 1968.

Authority

The Secretary of the Interior is authorized to conduct special studies on water pollution problems at the request of a state by Section 5 of the Federal Water Pollution Control Act as amended.

The State of Washington has made such a request through a letter dated July 24, 1967 to the Federal Water Pollution Control Administration.

The Secretary of the Interior is also authorized through Executive Order 11288 to assist other Federal agencies in the abatement and prevention of water pollution.

Study Area

Three sites were selected for study on the basis of types of facilities and suitability for study. These were Crystal Mountain Ski Area near Mt. Rainier National Park in the State of Washington, Timberline Lodge on Mt. Hood, approximately 50 miles east of Portland, Oregon and Bachelor Butte Ski Area approximately 20 miles west of Bend, Oregon. Figure 1 illustrates the location of these areas. To compare the various lodges on an equal basis, the number of plumbing fixtures were determined and weighted according to fixture-units which is defined by the American Standard National Plumbing Code, ASA A40.8-1955, as "a quantity in terms of which the load-producing effects on the plumbing system of different kinds of plumbing fixtures are expressed on some arbitrarily chosen scale". For example, a water closet, flush valve operated, has 8 fixture-units while a lavatory has 2 fixture-units.

Crystal Mountain

This area has a day-lodge with a lunch counter and ski patrol office, an area business office and ski equipment rental and sales

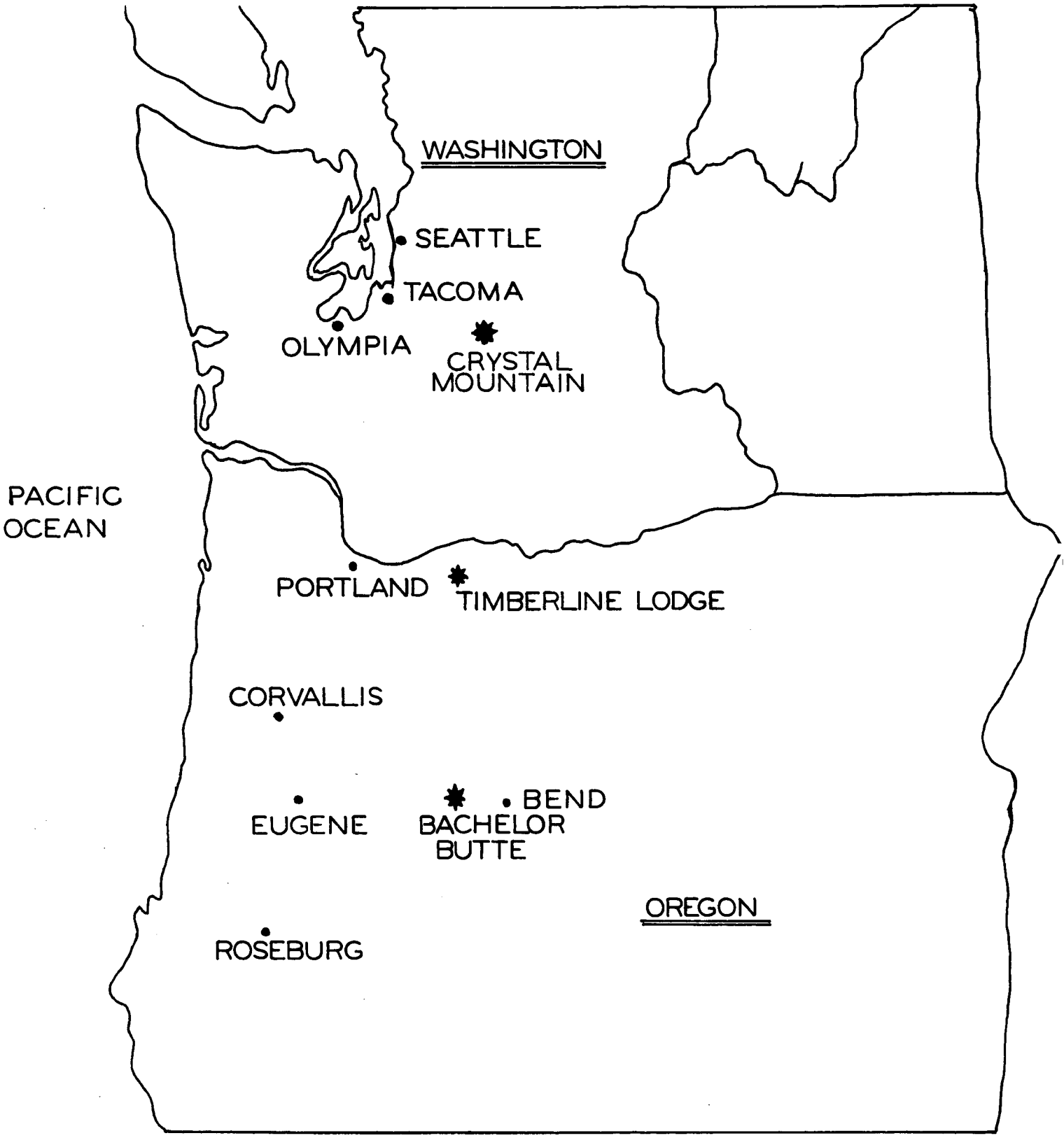


FIGURE 1. STUDY AREA

office, a non-denominational chapel, two motel-type overnight lodges (Crystal House and Silver Skis Chalet), a combination overnight lodge, lounge and restaurant complex (Alpine Inn) and a series of privately owned condominiums. The condominiums were not included in the study of this area. The area is open 7 days per week and particularly caters to the skier holiday type of operation.

It is estimated that the day lodge has 150 fixture-units, the Alpine Inn has 225 fixture-units, Silver Skis Chalet has 380 and the Crystal House has 150 fixture-units.

The day lodge, the ski shop and the chapel have a total of 13 employees during the week and 36 on weekends. Of these totals, 1 employee stays overnight during the week and 13 on weekends.

The Alpine Inn, including the restaurant and lounge, employs 8 people on weekdays and 13 on weekends. Approximately 7 stay overnight on weekdays and 9 on weekends.

The Silver Skis Chalet employs 3 people on weekdays and 4 people on weekends. Two people stay overnight on both weekdays and weekends.

The Crystal House employs 3 people on weekdays and 4 people on weekends. Three people stay overnight on both weekdays and weekends.

The day lodge, chapel, Silver Skis Chalet and Crystal House are connected by sewers to an extended aeration type treatment

system. The treatment system effluent is discharged to a soil absorption drainfield. The Alpine Inn complex has a septic tank and drainfield waste treatment system.

Figures 2, 3, and 4 illustrate the various facilities of this area.

Timberline Lodge

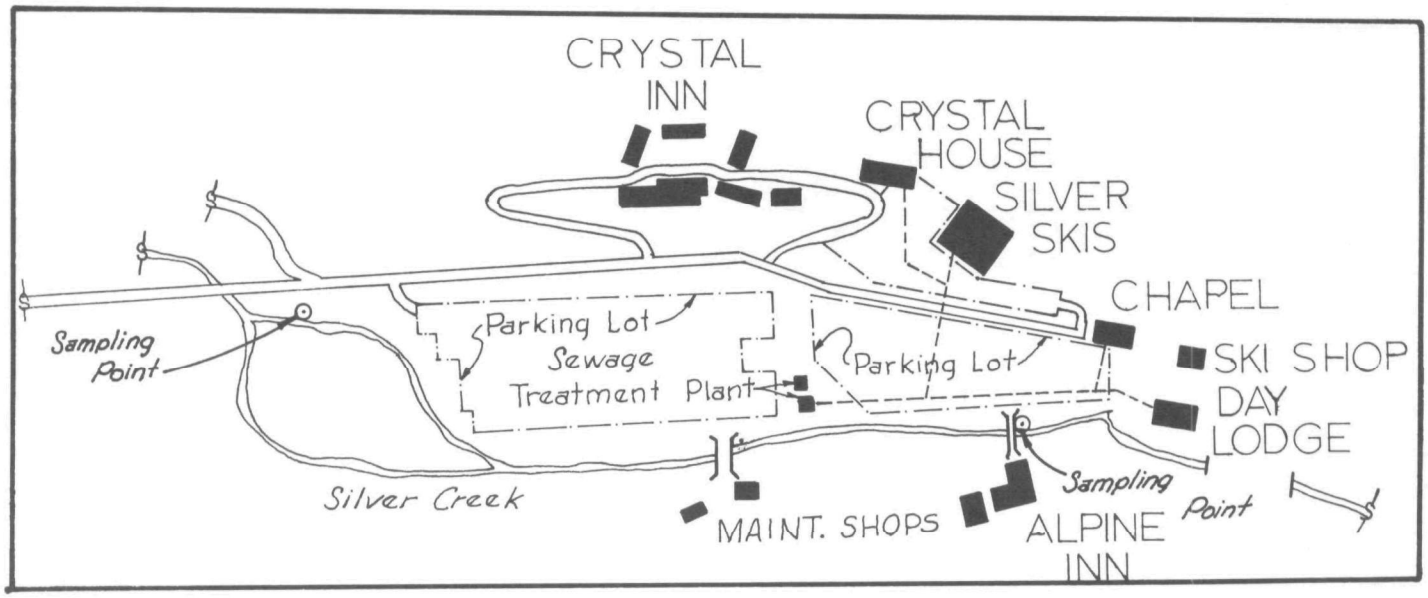
This area has a lodge that provides both overnight and day use accommodations including a ski shop, gift shop, first aid room, and a swimming pool.

The lodge has a cafeteria, a restaurant, and a bar, and a total of 76 rooms. Sixty of these rooms have private bathrooms and 16 share 2 hall bathrooms - one each for men and women. There are also 2 public restrooms.

The men's restrooms have 10 water closets, 8 urinals, 3 showers and 5 lavatories. The women's rooms have 11 water closets, 3 showers and 5 wash basins. It is estimated that the lodge has on the order of 400 fixture-units.

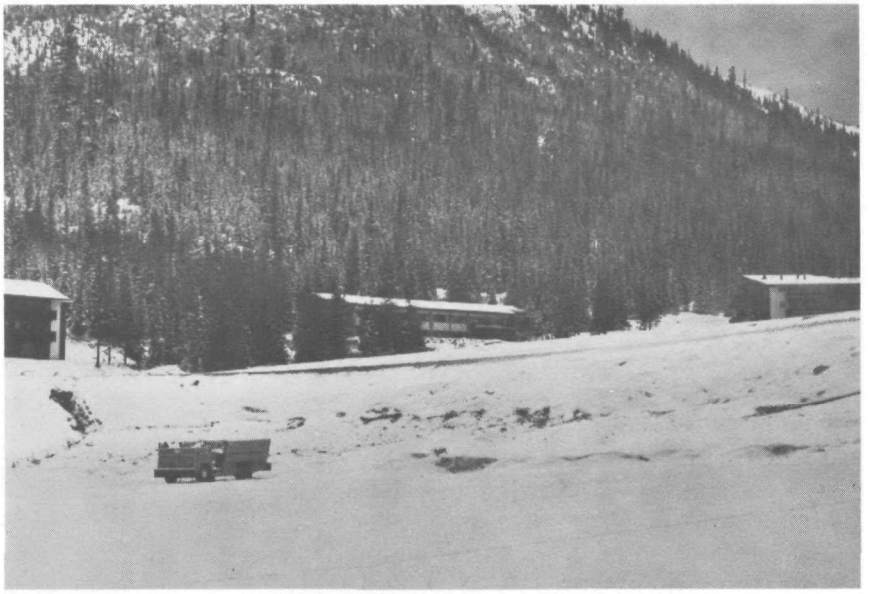
The lodge employs 90 to 95 permanent full-time people, 10 of whom reside at the lodge. In addition they use 10 part-time people on weekends. There are also 50 ski instructors at the area during weekends, 3 of whom are full-time during the week. The Ski Patrol, which has facilities at the lodge, has 20-25 members with 2 on a permanent basis.

SKI AREA LOCATION



DETAIL

FIGURE 2 CRYSTAL MOUNTAIN SKI AREA

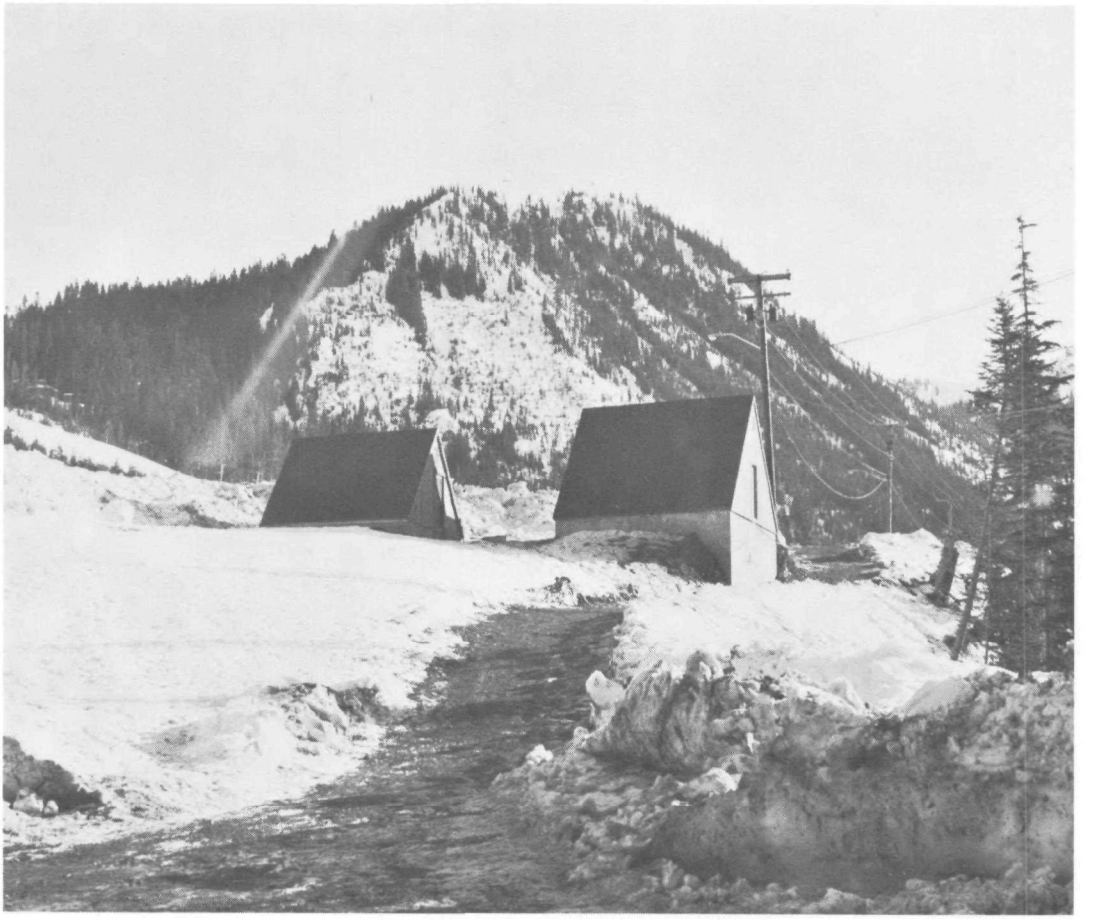


CRYSTAL HOUSE AND SILVER SKIS CHALET

ALPINE INN COMPLEX

FIGURE 3. CRYSTAL HOUSE, SILVER SKIS CHALET AND ALPINE INN COMPLEX

CHAPEL, SKI SHOP AND DAY LODGE



SEWAGE TREATMENT PLANT

FIGURE 4 CRYSTAL MOUNTAIN CHAPEL, SKI SHOP, DAY LODGE AND SEWAGE TREATMENT PLANT

The lodge wastewaters are treated at a 60,000 gpd extended aeration plant and then chlorinated. The plant effluent is discharged to a small tributary of the West Fork of the Salmon River.

Figure 5 illustrates this ski area and its facilities.

Bachelor Butte

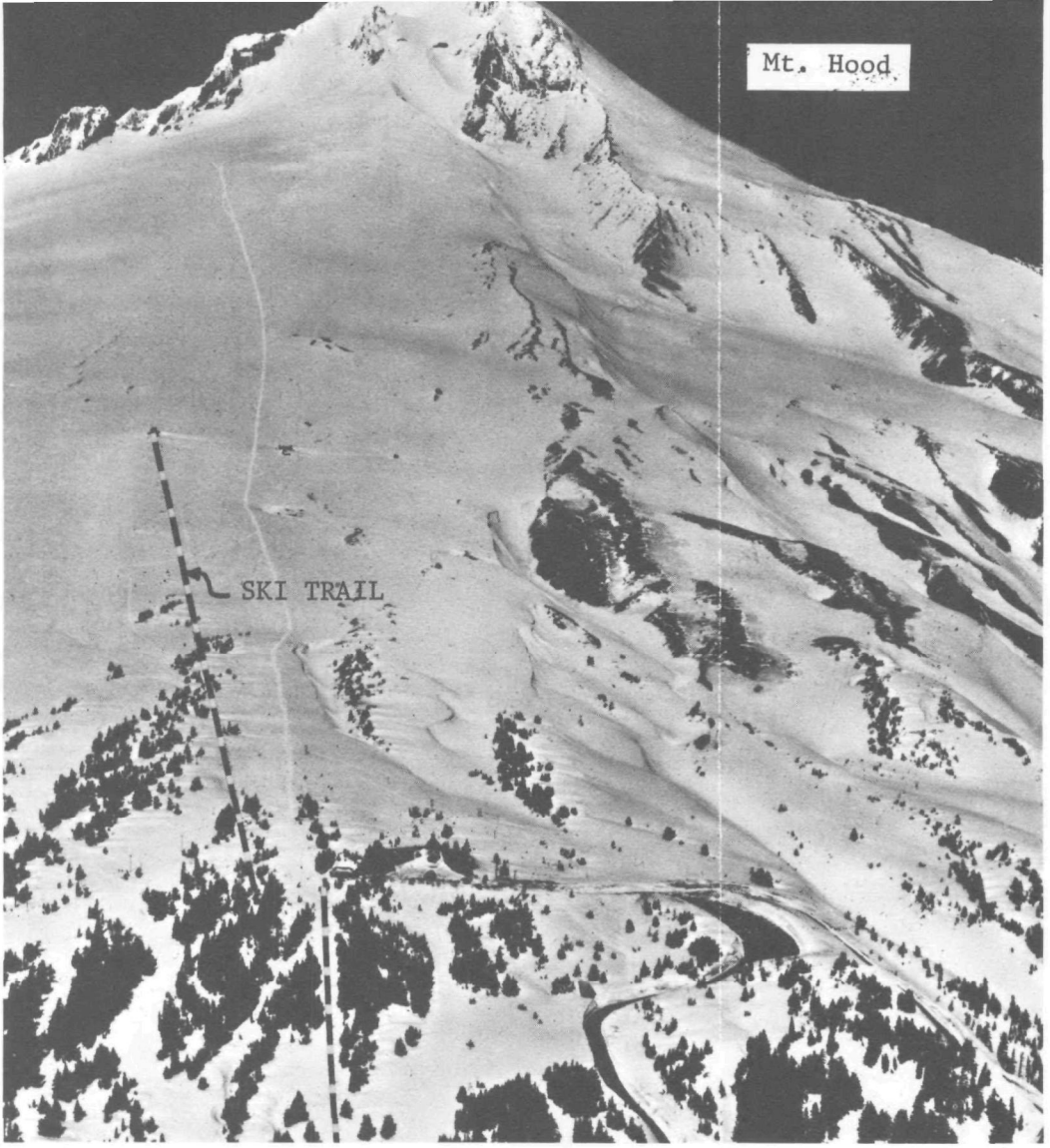
Accommodations at this area include a day lodge with cafeteria and an overnight lodge with restaurant and lounge. Only the day lodge has been included in this study due to lack of complete information from the overnight lodge.

During this study the area operated only during weekend periods.

The day lodge has 2 public restrooms - one each for men and women. The men's room has 6 urinals, 5 water closets and 1 circle sink. The women's has 10 water closets and 1 circle sink. This facility has approximately 120 fixture-units. The lodge employs approximately 5 persons on weekends and 2 to 3 on weekdays, none of whom stay overnight. The waste from this facility flows to a septic tank and drain field. Figure 6 illustrates the area location and day lodge.

Acknowledgments

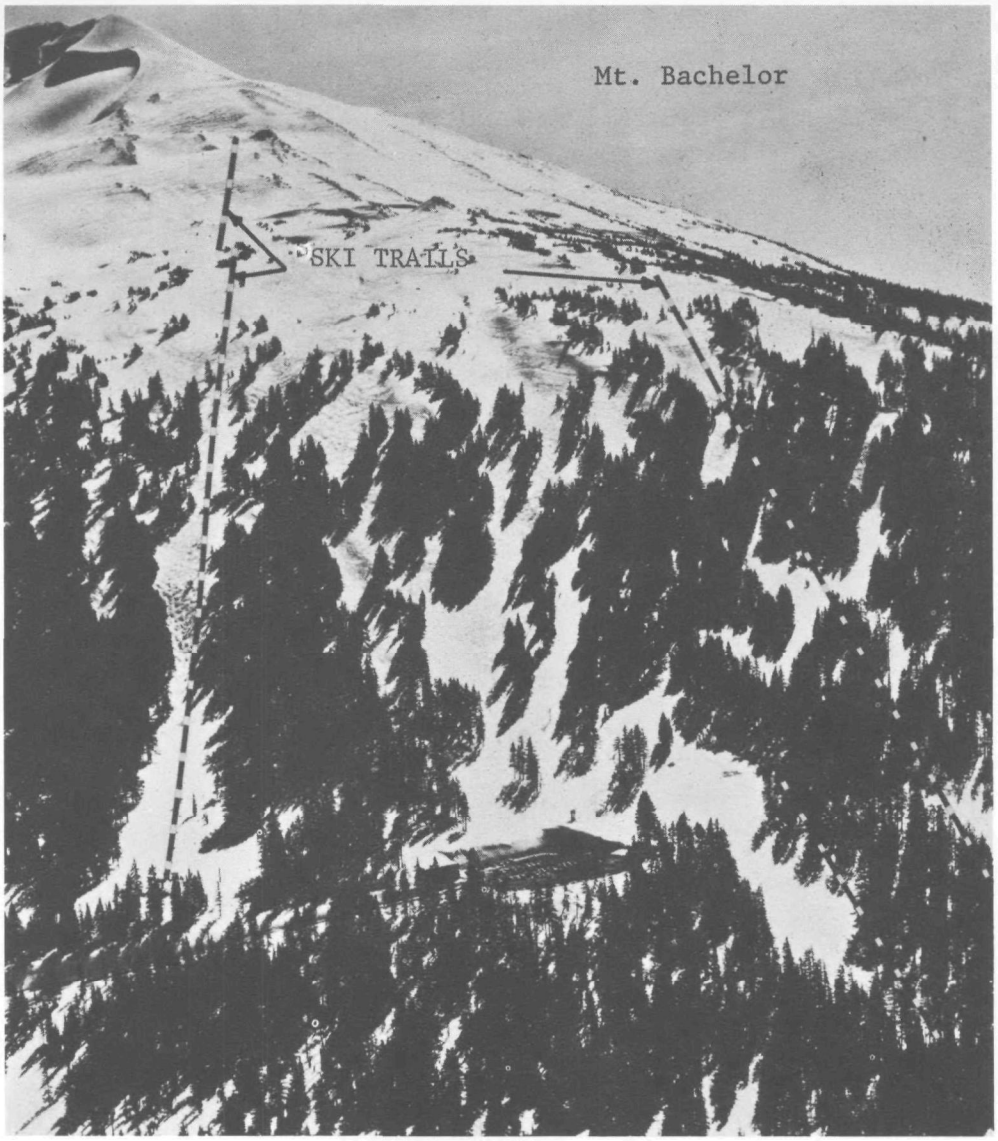
The assistance and cooperation of the following agencies in making this study is acknowledged:



TIMBERLINE LODGE SKI AREA

TIMBERLINE LODGE AND SEWAGE TREATMENT PLAN

FIGURE 5. TIMBERLINE LODGE SKI AREA



SKI AREA LOCATION

DAY LODGE

FIGURE 6 BACHELOR BUTTE SKI AREA

1) U. S. Forest Service

   Mt. Hood National Forest, Zig Zag Ranger Station

   Snoqualmie National Forest, White River Ranger District

   Deschutes National Forest, Bend Ranger District

2) Crystal Mountain, Inc.

3) Timberline Lodge Corp.

4) Bachelor Butte Ski Area

SUMMARY

Findings

1. Approximately 70% of water used at Crystal Mountain Ski Area is returned as wastewater, which is lower than what was expected. This is attributed to consumptive and exfiltration losses.

2. Day Lodge water use relationships as a function of total daily visitors were derived for Crystal Mountain and Bachelor Butte ski areas. These relationships with the 95% confidence limits of the coefficients are:

Crystal Mountain	$Q = 3000 + 2.61 \pm 0.46(TV)$
Bachelor Butte	$Q = 1095 + 0.83 \pm 0.25(TV)$

3. Overnight lodge water use relationships as a function of total daily overnight guests were derived for three lodges at Crystal Mountain. Their relationships indicated an average per guest water use that varied from 17 to 57 gpd and a base water use that varied from 780-3470 gpd. These relationships with the 95% confidence limits of the coefficients are:

Alpine Inn	$Q = 3470 + 57 \pm 15(G)$
Silver Skis	$Q = 2100 + 34 \pm 7(G)$
Crystal House	$Q = 780 + 17 \pm 5(G)$

4. A combined overnight-day lodge water use relationship was derived from data for Timberline Lodge ski area and an assumed 30% consumptive loss. These data indicated the following average

relationship with 95% confidence limits of the coefficients:

$$W = 6700 + 1.4 \pm 0.4(TV) + 23 \pm 13(G)$$

5. Data on sewage flow variations at Crystal Mountain and Timberline Lodge indicated the following ratios:

a. The ratio of 16-hour to 24-hour average flow varied from 1.25 to 1.48

b. The ratio of peak to 24-hour average flow varied from 8.5 to 10.9 flow, and

c. The ratio of maximum hour to 24-hour average varied from 3.1 to 4.2.

6. The raw wastewater temperature at Crystal Mountain Ski Area varied from 5 - 7°C above the air temperature.

7. The average wastewater strengths in mg/l (except pH) from Timberline Lodge and Crystal Mountain are as follows:

Parameter	Timberline Lodge	Crystal Mountain
pH	6.2	6.6
TS	657	785
% Volatile TS	88	94
SS	321	372
% Volatile SS	87	92
COD	749	832
TPO_4	12.7	13.2
% OPO_4	50	55
TKN	76.6	80.0

Parameter	Timberline Lodge	Crystal Mountain
NH_3	28.5	17.3
BOD_5	395	382
% Soluble BOD_5	63	-

8. Correlations between daily visitor and overnight use and the various wastewater parameters gave the following relationships with 95% confidence limits in terms of pounds per day:

$$SS\ (lb/day) = 0.059\ E + 0.0031 \pm 0.01265(TV) + 0.292 \pm 0.21(G)$$

$$COD\ (lb/day) = 0.24\ E + 0.0168 \pm 0.0133(TV) + 0.0844 \pm 0.23(G)$$

$$TPO_4(lb/day) = 0.00017\ E + 0.0136 \pm 0.012(G)$$

$$TKN\ (lb/day) = 0.0156\ E + 0.00886 \pm 0.0096(TV)$$

$$BOD_5(lb/day) = 0.17\ E + 0.0057 \pm 0.0078(TV) + 0.041 \pm 0.132(G)$$

Conclusions

1. Water use and wastewater discharged at the various facilities at winter sports areas is a linear function of full-time employees, number of fixture-units, and overnight guests and total daily visitors.

2. Base use which was defined as the fixed amount of water required to run a facility is apparently a function of the number of full-time employees and number of fixture-units. An average value was calculated of 1.73 gallons per day per employee per fixture-unit. This value had a range from 1.49 to 1.93 at the six lodges studied.

3. Per capita water use per total visitor at day lodges is apparently a function of area operation which in turn affects the percent of skiers and non-skiers. The two areas studied have been classed as:

Type I: Resort area operating 7 days per week.

Type II: Weekend area with major use primarily on weekends only.

4. Per capita water use per overnight guest at overnight lodges is a function of type of facility and type of guest that stays there. There are at least three types of overnight lodges:

Type I: Dormitory

Type II: Condominium

Type III: Dormitory with attached restaurant and lounge

Type I has the least per capita use and Type III has the maximum.

5. The quantity of various wastewater parameters discharged is a linear function of number of full-time employees, and either or both total visitors and overnight guests depending on the facility. This relationship was verified by multiple linear regression analysis techniques. Statistically significant but highly variable relations were developed for COD, BOD_5, SS, TKN, and TPO_4.

Recommendations

1. That the maximum value of the 95 percent confidence limit be used in selecting design values.

2. That a consumptive loss be assumed when estimating wastewater flows from water use relationships.

3. That the peak flow be estimated at 10 times the average daily flow.

4. That the following relationships be used to estimate water use at various lodges at winter sports areas.

Day Lodges

Type I: $Q = 1.73(E)(f.u.) + 3.07(TV)$

Type II: $Q = 1.73(E)(f.u.) + 1.08(TV)$

Overnight Lodges

Type I: $Q = 1.73(E)(f.u.) + 22(G)$

Type II: $Q = 1.73(E)(f.u.) + 41(G)$

Type III: $Q = 1.73(E)(f.u.) + 72(G)$

Combined Overnight-Day Lodge

$$Q = 1.73(E)(f.u.) + 1.8(TV) + 36(G)$$

5. That the following relationships be used for estimating the BOD_5 and COD strength of wastewaters from winter sports areas:

BOD_5 (lb/day) $= 0.17(E) + 0.0135(TV) + 0.173(G)$

COD (lb/day) $= 0.24(E) + 0.03(TV) + 0.31(G)$

6. That the following relationships be used to estimate the solids strength of winter sports area wastewaters:

SS (lb/day) $= 0.059(E) + 0.013(TV) + 0.29(G)$

$VSS = 0.90(SS)$

STUDY PROCEDURES

Crystal Mountain

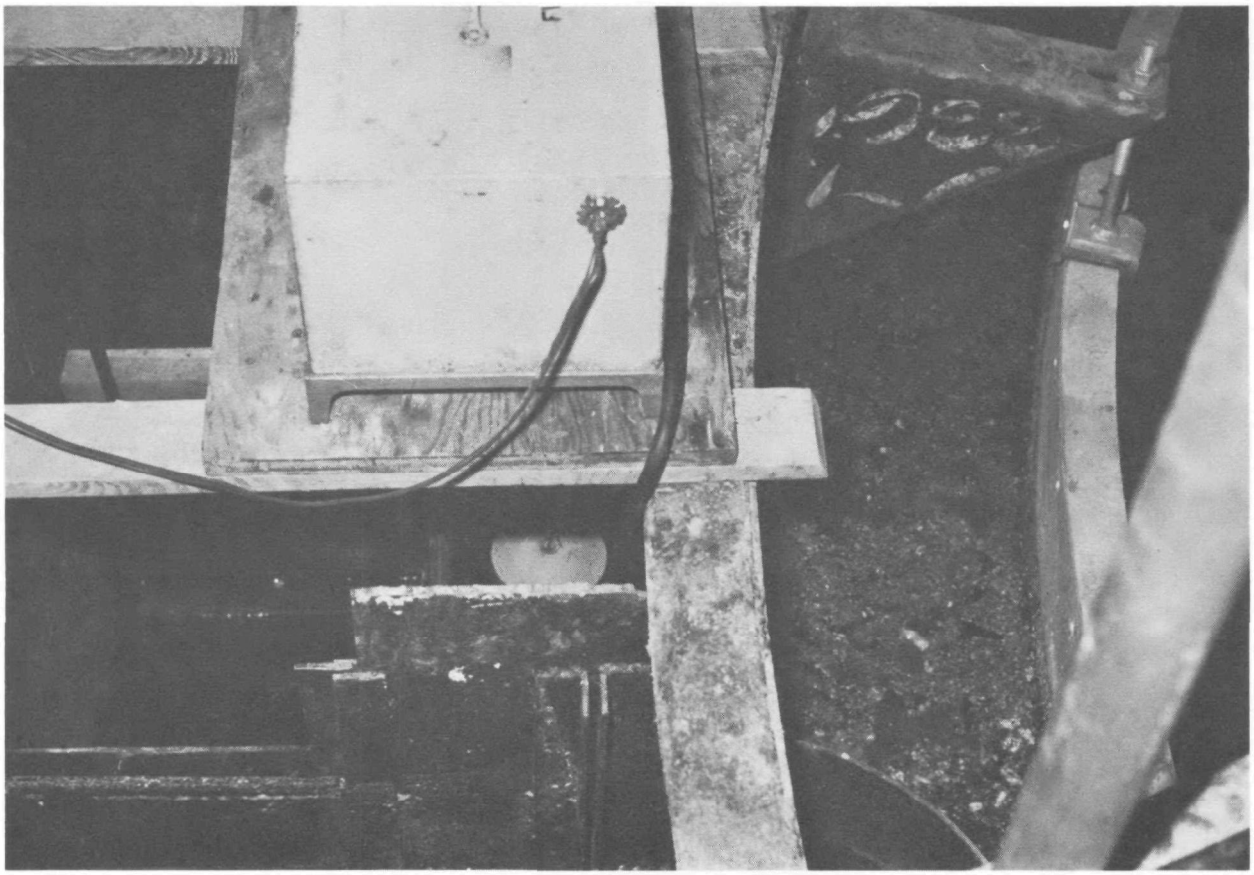
Water use data were collected for the Day Lodge, Alpine Inn, Crystal House and Silver Skis Chalet by reading water meters at each location every Friday and Monday at approximately 1:00 pm from January 12 through April 26, 1968. Total daily visitor attendance at the area was determined from a traffic counter which was installed and read by the U. S. Forest Service and an estimated 4 persons per vehicle.

Overnight guests were recorded by the lodge owners and submitted to the U. S. Forest Service Snow Ranger at the area.

Wastewater flow to the treatment plant was measured by installing a 60° V-notch weir on the effluent side of the plant clarifier. A water stage recorder* was installed to record the gage height which was then converted to flow. An 8-day chart was used and changed by the U. S. Forest Service Snow Ranger once per week. This recorder was installed on January 12 and removed on April 26, 1968. Figure 7 illustrates the installation of this unit.

The raw wastewater quality was determined by collecting samples every hour at an influent manhole before the treatment plant.

* Leupold-Stevens Type F Recorder



FLOW MEASUREMENT WEIR AND RECORDER

RAW SEWAGE SAMPLING LOCATION AND SAMPLER

FIGURE 7. CRYSTAL MOUNTAIN SURVEY EQUIPMENT

These samples were collected using an automatic sampler* and then composited porportionately with the flows measured by the recorder. See Figure 7 for an illustration of this sampler and the location of the sampling point.

The wastewater samples were put into an iced container and sent via bus to the Pacific Northwest Water Laboratory in Corvallis, Oregon for analysis. Analyses of unpreserved samples for BOD_5 occurred within a 24-hr period. Samples for COD analysis were preserved with concentrated sulfuric acid and samples for the nitrogen and phosphorous forms were preserved with mercuric chloride. A grab sample that was collected on January 12, transported on ice to the Pacific Northwest Water Laboratory and analyzed immediately and 24-hrs later for BOD_5 showed less than 10% difference in values.

Three surveys were made at the area from February 1-18, March 8-12, and April 26-29, 1968.

Data were collected on air temperature and influent sewage temperature from March 8 to March 14 using continuous recording thermometers**

Timberline Lodge

Total daily visitor attendance at the area was measured by a traffic counter installed and maintained by the Oregon State Highway Department.

* Servco Sampler

** Ryan Recording Thermometers

Overnight guests were recorded by the Timberline Lodge Management on a daily basis and submitted to the U. S. Forest Service on a monthly basis.

Wastewater flow from the area is continuously measured by a 22.5° V-notch weir at the sewage treatment plant. The plant operator reads a totalizer on the weir-stage recorder daily and submits this information on a monthly basis to the Oregon State Sanitary Authority. Copies of these monthly reports were provided by the U. S. Forest Service.

The raw wastewater quality of the area wastes was determined in a manner similar to that described for the Crystal Mountain Surveys. Figure 8 illustrates the samplers and location where these data were collected.

Bachelor Butte

Water use data were collected at the day lodge by reading the lodge water meter. This meter was read as often as possible by the lodge manager and the data then was given to the U. S. Forest Service Snow Ranger at the area.

Total daily visitor data were obtained from a traffic counter at the area. Data on overnight guests at the overnight lodge were provided by the lodge manager.

Data at this area were collected from the period December 15, 1967 through May 5, 1968.

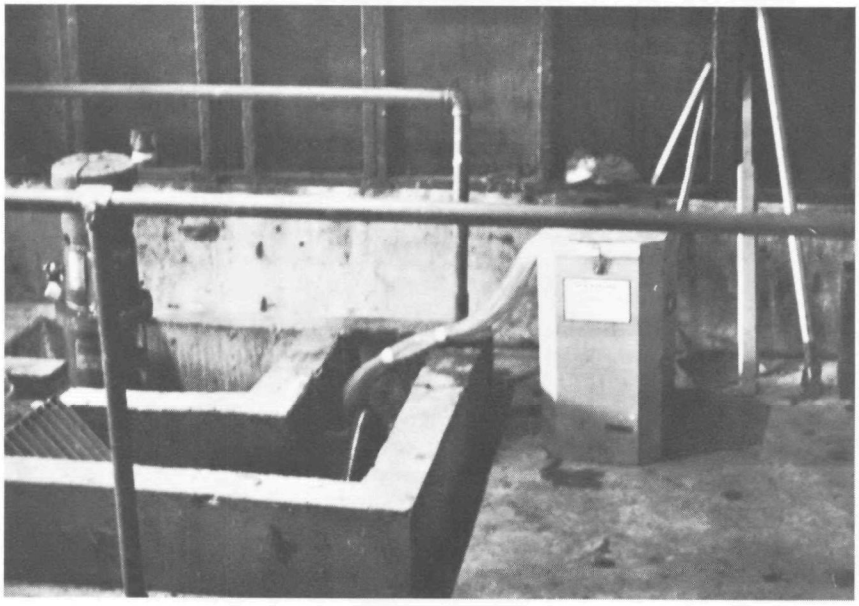


FIGURE 8 TIMBERLINE LODGE RAW SEWAGE SAMPLER AND LOCATION.

RESULTS

Waste Quantities

In order to measure consumptive water loss and to provide a basis for converting water use data collected to a reasonable value of wastewater flow, water used and waste discharged were measured at Crystal Mountain for the period 2/12-4/29/68. This comparison indicated that approximately 70% of the water used is returned as waste and that the relationship is linear or that the percentage returned is constant. Figure 9 shows this relationship. The data points, which fall well outside the relationship, are attributed primarily to infiltration which occurred as a result of heavy rainfall and warm weather during this period.

Day Lodge Water Use

The water use data obtained for the two day-lodges, Crystal Mountain and Bachelor Butte, indicate a linear relationship between water use and total daily visitors. These relationships together with the statistical significance of the per visitor use are summarized below:

TABLE 1: DAY LODGE WATER USE RELATIONSHIPS

Area	Relationship	Confidence Limits of Per Visitor Use,gpd 90%	95%	99%
Crystal Mountain	Q=3000+2.61 TV	2.22-2.99	2.15-3.07	1.99-3.23
Bachelor Butte	Q=1095+0.83 TV	0.62-1.04	0.58-1.08	0.50-1.16

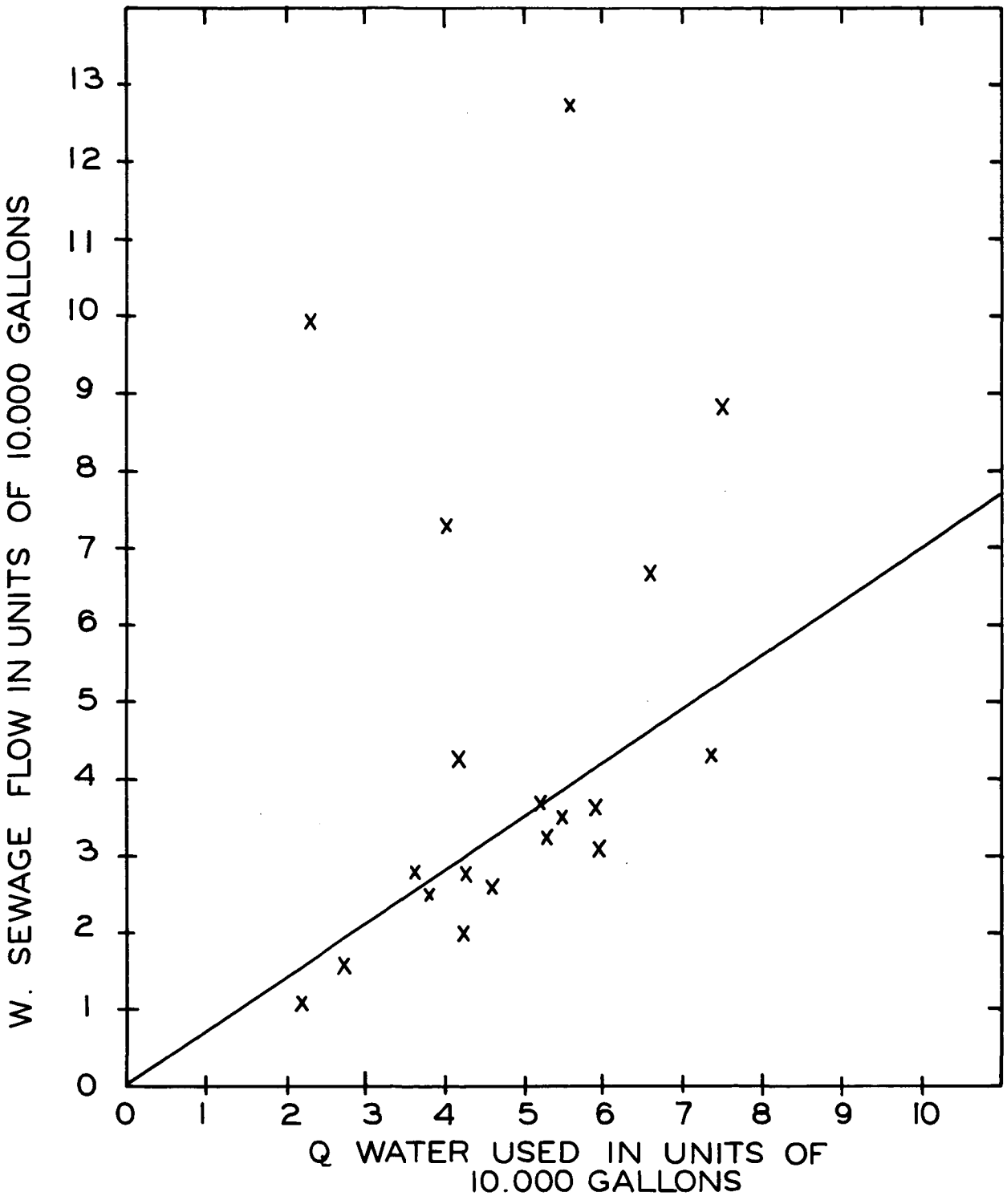


FIGURE 9. CRYSTAL MOUNTAIN WASTE FLOW VS WATER USE

Figure 10 illustrates the data collected and the computed relationships.

As can be seen, the mean per visitor use varies from 0.83 gpd for Bachelor Butte to 2.61 gpd for Crystal Mountain with "base use" at these areas 1095 and 3000 gpd respectively. This base use which has been defined previously includes the quantity of water required to run the establishment regardless of number of visitors and may include use for steam heating systems, automatic flush urinals, and employees use.

Overnight Lodges

The three overnight lodges studied indicated a highly variable per capita use per overnight guest that seemed to vary also with type of facility and size.

The Alpine Inn, which has complete overnight facilities with a restaurant and lounge, had the highest per guest and base water use of the three units studied with an average per guest use of 57 gpd and a base use of 3470 gpd. The 95% confidence limits of the per guest use varied from 41-72 gpd.

The Silver Skis Chalet, the next largest unit had a base use of 2100 gpd and a per guest use of 34 gpd. The per guest use of 34 gpd for this facility showed the least variation with a 95% confidence interval from 27-41 gpd.

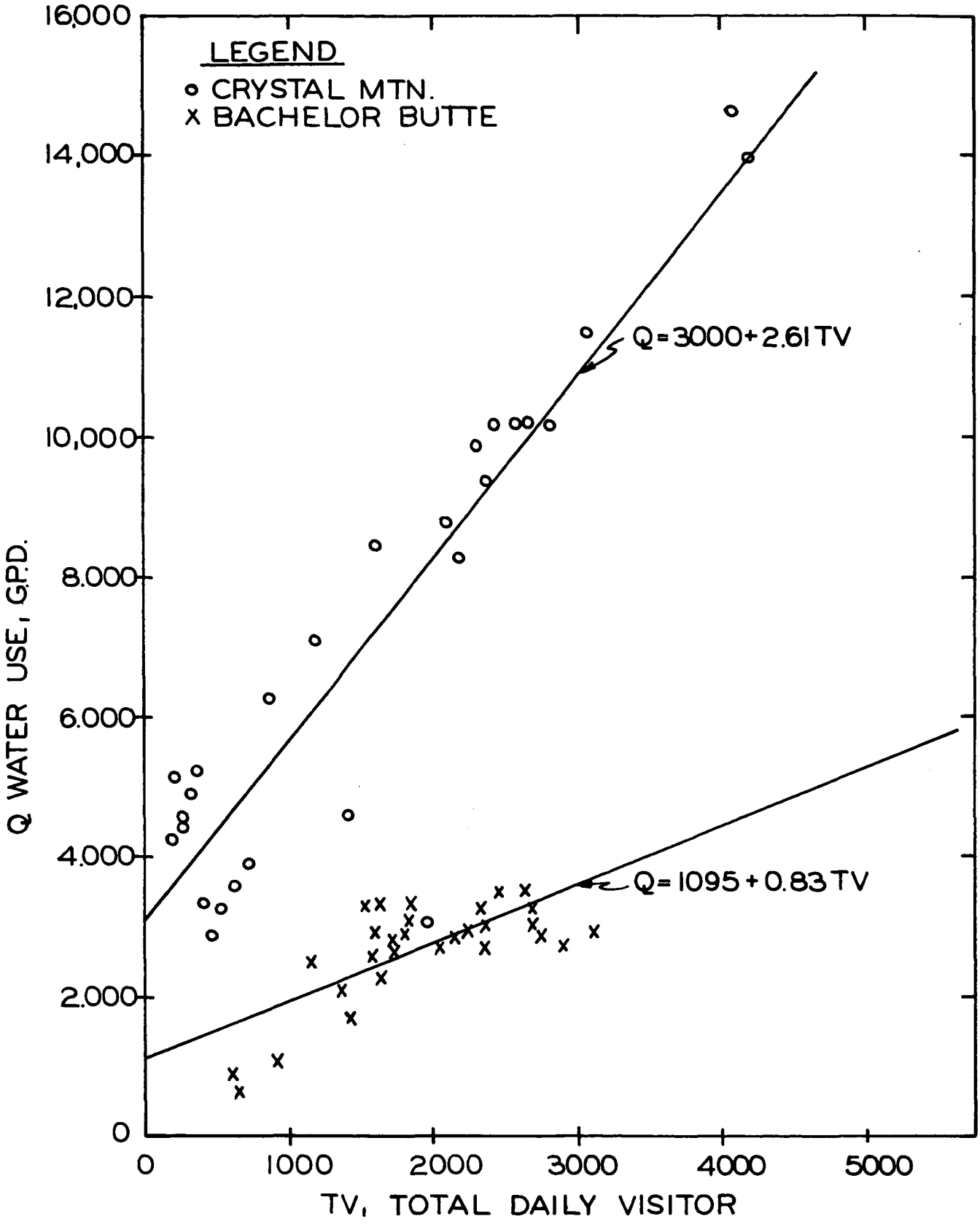


FIGURE: 10 DAY LODGE WATER USE

The Crystal House, the smallest unit, had the smallest base use and per guest use with 780 gpd and 17 gpd respectively. The 95% confidence limits of the guest use varied from 11-22 gpd.

These data and the computed relationships are shown in Figure 11.

The relationships together with the statistical significance of the per guest use are summarized below.

TABLE 2: OVERNIGHT LODGE WATER USE RELATIONSHIPS

Unit	Relationships	Confidence Limits of Per Guest Use, gpd 90%	95%	99%
Alpine Inn	Q=3470+57G	44-70	41-72	36-78
Silver Skis	Q=2100+34G	28-40	27-41	25-43
Crystal House	Q=780+17G	12-21	11-22	9-24

Combined Overnight-Day Lodge

The only combined overnight-day lodge studied was that at Timberline Lodge. Analysis of the data indicated a base flow of 4700 gpd, an average per visitor waste flow with 95% confidence limits of 1.0 gpd ($\pm$0.26) and an average per guest flow of 16 gpd ($\pm$9). However, based on the 70% wastewater to water use ratio, the average water use figures would be 1.4 and 23 gpd respectively for total visitor and overnight guests, which are in the same range as those reported previously for the day lodges and overnight lodges. The computed relationship, then, for water use at a combined overnight-day lodge is as follows:

$$Q = 6700 + 1.4 \pm 0.4(TV) + 23 \pm 13(G)$$

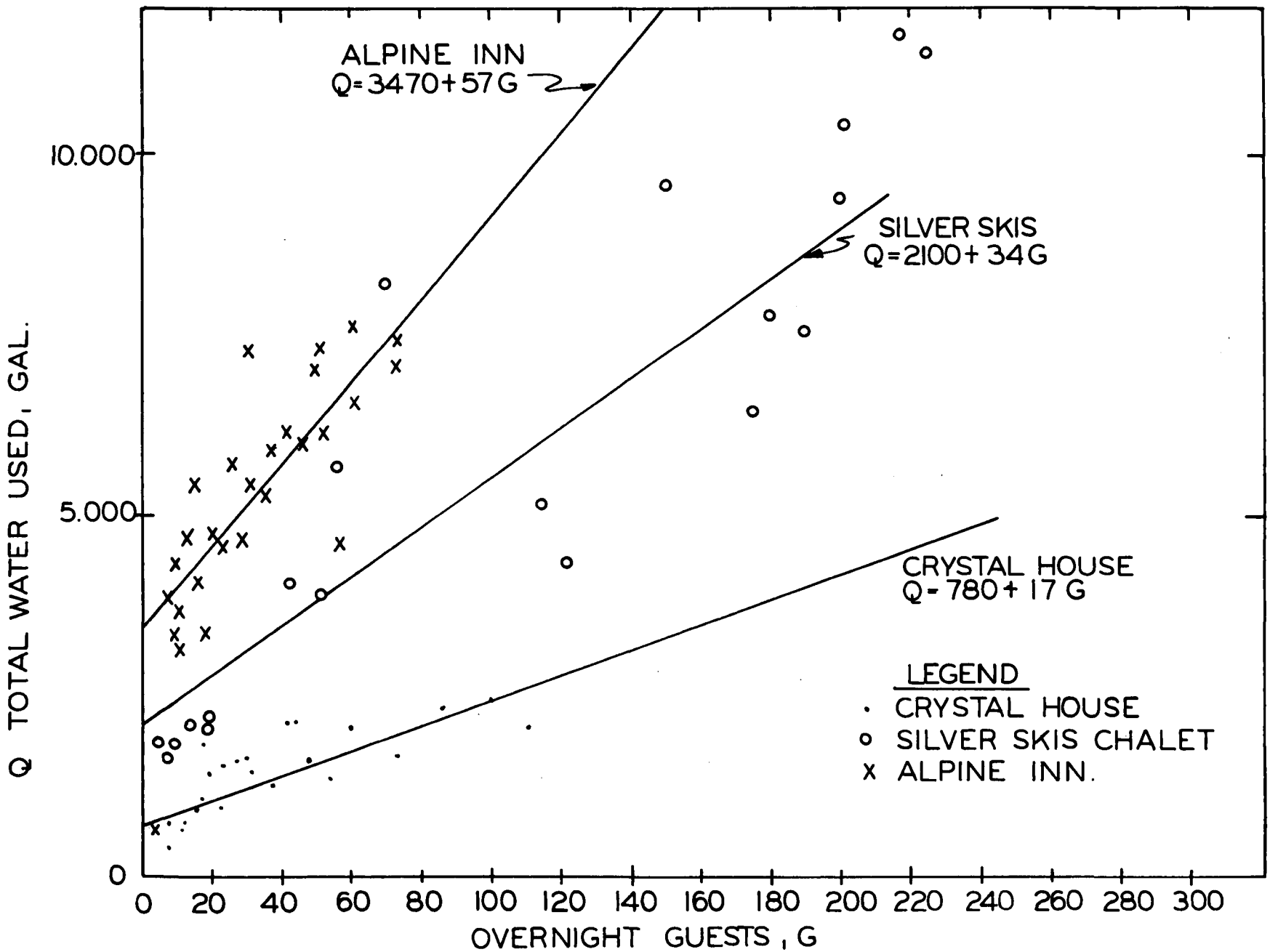


FIGURE 11. OVERNIGHT LODGE WATER USE

Sewage Flow Variations

The hourly, daily, and weekly sewage flow fluctuations were studied at both Crystal Mountain and Timberline Lodge. Pertinent ratios are reported for the 16-hour average, the maximum hour and the maximum peak in terms of the 24-hour average flows for both weekdays (Monday through Friday) and weekends (Saturday and Sunday).

The average ratio of 16-hour to 24-hour average flow for Timberline Lodge was 1.48 on weekdays with a range from 1.1 to 2.0. For weekends the average was lower at 1.28 with a range from 1.0 to 1.7.

The ratio of maximum hour to 24-hour average flow at Timberline Lodge was 4.2 on weekdays with a range from 1.1 to 9.5 and 3.1 on weekends with a range from 1.2 to 5.2.

The average ratio of 16-hour to 24-hour average flow at Crystal Mountain was essentially the same for both weekdays and weekends with values of 1.25 and 1.26 respectively. This ratio showed a range from 1.0 to 2.2.

The average ratio of peak flow to 24-hour average flow at Crystal Mountain was higher for weekdays than weekends, with values of 10.9 and 8.5 respectively. The range was from 3.0 to 30.0 for this ratio.

Table 3 summarizes these data.

Waste Quality

Data collected on the physical, chemical and organic strength of the wastewater from the two winter recreation areas studied,

Crystal Mountain and Timberline Lodge, are summarized in Table 4. Complete data are presented in the Appendix.

TABLE 3: SEWAGE FLOW VARIATIONS

Flow Ratio	Timberline Lodge	Crystal Mountain
Weekday		
16-hr ave.	1.48	1.25
Max. ave.	4.2 a/	10.9 b/
Weekend		
16-hr ave.	1.28	1.26
Max. ave.	3.1 a/	8.5 b/

a/ ratio is for maximum 1-hour average

b/ ratio based on maximum peak daily flow

Physical

Significant parameters studied in this category include temperature, pH and solids.

Temperature data, which is particularly significant if a biological treatment process is considered at the area, was studied at Crystal Mountain by installing continuous recording thermometers as previously described.

The results of this study, presented in Figure 12, indicate that the waste temperature runs approximately 5-7°C above the air temperature. For the first several days of this study, March 8 and

TABLE 4: AVERAGE RAW WASTEWATER QUALITY
FOR TIMBERLINE LODGE AND CRYSTAL MOUNTAIN SKI AREAS

Analysis	Area			
	Timberline Lodge		Crystal Mountain	
	Average	Standard Deviation	Average	Standard Deviation
BOD (Total) mg/l	395	126	382	170
BOD (Centrifuged) mg/l	250	-	88	-
COD mg/l	749	198	832	233
TS mg/l	657	-	785	-
TVS mg/l	426	-	562	-
SS mg/l	321	177	372	208
VSS mg/l	278	-	341	-
pH (field)	6.2	-	6.6	-
Alk mg/l	205	-	277	-
TPO_4 mg/l as P	12.7	2.4	13.2	6.6
OPO_4 mg/l as P	6.2	1.5	7.4	3.0
NH_3 mg/l as N	28.5	36.5	17.3	14.9
NO_2 mg/l as N	0.09	-	0.08	-
NO_3 mg/l as N	0.22	-	0.21	-
TKN mg/l as N	76.6	-	80.0	29.3
Cl mg/l	48.0	-	35.0	-
TH mg/l as $CaCO_3$	30.0	-	60.0	-

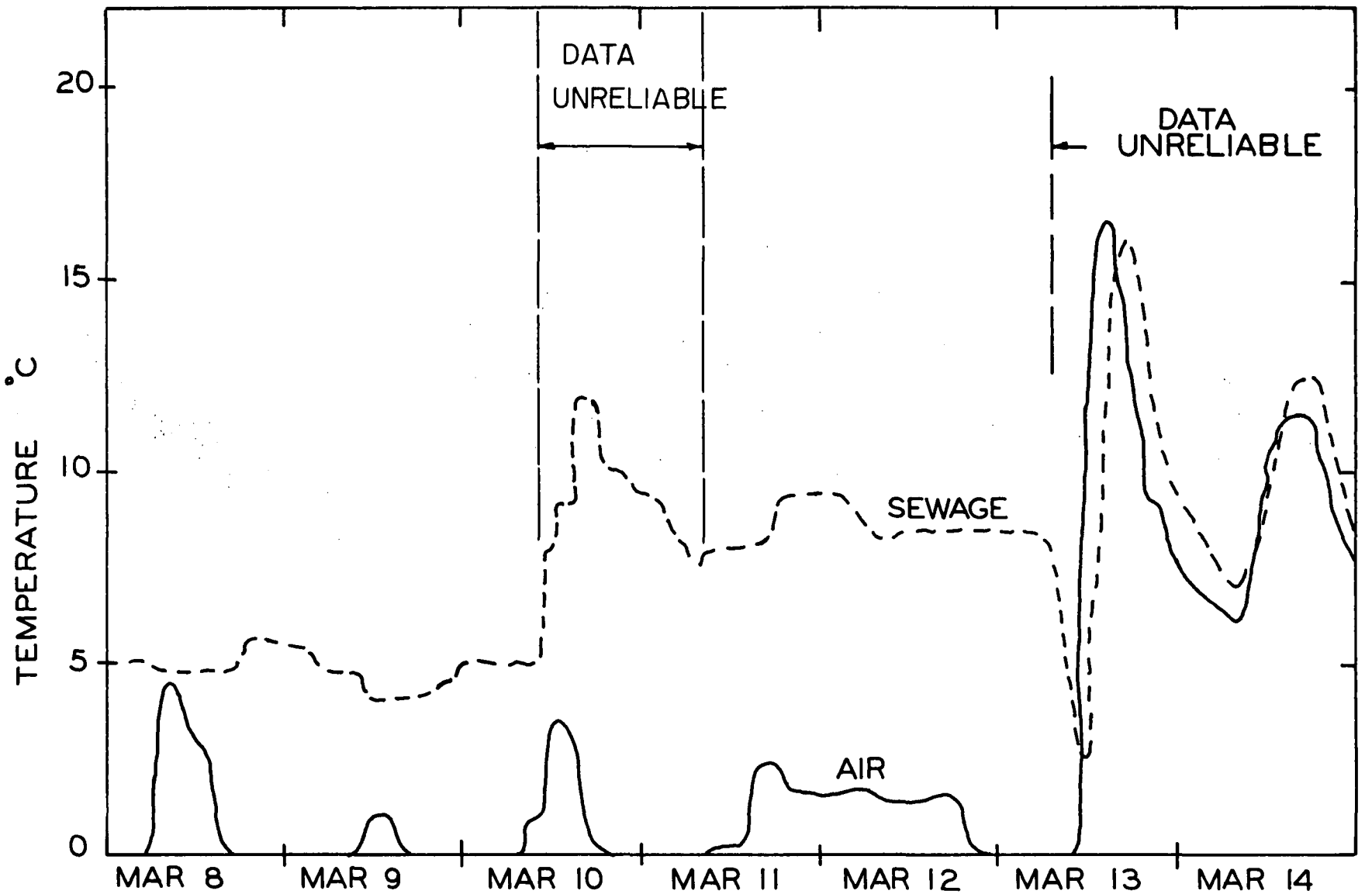


FIGURE 12. CRYSTAL MOUNTAIN AIR AND SEWAGE TEMPERATURES

9, the waste temperature held constant at approximately 5°C, regardless of air temperature. Then from March 10 through March 11 the waste tmperature varied almost consistently 6-7°C above the air temperature. Temperature was again constant from March 11-13, but then varied with air temperature from March 13-14. It is believed that data are unreliable for the periods of high variation.

It should be noted that the temperature relationships presented here are specific to the Crystal Mountain location and should serve only as a guide if applied to other areas. This is because of the physical characteristics of the sewerage system such as water tightness, depth, slope, etc. and the types and numbers of fixtures contributing to flow. All of these variables are specific to Crystal Mountain for the data presented.

The second parameter in this category is pH which is an approximate measure of the acidity or alkalinity of the waste.

The Crystal Mountain pH as measured in the field ranged from 6.1 to 7.0. For Timberline Lodge the range was from 5.5 to 7.3 For both areas, the laboratory analysis for pH gave a value approximately 10 percent greater than that obtained in the field. This is attributed to differences in analytical instruments and changes in transit from the field to the laboratory.

Solids are the third parameter in this group and include analytical determinations for total solids, total volatile solids, suspended solids and volatile suspended solids.

Total solids averaged 657 mg/l for Timberline Lodge and 785 mg/l for Crystal Mountain. The percent volatile matter was 88 and 94 percent respectively for the two areas.

Suspended solids averaged 321 and 372 mg/l for Timberline Lodge and Crystal Mountain respectively with corresponding standard deviations of 177 mg/l and 208 mg/l. The percent volatile matter was 87 percent for Timberline and 92 percent for Crystal Mountain.

Chemical

Included in this group are the parameters chemical oxygen demand, (COD), alkalinity (Alk), total and ortho phosphates (TPO_4 and OPO_4), chlorides (Cl), total hardness (TH), and ammonia, nitrite, nitrate and total kjeldahl nitrogen (NH_3, NO_2, NO_3 and TKN).

The average COD for Timberline Lodge was 749 mg/l with a standard deviation of 198 mg/l. For Crystal Mountain this average COD was 832 with a standard deviation of 233 mg/l.

The average alkalinity, total hardness and chlorides in the wastewaters at both Crystal Mountain and Timberline Lodge were similar and not much different than a normal domestic sewage.

Phosphate analyses for the two areas for total and ortho phosphates forms were very close to the same for both areas. Total phosphate analysis gave an average value of 12.7 and 13.2 mg/l for Timberline and Crystal respectively with respective standard deviations of 2.4 and 6.6 mg/l. Soluble or ortho phosphates were approximately 50-55 percent of the total phosphates.

Analysis for the nitrogen forms NH_3, NO_2, NO_3, and TKN, indicated that essentially all of the nitrogen in the wastewater is in the form of NH_3 and organic nitrogen which is typical of domestic wastewaters.

For Timberline Lodge the average TKN concentration, which measures NH_3 and organic nitrogen, was 76.6 mg/l. Approximately 37 percent or 28.5 mg/l was in the form of NH_3.

For Crystal Mountain the average TKN was 80.0 mg/l with a standard deviation of 29.3 mg/l. Approximately 22 percent or 17.3 mg/l was in the form of NH_3.

Biological

The only parameter studied in this category was the 5-day 20°C biological oxygen demand (BOD_5) which is a standard measure of the degradable organic strength of a wastewater. Average concentrations at the two areas studied were determined together with correlation between COD and total visitors and overnight guests. The soluble portion of the BOD_5 at Timberline was also determined for the first phase of the survey at this area.

The values reported here are most likely on the order of 10 percent low due to degradation during time of transit from the field to the laboratory. This figure was measured prior to surveys at each area as explained previously.

The average concentrations determined at both areas were very close to the same with an average value of 395 mg/l (standard deviation 126 mg/l) for Timberline Lodge and an average of 382 mg/l (standard deviation of 170 mg/l) for Crystal Mountain. Data collected

at Timberline indicated that approximately 63 percent of the total BOD_5 is soluble.

Correlation Analyses

Correlation analyses between total visitor use, overnight guests and the parameters suspended solids, COD, BOD_5, total kjeldahl nitrogen and total phosphate were made from the combination of data from Timberline Lodge and Crystal Mountain. These analyses were made using multiple linear regression analysis techniques and on the assumption that the data fit a linear relation of the form

$$y = a + b(TV) + C\ (G)$$

where

y = dependent variables SS, COD, BOD_5, TKN and TPO_4

a = base value constant

b = total visitor coefficient

TV = independent variable, total visitors

C = overnight guests coefficient

G = independent variable, overnight guests

The correlation equations for the 5 parameters studied are summarized in Table 5, together with the 95% confidence limits of the coefficient developed.

TABLE 5

SUMMARY OF CORRELATION ANALYSES

Parameter, lb/day	Base Value Constant lb/employee/day a/	Average lb/total visitor per day	95% Confidence Limits lb/total visitors/day	Average lb/overnight guest/day	95% Confidence Limits lb/overnight guest/day
Suspended Solids, SS	0.059	0.00031	± 0.01265	0.292	± 0.21
Chemical Oxygen Demand, COD	0.24	0.0168	± 0.0133	0.0844	± 0.23
Biochemical Oxygen Demand, BOD_5	0.17	0.0057	± 0.0078	0.041	± 0.132
Total Kjeldahl Nitrogen, TKN	-0.0473	0.0062	± 0.0105	0.0697	± 0.190
Total Phosphates TPO_4	0.00098	-0.00016	± 0.0007	0.0154	± 0.0116

a/= These values based on a total of 109 full-time employees contributing to base use at the areas studied.

$SS = 0.059\ E + 0.00031 \pm 0.01265(TV) + 0.292 \pm 0.21(G)$

$COD = 0.24\ E + 0.0168 \pm 0.0133(TV) + 0.0844 \pm 0.23(G)$

$BOD_5 = 0.17\ E + 0.0057 \pm 0.0078(TV) + 0.041 \pm 0.132(G)$

$TKN = -0.0473\ E + 0.0062 \pm 0.0105(TV) + 0.0697 \pm 0.190(G)$

$TPO_4 = 0.00098\ E + 0.0154 \pm 0.0116(G) - 0.00016 \pm 0.0007(TV)$

DISCUSSION

Consumptive Use

Consumptive water loss at the Crystal Mountain ski area was measured at 30 percent. This value seemed extremely high when considering normal consumptive uses such as for cleaning, culinary purposes and etc. However, the value may not be unreasonable if additional losses for heating system make-up water, and exfiltration losses in the sewerage system are considered.

Water Use

From the relationships developed for estimating water use at various winter sports area facilities, it is apparent that there are two primary factors involved: Base use and the per capita use of total visitors and/or overnight guests.

The base water use at the various lodges appears to be primarily a function of number of employees and number and type of water using fixtures as measured by fixture-units (f.u.). This is demonstrated by the consistency of the unit base flow values (gallons/employee/fixture-unit) as shown in Table 6. The range of these values is from 1.49 to 1.93 with differences easily accounted for by errors in estimating the number of fixture-units at the lodges. For this reason it is felt that an average value of the unit flows would be a more representative value rather than assuming that the value varies with type of lodge. The

average unit flow value is 1.73 and is used for all the lodges throughout the remainder of this report. The fact that this figure is apparently consistent for all the lodges regardless of type and location should permit the application of the relationships developed in this report to any winter recreation facility regardless of size or location, if a reasonable estimate can be made of the number of full-time employees and lodge fixture-units.

TABLE 6

CONVERSION OF BASE FLOW TO UNIT TERMS

Lodge	Full Time Employees E	Fixture Units f.u.	Base Flow gpd	Unit Base Flow gpd/E/f.u.
Timberline Lodge	15[a/]	300	6700	1.49
Crystal Day Lodge	13	150	3000	1.54
Bachelor Day Lodge	5	120	1095	1.83
Alpine Inn	8	225	3470	1.93
Silver Skis	3	380	2100	1.84
Crystal House	3	150	780	1.73

a/ Based on number of employees that stay overnight

Per capita water use per total visitor at the two day lodges varied from 0.83 gpd at Bachelor Butte to 2.61 gpd at Crystal Mountain. This variance is attributed to the fact that the Bachelor Butte area is principally a weekend sports area with a high percent of skiers in the total visitor use, whereas Crystal Mountain is

quite active 7 days a week with a much lower percent of skiers. Because of the wide difference in per capita water use and difference in type of area, it is felt that the figures from the two areas cannot be averaged into a figure representative of day lodges in general, but should be considered separately. The per capita water use per total visitor at Timberline Lodge was 1.4 gpd., or between that for Bachelor and Crystal. The area could also be considered as operating somewhere between the two.

There was considerable difference in the per capita use per overnight guest at the overnight lodges, with a range from 17 to 57 gpd. This difference is attributed to type of facility and type of guests that stay there. The Crystal House which had the lowest per guest use of 17 gpd is primarily a dormitory type facility with individual bathrooms for each room. It is reasoned that a younger aged population, young married couples or groups of young men or women would stay here. This group is more active and most likely spend considerable amount of a day's time away from their rooms, thereby giving a low per capita water use. The Silver Skis Chalet on the other hand has complete apartments with kitchen facilities and is more suited to accommodate full families, where perhaps the wife or children may not ski. It is presumed, then, that this segment of the population would probably spend more time in their rooms than the younger type which may stay at the Crystal House and,therefore,use more water. The Alpine Inn which had the

highest per capita use has dormitory type and family type accommodations which would be expected to give a use somewhere between that for Crystal House and Silver Skis Chalet. However, the lounge and restaurant, which serves guests other than those staying at the Alpine Inn, would be expected to raise the per capita use, as is the case. Per capita use per overnight guest at Timberline Lodge was calculated as 23 gpd which is higher than the dormitory type lodge but lower than the condominium type.

Sewage Flow Variations

The sewage flow variations at Crystal Mountain and Timberline Lodge are very similar to those of small communities with 16-hour average to 24-hour average flow ratios of 1.25 to 1.5 and maximum ratios of 3.1 to 10.9 for hourly and peak flows to 24-hour averages. While these values are not unusually high, it should be noted that the extreme range of these variations is quite high with peak flows being as high as 30 times the average daily and the 16-hour average being as high as 2 times the average daily. A more extreme variation in flows on weekdays was noted but is not considered unusual because of the lower use during this period when extremes would be more noticeable.

Wastewater Quality

The quality of the wastewaters discharged at both the Timberline and Crystal ski areas showed little significant variation in the

average values of the data collected and were quite similar to a strong municipal sewage in terms of BOD_5, COD, SS and nutrients.

The statistical correlation analyses between the various waste parameters and use indicated relationships dependent on full-time employees, overnight guests and total visitors. As was expected, the relationships developed were linear, quite variable, and indicated that the contribution from an overnight guest or a full-time employee is considerably greater than that from daily visitor. The relationships also indicated that the per capita contributions of BOD_5 and COD from full-time employees are essentially the same as those from a normal residential population.

The total kjeldahl (TKN) relationship, which gave a negative value for full-time employees, is obviously unreliable. This is attributed to the fact that there were insufficient data available to properly define the relationship (approximately 1/2 the number of data used in developing the other relations).

The total phosphate (TPO_4) relationship also gave a negative coefficient but for total visitors in this case. The fact that the average value is negative is attributed primarily to a lack of sufficient data to adequately define the average value of the total visitor coefficient, but also due to the relative insignificance of the total visitor contribution of TPO_4 as compared to overnight guests. However, the fact that the 95% confidence limit of the total visitor coefficient does have a positive figure, and in

actuality could probably range from near zero to 0.00054 lb/day would seem to indicate that perhaps the relationship may have some application. The weak relationship of the total visitor coefficient is not unusual when considering the expected sources of TPO_4 in the wastewater. It was found that the TPO_4 is principally in the soluble orthophosphate form which comes principally from phosphate base detergents and soaps. Since the total visitor would have little reason to use soaps while at a ski area, it is not unusual to see a very low per capita contribution of TPO_4 from total visitors.

DESIGN RECOMMENDATIONS

It is felt that the data presented in this report will support recommendations for design values of wastewater flows from various types of facilities at winter sports areas and for the organic and nutrient strength of these wastewaters. It is recognized that there may be circumstances where the recommendation of this report does not apply. However, this is left up to the judgement of the design engineer.

Design Flow

It is the recommendation of this report that the upper limit of the 95% confidence interval for all of the relationships developed be used when considering the selection of a loading value. The selection of this confidence interval is based on the low stream flow criteria recommended in the Federal Water Pollution Control's Guidelines issued as an aid to the States in their development of water quality standards. This guide suggests the use of the 10-day low flow with a recurrence interval of 25 years. This offers protection approximately 96 percent of the time.

It is also recommended that average wastewater flows calculated from water use should be adjusted for a consumptive loss. While the consumptive loss measured in this study was 30 percent there is not sufficient data to recommend that this percentage be used for all areas.

On the basis of the results from the flow study at the two day lodges, Crystal Mountain and Bachelor Butte, it appears necessary to characterize day lodges by two types: Type I as a resort type with 7-day a week operation and Type II, the weekend type with primarily weekend use only. For estimating the daily water use in gallons per day from day lodges, the following relationships are recommended:

Type I: $Q = 1.73\ (E)(f.u.) + 3.07(TV)$

Type II: $Q = 1.73\ (E)(f.u.) + 1.08(TV)$

where

Q = water use, gallons per day

E = number of full-time employees

f.u. = number of lodge fixture-units

TV = total visitors to area that day

Since there are also various types of overnight lodges with per capita water use varying by type, overnight lodges have been classed as follows:

Type I: Dormitory type with no cooking facilities (Crystal House).

Type II: Condominium type with full kitchens and bathroom facilities (Silver Skis Chalet).

Type III: Dormitory type with attached restaurant and lounge (Alpine Inn).

The following relations are recommended for estimating water use from these three types of overnight lodges:

Type I: $Q = 1.73\ (E)(f.u.) + 22(G)$

Type II: $Q = 1.73\ (E)(f.u.) + 41(G)$

Type III: $Q = 1.73\ (E)(f.u.) + 72(G)$

The third type of lodge studied during this survey was the combined day-overnight lodge at the Timberline Lodge ski area. Since the water use at this type of lodge is affected by both total visitor and overnight guests, both of these parameters are included as independent variables in the relation.

Combined Overnight-Day Lodge

$$Q = 1.73(E)(f.u.) + 1.8(TV) + 36(G)$$

The peak daily flow is also an important parameter in sizing secondary clarifier overflow rates to insure against the carryover of biological solids. Since the data for this parameter was obtained from only one system and it is known that peak flow varies with size, the use of the figure should be limited to areas of similar size. The figure recommended for the peak design flow rate is 10 times the average 24-hour daily average as computed from the previously given relationships.

Design Organic Loading

In a secondary biological treatment system the organic loading in terms of ultimate BOD (estimated by COD) or five-day BOD is of primary importance in sizing lagoons, aeration tank volumes, aerator capacities, and final clarifiers. The following relations are recommended for use in estimating the organic loading from a combined system at a winter sports area:

$$\text{Ultimate BOD(COD)} = 0.24\ (E) + 0.03(TV) + 0.31(G)$$

or

$$BOD_5 = 0.17\ (E) + 0.0135(TV) + 0.173(G)$$

Design Solids Loading

Suspended solids are a significant design parameter of a treatment system as they directly affect the quantity of solids that must be disposed of, through settling in a septic tank, primary settler, or in a lagoon.

The following relationship is recommended for use in estimating the total suspended solids in wastewater from a winter sports area:

$$SS\ (lb/day) = 0.059\ (E) + 0.013(TV) + 0.29(G)$$

It will be noted that the average per capita value for the contribution from overnight guests of 0.29 lb/day is used rather than the maximum value of the 95% confidence limit, which would be 0.503 lb/day. This is done because it is felt that a value as high as the 0.503 lb/day is unreasonably high on the basis of values reported in the literature.

To provide the reader with a better understanding in the use of the recommended relationships presented in this report, an example of how they may be applied is given as follows:

Design Example

Assume a winter sports area that has a Type I day lodge (7-day a week operation) with 15 full-time employees and 150 fixture-units and a Type III overnight lodge with 5 employees and 200 fixture-

units. Assume also that the projected maximum use at the area for design purposes is 10,000 daily total visitors and 200 overnight guests. Assume also a 30% consumptive loss of water.

Design Flow:

Type I Day Lodge $Q = (1.73)(E)(f.u.) + 3.07(TV)$

$Q = (1.73)(15)(150) + (3.07)(10,000)$

$Q - 3900 + 30,700$

$Q = 34,600$ gpd

Type III Overnight Lodge $Q = (1.73)(E)(f.u.) + 72(G)$

$Q = (1.73)(5)(200) + 72 \times 200$

$Q = 1730 + 14,400$

$Q = 16,130$ gpd

Design Waste Flow $W = 50,730 \times 0.7 = 35,500$ gpd

Design Organic Load:

BOD_5 (lb/day) $= 0.17(E) + 0.0135(TV) + 0.173(G)$

$= (0.17)(20) + 0.0135(10,000) + 0.173 \times 200$

$= 3.4 + 135 + 34.6$

$= 173$ lb/day

BOD_5 Concentration $= 173/8.34 \times 0.0355 = 585$ mg/l

Design Solids Load:

SS (lb/day) $= 0.059(E) + 0.013(TV) + 0.29(G)$

$= (0.059)(20) + (0.013)(10,000) + (0.29)(200)$

$= 1.2 + 130 + 58$

$= 189.2$ lb/day

SS Concentration $= 189.2/8.34 \times 0.0355 = 640$ mg/l

APPENDIX

TABLE A-1: CRYSTAL MOUNTAIN
VISITOR AND GUEST DATA

Period	Area Total Vis.	Day Lodge Skiers	Alpine Inn G	Silver Ski G	Crystal H. G
1/12-15	7119	3943	132	66	219
1/15-19	1473	552	32	78	39
1/19-22	1473	552	110	870	162
1/22-26	7810	4447	54	75	147
1/26-29	12287	8733	151	900	258
1/29-2/2	1869	1361	42	486	78
2/2-2/5	7343	5091	155	601	144
2/5-2/9	2212	1595	76	75	90
2/12	12426	9251	155	600	333
2/16	2544	1705	64	210	126
2/19	7842	5135	220	675	180
2/23	3150	2059	117	150	78
2/26	7607	5967	124	600	50
3/1	1640	798	31	57	22
3/4	6311	4538	77	630	70
3/8	1327	491	59	167	68
3/11	9237	5396	218	650	131
3/15	1450	926	94	55	65
3/15-3/18	7794	4567	184	540	91
3/22	3443	2373	80	25	48

TABLE A-1: CRYSTAL MOUNTAIN
VISITOR AND GUEST DATA (CONT.)

Period	Area Total Vis.	Day Lodge Skiers	Alpine Inn G	Silver Ski G	Crystal H. G
3/25	6797	5085	92	510	88
3/29	1106	723	44	31	29
4/1	7941	5547	108	525	61
4/5	876	688	37	36	43
4/8	4762	3712	138	450	80
4/12	4722	4166	229	175	166
4/15	6661	4660	177	210	65
4/19	801	668	24	19	32
4/22	5671	3713	93	168	47
4/26	254	143	16	8	12

TABLE A-2: CRYSTAL MOUNTAIN WATER USE, GAL.

Period	Day Lodge	Alpine	Crystal H.	Silver Skis
1/12-15	28,000	NA	5,000	24,700
1/15-19	12,900	15,250	2,550	9,000
1/19-22	22,300	17,850	4,050	22,700
1/22-26	12,150	18,750	4,950	8,630
1/26-29	44,000	21,000	7,050	35,000
1/29-2/1	11,550	14,600	3,450	17,450
2/2-5	30,400	18,450	4,800	18,800
2/5-9	12,800	13,500	3,740	8,250
2/9-12	41,800	22,100	6,300	28,200
2/12-16	14,350	16,150	5,910	15,750
2/16-19	30,100	21,200	6,200	34,200
2/19-23	15,350	18,700	5,690	20,600
2/23-26	28,900	18,350	5,540	31,300
2/26-3/1	13,250	17,350	2,020	8,400
3/1-4	26,300	17,150	4,640	24,900
3/4-8	19,750	21,800	4,340	16,200
3/7-8	6,570	-	1,400	5,900
3/8-9	11,550	-	2,780	13,700
3/9-10	14,350	-	2,830	13,720
3/10-11	7,620	-	1,065	7,130

TABLE A-2: CRYSTAL MOUNTAIN WATER USE, GAL.
(CONT.)

Period	Day Lodge	Alpine	Crystal H.	Silver Skis
3/11-12	4,330	-	635	4,320
3/12-13	4,360	-	765	4,230
3/8-11	34,500	22,400	6,360	34,900
3/11-15	20,800	18,350	3,440	17,800
3/15-18	30,600	19,700	5,010	23,400
3/18-22	25,200	18,950	3,000	14,550
3/25-29	18,200	12,550	2,920	6,740
3/29-4/1	30,600	15,900	3,440	19,350
4/1-5	16,850	13,500	2,470	7,250
4/5-8	25,200	18,000	4,800	29,600
4/8-12	28,100	18,550	8,450	38,100
4/12-15	24,800	22,900	3,300	24,500
4/15-18	13,400	13,100	1,570	7,420
4/18-22	18,350	21,900	2,700	17,000
4/22-26	4,800	2,510	600	15,100
4/26-29	13,920	-	2,510	30,400
4/27-28	5,600	-	1,445	-
4/28-29	4,490	-	580	4,450

TABLE A-3: BACHELOR BUTTE WATER USE

Day Lodge		Area	
Meter Reading	Use Gal.	Total Visitors	Skiers
25,500	-	302	249
25,600	100	531	445
26,100	500	1,858	1,559
29,300	3,200	-	-
31,000	1,700	1,425	1,193
-	-	160	132
-	-	221	182
-	-	299	246
31,400	400	251	207
31,500	100	166	137
31,700	200	1,581	1,319
34,300	2,600	1,802	1,484
-	-	115	95
-	-	132	109
-	-	146	120
37,500	3,200	92	76
37,600	100	477	400
37,700	100	1,813	1,514
40,500	2,800	1,860	1,543
-	-	208	171
-	-	180	148

TABLE A-3: BACHELOR BUTTE WATER USE

Day Lodge		Area	
Meter Reading	Use Gal.	Total Visitors	Skiers
-	-	330	272
-	-	537	442
44,200	3,700	401	330
44,300	100	2,354	1,960
46,800	2,500	2,383	1,963
-	-	319	263
-	-	302	249
-	-	364	300
49,800	3,000	673	554
-	-	670	552
50,200	400	2,378	1,974
52,800	2,600	2,373	1,954
55,400	2,600	667	549
-	-	625	515
-	-	374	308
-	-	684	563
55,600	200	775	638
59,100	3,500	2,651	2,212
-	-	2,907	2,405
61,800	2,700	191	157
-	-	296	244

TABLE A-3: BACHELOR BUTTE WATER USE

Day Lodge		Area	
Meter Reading	Use Gal.	Total Visitors	Skiers
-	-	310	255
-	-	656	540
-	-	969	798
-	-	1,986	1,647
-	-	2,390	227
-	-	276	174
-	-	211	199
-	-	242	210
62,000	200	255	179
64,700	2,700	2,051	1,710
-	-	2,389	1,973
67,700	3,000	231	190
-	-	216	260
-	-	389	238
-	-	245	202
67,800	100	366	307
71,300	3,500	2,450	2,062
-	-	3,114	2,570
74,200	2,900	1,768	1,456
77,000	2,800	1,529	1,268
80,300	3,300	1,814	1,513

TABLE A-3: BACHELOR BUTTE WATER USE

Day Lodge		Area	
Meter Reading	Use Gal.	Total Visitors	Skiers
83,400	3,100	1,623	1,343
86,700	3,300	1,718	1,421
90,300	3,600	2,972	2,459
94,600	4,300	3,218	2,656
		738	608
99,100	4,500	520	428
100,400	1,300	656	540
101,100	700	931	767
102,200	1,100	622	512
103,100	900	2,690	2,220
106,390	3,290	2,336	1,924
109,660	3,260	310	255
-	-	248	204
-	-	197	162
-	-	360	302
-	-	378	311
110,090	430	2,754	2,284
113,000	2,910	2,696	2,220
116,000	3,000	166	137
-	-	146	120
-	-	194	160

TABLE A-3: BACHELOR BUTTE WATER USE

Day Lodge		Area	
Meter Reading	Use Gal.	Total Visitors	Skiers
-	-	183	151
116,200	200	231	190
119,100	2,900	2,166	1,784
-	-	1,721	1,417
121,800	2,700	85	70
-	-	129	106
-	-	177	146
-	-	160	132
-	-	191	157
122,000	200	1,649	1,358
124,300	2,300	1,353	1,114
126,400	2,100	106	87
-	-	163	134
-	-	153	126
-	-	234	193
-	-	157	129
126,600	200	1,146	944
129,100	2,500	1,591	1,310
132,000	2,900	-	-
132,200	200	1,173	966
135,600	3,400	1,387	1,142

TABLE A-3: BACHELOR BUTTE WATER USE

Day Lodge		Area	
Meter Reading	Use Gal.	Total Visitors	Skiers
137,100	1,500	408	336
138,600	1,500	319	263

TABLE A-4: Crystal Mountain Raw Sewage

Analysis	2/10	2/11	2/12	2/13	2/14	2/16	2/17	2/18	2/19	3/8	3/9	3/10	3/11	4/26	4/27	4/28	4/29	Ave
BOD		335	350	188	255		500	640	520	230	333	330	490	183	198	450	740	382
COD		1081	1314	514	652	833	838	1380	1002	-	-	710	-	310	337	680	1270	832
TS		736	960	740	688	740	900	1300	1090	624	420	1000	340	504	528	848	1160	785
TVS		520	608	560	500	472	612	952	800	480	290	800	172	364	328	624	896	562
SS		340	456	300	310	360	450	860	168	260	136	540	192	168	296	340	780	372
TVSS		300	408	280	310	312	390	780	160	196	120	490	180	164	260	340	780	341
Lab pH		8.0	8.2	7.8	-	7.4	7.6	7.0	7.4	6.9	7.2	7.5	8.1	6.7	7	7.8	7.7	7.5
Alkalinity		350	392	191	235	378	334	307	370	162	167	248	270	167	208	347	283	277
TPO_4 as P		11.4	11.8	8.1	20.7	14.4	19.5	28.9	18.2	6.4	4.5	14.1	6.6	5.1	9.5	13.5	17.3	13.2
OPO_4		7.6	7.2	5.8	5.9	9.0	12.1	11.3	10.6	3.8	3.1	5.8	4.3	3.5	6.5	8.8	11.6	7.4
NH_3 as N		11.5	14.5	59.4	-		-	0.5	31.4	8.7	8.9	13.7	14.1	8.2	14.6	15.5	23.4	17.3
NO_3 as N		0.33	0.29	0.35	0.36		0.29	0.37	<0.05	0.1	0.1	0.07	0.11	0.2	0.32	0.3	0.07	.21
NO_2 as N		0.07	0.09	0.09	0.03		0.05	0.04	0.04	0.05	0.11	0.12	0.04	0.06	0.1	0.13	0.21	0.08
TKN as N		112	103	60.0	72		83	94	114.4	40.5	54.1	70.3	51.3	42	59	126	118	80.0
Cl		4		23	35	3	67		86	26	34	30	36	16	25	48	47	35
TH		47	50	42	47	48	77	82	86									60
CaH																		
Color		100	60	75		75	100	-	150	75	40	300	100	175	100	200	400	140
Hours in Composite		19	24	20	17	19	23	22	21	20	20	20	24	19	20	24	19	
Flow gpd	14,700	32,900	14,350	6,020	5,660	9,840	26,600	17,100	5,805	19,100	47,000	24,000	17,400	2,590	5,590	11,610	9,090	14,916
Field pH		6.3	6.1	6.6	6.7	6.5	6.7	6.2	6.4	6.9	6.7	6.7	6.8	7.0	6.6	6.7	6.9	6.6

Note: All values in mg/l except pH, Color, and Flow (gpd)

TABLE A-5: DAY LODGE DATA

Crystal Mountain		Bachelor Butte	
Water Use gpd	Visitors	Water Use gpd	Visitors
9,350	2,370	3,200	1,858
5,030	210	1,700	1,425
3,040	1,952	2,600	1,581
14,667	4,096	2,800	1,802
2,887	467	2,800	1,813
10,130	2,444	3,300	1,860
3,200	553	2,500	2,354
13,850	4,142	2,700	2,383
3,590	636	2,600	2,378
10,060	2,814	2,600	2,373
3,840	788	3,500	2,651
9,630	2,540	2,700	2,907
3,310	410	2,700	2,051
8,767	2,104	3,000	2,389
4,937	332	3,500	2,450
11,500	3,080	2,900	3,114
5,200	362	2,800	1,768
10,200	2,598	3,300	1,529
6,300	861	3,100	1,814
9,867	2,266	3,300	1,623
4,550	277	3,600	1,718

TABLE A-5: DAY LODGE DATA
(CONT.)

Crystal Mountain		Bachelor Butte	
Water Use	Visitors	Water Use	Visitors
gpd		gpd	
10,200	2,647	4,300	2,972
4,210	219	4,500	3,956
8,400	1,587	1,300	520
7,025	1,180	700	656
8,260	2,220	1,100	931
4,460	267	900	622
4,580	1,415	3,290	2,690
-	-	3,260	2,336
-	-	2,910	2,754
-	-	3,000	2,696
-	-	2,900	2,166
-	-	2,700	1,721
-	-	2,300	1,649
-	-	2,100	1,353
-	-	2,500	1,146
-	-	2,900	1,591

TABLE A-6: OVERNIGHT LODGE DATA

Alpine Inn		Silver Skis		Crystal House	
Water Use gpd	Guests	Water Use gpd	Guests	Water Use gpd	Guests
3,810	8	2,250	20	1,667	73
5,950	37	7,560	190	637	10
4,700	14	2,160	19	1,350	54
7,000	50	11,670	300	1,237	37
3,650	10	4,360	122	2,350	86
6,150	52	6,270	201	862	20
3,370	19	2,060	19	1,000	48
7,360	52	9,400	200	935	22
4,040	16	3,940	52	2,100	111
7,100	73	11,400	225	1,480	32
4,670	29	5,150	115	2,067	60
6,120	41	10,430	200	1,422	20
4,340	8	2,100	14	1,846	17
5,720	26	8,300	210	505	6
5,450	15	4,050	42	1,546	23
7,460	73	11,630	217	1,085	17
4,600	24	4,600	52	2,120	44
6,600	61	7,800	180	860	16
4,750	20	7,230	170	1,670	30
5,400	31	1,685	8	750	12
3,150	11	6,450	175	1,273	29

TABLE A-6: OVERNIGHT LODGE DATA
(CONT.)

Alpine Inn		Silver Skis		Crystal House	
Water Use gpd	Guests	Water Use gpd	Guests	Water Use gpd	Guests
5,300	36	1,813	9	730	7
3,370	9	9,530	150	1,146	20
6,000	46	8,170	70	617	11
4,640	57	1,870	5	1,600	27
7,630	59	5,660	56	2,113	42
3,270	6	-	-	1,100	22
7,300	31	-	-	392	8
-	-	-	-	900	16

TABLE A-7: TIMBERLINE LODGE SEWAGE FLOWS, gpd

	Month							
Date	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1	-	3,800	14,000	10,200	14,200	6,400	4,400	5,800
2	-	6,200	6,600	-	14,000	6,400	5,200	6,000
3	-	9,800	4,600	6,600	14,400	7,000	5,200	3,400
4	-	5,208	4,600	14,000	8,200	6,600	9,200	3,400
5	-	3,792	4,000	6,200	5,800	5,600	10,000	4,000
6	-	3,640	9,000	7,600	5,600	9,000	4,000	4,200
7	4,000	3,200	10,000	5,200	4,400	10,000	4,600	6,600
8	2,000	3,360	15,800	5,200	4,600	4,000	3,600	6,600
9	3,000	9,800	4,200	6,600	10,200	4,000	5,200	5,600
10	3,600	8,400	6,400	14,600	11,800	10,800	4,800	4,200
11	4,840	5,660	23,800	13,600	6,000	10,200	12,000	4,000
12	8,160	9,880	3,600	6,200	9,200	21,000	7,000	4,000
13	3,240	5,620	12,400	6,200	7,800	9,800	6,400	8,200

TABLE A-7: TIMBERLINE LODGE SEWAGE FLOWS, gpd (CONT.)

	Month							
Date	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
14	2,580	3,500	1,800	6,200	8,800	12,800	3,600	6,200
15	2,000	3,600	10,000	4,800	7,000	8,800	4,000	10,200
16	2,010	7,480	44,000	4,200	9,200	8,800	3,600	13,000
17	2,010	9,702	4,200	8,600	12,200	7,700	4,200	8,400
18	5,560	10,010	4,600	12,400	5,620	8,200	9,600	8,000
19	6,020	5,400	4,200	5,000	7,180	6,000	15,400	4,200
20	4,400	6,400	12,400	5,400	6,200	6,200	15,000	15,600
21	3,980	5,080	12,600	6,000	6,600	10,000	2,600	8,000
22	4,640	5,440	7,000	12,400	5,400	7,000	5,100	8,200
23	5,100	8,040	4,800	13,000	17,800	5,600	5,100	11,000
24	5,420	7,200	5,400	19,000	10,600	5,000	7,000	9,000
25	8,800	13,400	6,200	17,600	5,400	5,800	6,600	5,800
26	14,320	14,000	4,800	12,000	4,200	4,000	5,400	6,600

TABLE A-7: TIMBERLINE LODGE SEWAGE FLOWS, gpd (CONT.)

	Month							
Date	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
27	6,040	11,800	13,400	10,000	3,800	10,200	6,000	6,800
28	9,280	10,800	14,200	10,200	4,000	13,800	3,200	6,800
29	3,400	11,800	6,200	9,000	4,400	10,000	4,800	7,400
30	3,600	10,000	5,200	-	11,200	9,400	5,800	8,600
31	-	12,400	5,400	-	13,000	-	5,200	-

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE

Date	Total Visitors	Total Skiers	Overnight Guests
Dec. 1	830	78	36
2	3,536	786	107
3	4,308	1,047	24
4	522	45	17
5	553	54	22
6	700	117	11
7	641	133	14
8	774	172	46
9	4,064	414	147
10	5,380	664	77
11	641	81	78
12	1,113	145	72
13	959	158	57
14	1,059	174	76
15	819	254	60
16	2,428	518	56
17	4,112	1,107	97
18	935	287	80
19	924	388	93
20	784	242	66
21	725	226	76

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE
(CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
Dec.			
22	1,424	118	78
23	2,800	601	141
24	3,048	510	171
25	2,576	95	128
26	3,064	668	169
27	4,972	841	180
28	5,200	1,272	172
29	4,636	1,393	175
30	6,476	1,616	169
31	-	1,257	170
Jan 1	-	614	75
2	-	215	57
3	-	173	45
4	784	223	43
5	553	109	51
6	4,960	1,571	144
7	4,152	1,358	15
8	529	62	24
9	581	80	23
10	588	119	36
11	676	162	30

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE (CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
Jan.			
12	375	93	57
13	5,480	1,127	137
14	6,004	715	28
15	483	50	32
16	497	102	31
17	609	90	31
18	746	181	39
19	1,040	107	164
20	5,800	970	188
21	4,128	1,151	55
22	952	327	42
23	816	130	39
24	679	75	37
25	616	132	79
26	651	170	120
27	4,740	1,424	145
28	4,568	1,292	41
29	522	101	25
30	735	224	35
31	434	44	39

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE
(CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
Feb 1	595	147	40
2	763	75	77
3	4,960	1,012	154
4	5,620	1,135	50
5	945	265	55
6	1,183	417	35
7	833	187	34
8	1,001	235	39
9	1,103	222	117
10	6,756	1,081	159
11	9,080	1,370	71
12	1,082	0	53
13	819	43	42
14	917	128	46
15	864	134	31
16	840	120	75
17	4,048	857	145
18	5,760	718	22
19	434	0	25
20	536	40	26
21	525	60	72

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE
(CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
Feb.			
22	2,560	256	170
23	823	240	189
24	6,716	1,614	185
25	8,024	1,506	63
26	816	128	55
27	1,582	167	50
28	917	151	44
29	945	220	53
March			
1	732	109	119
2	7,620	1,453	177
3	6,680	1,220	88
4	515	94	86
5	511	107	78
6	935	185	62
7	606	158	60
8	742	137	137
9	5,140	1,277	145
10	6,364	1,219	113
11	1,204	320	150
12	1,218	320	154

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE
(CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
March			
13	1,393	462	113
14	1,540	542	137
15	1,614	512	132
16	2,984	727	139
17	3,988	996	61
18	718	297	80
19	1,040	307	84
20	1,344	372	32
21	1,330	388	45
22	1,071	250	71
23	3,292	614	113
24	4,456	928	52
25	417	91	0
26	567	86	33
27	483	109	24
28	651	59	29
29	623	73	108
30	3,548	759	163
31	5,340	1,167	45
April			
1	413	102	46

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE (CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
April			
2	490	70	55
3	623	119	25
4	641	145	24
5	564	95	83
6	1,912	444	111
7	3,240	979	160
8	767	281	156
9	1,117	276	181
10	1,383	344	216
11	851	293	166
12	872	262	145
13	2,844	759	148
14	2,424	300	102
15	522	334	116
16	469	195	90
17	774	279	102
18	816	312	86
19	595	197	32
20	-	-	65
21	-	-	22

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE
(CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
April			
22	-	-	14
23	473	55	24
24	546	97	16
25	413	84	10
26	588	50	130
27	2,728	564	137
28	4,924	666	6
29	690	91	94
30	455	13	8
May 1	466	0	11
2	560	0	7
3	658	0	0
4	2,100	0	119
5	3,040	0	46
6	431	0	33
7	567	0	11
8	630	0	24
9	641	0	16
10	574	0	62
11	1,440	0	134
12	2,020	0	6

TABLE A-8: SKI AREA SURVEY - TIMBERLINE LODGE (CONT.)

Date	Total Visitors	Total Skiers	Overnight Guests
May			
13	357	0	7
14	357	0	5
15	504	0	3
16	616	0	5
17	735	0	42
18	2,276	0	145
19	2,388	0	113
20	494	0	10
21	462	0	5
22	490	0	4
23	403	0	6
24	718	0	63
25	1,296	0	109
26	1,836	0	9
27	483	0	11
28	434	0	18
29	462	0	33
30	2,867	0	23
31	994	0	53

TABLE A-9: TIMBERLINE LODGE RAW SEWAGE

	Analysis	1/21	1/22	1/23	1/24	1/25	1/26	1/27	1/29	5/10	5/11	5/12	5/13	Ave.
	BOD_T	485	540	620	460	-	460	430	388	145	198	280	345	395
	BOD_C	245	340	255	225	-	215	265	205	-	-	-	-	250
	COD_T	899	917	994	868	827	869	636	659	286	533	710	790	749
	COD_C	540	-	-	377	459	320	296	-	-	-	-	-	398
	TS	853	-	620	570	-	1000	-	-	350	432	570	860	657
	TVS	586	-	474	414	-	730	-	-	196	180	448	384	426
	SS	420	-	480	380	-	600	-	-	92	156	244	192	321
	TVSS	390	-	400	300	-	540	-	-	80	130	212	172	278
Lab	pH	8	7.2	6.5	6.5	-	6.7	7.7	7.8	6.4	-	6.0	6.2	6.8
	Alk	294	360	112	96	-	131	349	384	122	130	115	165	205
Field	pH	7.3	6.7	6.0	6.0	-	6.2	7.1	7.2	5.6	5.5	5.7	5.8	6.2
	TPO_4	12.6	14.5	12.4	9.8	-	16.5	14.1	12.5	9.5	14.9	9.7	-	12.7
	OPO_4	6.8	7.4	6.7	4.7	-	6.9	6.6	7.6	4.4	7.7	3.6	-	6.2
	NH_3	-	-	-	-	-	22.7	5.9	102	8.0	16.9	15.9	-	28.5
	NO_3	-	-	0.12	0.2	0.27	0.08	0.49	0.07	0.08	0.59	0.12	-	.22

TABLE A-9: TIMBERLINE LODGE RAW SEWAGE (CONT.)

Analysis	1/21	1/22	1/23	1/24	1/25	1/26	1/27	1/29	5/10	5/11	5/12	5/13	Ave.
NO_2	-	-	0.06	0.08	0.21	0.08	0.11	0.03	0.05	0.08	0.08	-	.09
KN	89.2	112.7	49.3	44.6	57.6	49.3	105.3	203.0	44.0	56.0	32.4	-	76.6
Cl	-	-	-	-	-	-	-	-	23	13	14	140	48
TH	26	36	36	27	-	24	29	35	21	40	23	29	30
CaH	22	30	31	22	-	23	19	26	20	37	1	25	23
Hrs in Composite	24	24	24	12	12	24	24	7	24	-	-	-	19
FLOW gpd	12,400	10,400	6,000	4,800	9,800	5,200	9,200	12,000	3,800	5,700	15,800	5,200	8,358