UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Water-supply possibilities from springs for Pretty Eagle and Ok-A-Beh sites, Bighorn Canyon National Recreation Area, Montana

By R. D. Feltis

Prepared for U.S. National Park Service

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Introduction

The Chief, Water Resources Center, U.S. National Park Service requested the U.S. Geological Survey to investigate the possibilities of developing a water supply from springs near Pretty Eagle and Ok-A-Beh sites in the Bighorn Canyon National Recreation Area. A lodge and campground is planned at the Pretty Eagle site and a marina at the Ok-A-Beh site. This report describes three optional plans to supply water to the sites and briefly mentions changes to the ecology that might result by developing springs. The general geology and hydrology of the area is described in a report R. D. Feltis (1968a) made to the Water Resources Center of the National Park Service.

According to the National Park Service map, Pretty Eagle--Ok-A-Beh Developed Area Plan, drawing number 617, October 1968, proposed facilities of the Pretty Eagle site (fig. 1, in pocket) include: 140 living units at the lodge, employee housing, restaurant, swimming pool, sauna, and golf course. At the campground there will be 200 campsites, 20 housekeeping shelter units, laundry, showers, and coffee shop. Proposed facilities at the Ok-A-Beh site include: a ranger station, a boat ramp, a comfort station, a fish-cleaning area, and a snack bar.

Currently (May 1970) a boat ramp and parking lot are being constructed at the marina. A well near the boat dock was drilled and tested (Feltis, 1968b); however, the well does not supply sufficient water for all the proposed facilities. Wells drilled near the proposed lodge and campground (fig. 1) would probably yield only very small quantities of water because the water-bearing zone of the major aquifer (the Madison Group) is drained in this area (Feltis, 1968a).

Three plans can be considered to develop a water supply for the two sites. The first is to pump water directly from Bighorn Lake (formerly named Yellowtail Reservoir). The second is to supply the Ok-A-Beh site from nearby springs and the existing well and supply the Pretty Eagle site from the reservoir. The third plan is to supply both sites with water from springs and the well at the boat dock. The principal disadvantages of plan one and two are that reservoir water would require treatment and filtration to prevent biological contamination. Also, the water from the reservoir does not always meet the recommended standards of the U.S. Public Health Service for chemical quality. The supply from the springs and well (plan three) would meet Public Health Service chemical quality standards; however, the total supply available is no more than 142 gpm (gallons per minute). Also, use of the springs will require pumping sewage outside the recharge area of the springs. A summary of each plan follows in the report after more detailed discussions of the springs, chemical quality of water, and sewage disposal.

Springs

The springs considered for a water supply are fed by water from the Amsden Formation, a fractured limestone underlain by shale. The Amsden Formation is recharged by precipitation on the plateau between Black Canyon and Lime Kiln Creek. Water in the aquifer moves north and is discharged by the springs (fig. 1).

Discharge of springs

On April 18, 1970, the discharge of 15 springs and 4 streams was measured. The measurement was made before the growing season; therefore, transpiration and evaporation would be small and would not tend to decrease discharge. The discharge measurements and approximate altitude of each site are listed in table 1, and the location of each measurement site is shown on figure 1.

Table 1.--Spring and stream discharge measurements

Site number	Location	Source	Altitude (feet)	Discharge 12-15-67 gpm	Discharge 12-15-67 gpd	Discharge 4-8-70 gpm	Discharge 4-8-70 gpd
1	SW¼SE¼SE¼ sec. 13, T. 6 S., R. 30 E.	Spring	3,840	10	14,400	8.8	12,700
2	SW¼SE¼SE¼ sec. 13, T. 6 S., R. 30 E.	Spring	3,840	---	-----	4.4	6,300
3	SW¼SE¼SE¼ sec. 13, T. 6 S., R. 30 E.	Spring	3,840	---	-----	1.8	2,600
4	SW¼SE¼SE¼ sec. 13, T. 6 S., R. 30 E.	Spring	3,840	---	-----	2.8	4,000
5	SW¼SE¼SE¼ sec. 13, T. 6 S., R. 30 E.	Spring	3,840	---	-----	.8	1,200
6	SW¼SE¼SE¼ sec. 13, T. 6 S., R. 30 E.	Spring	3,840	---	-----	1.5	2,200
7	SW¼NE¼SE¼ sec. 24, T. 6 S., R. 30 E.	Stream	4,020	35	50,400	---	-----
8	NE¼SW¼SE¼ sec. 24, T. 6 S., R. 30 E.	Spring	4,120	---	-----	8.2	11,800
9	SE¼SW¼SE¼ sec. 24, T. 6 S., R. 30 E.	Spring	4,160	---	-----	29	41,800
10	NE¼NW¼NE¼ sec. 19, T. 6 S., R. 31 E.	Stream	3,840	10	14,400	---	-----
11	SW¼SW¼NE¼ sec. 19, T. 6 S., R. 31 E.	Stream	3,960	15	21,600	26	37,400[1/]
12	SW¼SW¼NE¼ sec. 19, T. 6 S., R. 31 E.	Spring	3,920	---	-----	4.6	6,600
13	SE¼SW¼NE¼ sec. 19, T. 6 S., R. 31 E.	Spring	4,000	5.6	8,100	1.3	1,900
14	SW¼SW¼NW¼ sec. 19, T. 6 S., R. 31 E.	Spring	3,840	30	43,200	26	37,400

Table 1.--Spring and stream discharge measurements--continued

Site number	Location	Source	Altitude (feet)	Discharge 12-15-67 gpm	Discharge 12-15-67 gpd	Discharge 4-8-70 gpm	Discharge 4-8-70 gpd
15	NW¼SE¼SW¼ sec. 19, T. 6 S., R. 31 E.	Spring	4,040	---	-----	7.5	10,800
16	SW¼SE¼SW¼ sec. 19, T. 6 S., R. 31 E.	Stream	4,020	13	18,700	20	28,800 1/
17	NW¼NW¼SE¼ sec. 19, T. 6 S., R. 31 E.	Spring	4,000	---	-----	5.5	7,900
18	SW¼SW¼SE¼ sec. 19, T. 6 S., R. 31 E.	Spring	4,240	---	-----	6.6	9,500
19	NW¼SE¼NW¼ sec. 30, T. 6 S., R. 31 E.	Spring	4,380	---	-----	13	18,700
				Total (rounded)		122	176,000

1/ Streamflow not used to compute total spring discharge

Discharge from the springs has been measured only twice--December 15, 1967, and April 8, 1970. Thus, yearly fluctuations of discharge are unknown. The springs seem to be perennial as indicated by nearby vegetation. Monthly precipitation is greatest during June and snowmelt usually occurs during April and May; therefore, recharge would be greatest from April through June. There is probably a slight lag time between the rate of greatest recharge and the rate of greatest discharge; thus, discharge from the springs may be greatest during June and early July. Spring discharge probably then decreases until the following April or May. Transpiration and evaporation during June, July, and August consume water discharged from the springs and could cause a relatively abrupt decrease in discharge during July and August. Removal of vegetation near the springs and enclosures of the springs would help reduce evaporation and transpiration.

Based on the above reasoning, the discharge measurements during 1967 and 1970 probably are indicative of low flows from the springs. Additional discharge measurements should be made during May, July, September, and October to better define annual fluctuations and, more importantly, flow during the maximum use period.

Development of water supply from springs

Each spring can be developed by excavating the loose material from around the spring opening and constructing an enclosed catchment structure. Each catchment should include a drain to prevent damage by freezing and should be fenced. Pipelines should also include drains.

Utilization of the springs would require a collection system that would feed the water by gravity to a storage tank near the boat ramp. Water would be pumped from this storage tank to another tank in the Pretty Eagle area. Water could be supplied to the boat ramp area by gravity from the storage tank near the boat ramp. The water supply could be supplemented by water from the well drilled at the boat ramp area (Feltis, 1968b).

Development plans may require that facilities at the boat ramp site and lodge site be constructed in stages. The water supply could also be developed in stages. The amount of water could be increased by adding new springs to the water-supply system.

Springs 1 through 6 are at about the same altitude along the hillside above the boat ramp. The total yield of the 6 springs was 20 gpm (29,000 gpd, gallons per day). The springs can be developed by a collection system from which water would flow by gravity to a storage tank near the boat ramp.

Spring No. 14 can be added to the water system with about one-half mile of pipeline. Water would flow from the spring to the storage tank by gravity and would add 26 gpm (37,400 gpd) to the supply.

Springs number 8, 9, 12, 13, 15, 17, 18, and 19 yield about 75 gpm (108,000 gpd). Springs 8 and 9 could be connected to the collection system with 0.9 mile of pipeline (fig. 1) and would add 37 gpm (53,000 gpd). Spring 19 could then be added to springs 8 and 9 with 0.6 mile of pipeline making the total yield of the three springs about 50 gpm (72,000 gpd). Springs 12, 13, 15, 17, and 18 would add about 25 gpm (36,000 gpd) to the system with about with about 2 miles of pipeline construction as shown on figure 1.

The increases in water supply at each stage of development of the system are summarized in table 2.

Table 2.--Quantity of water available at various stages of development

Stage number	Springs to be developed (number from fig. 1)	Quantity available (gpm)	Total quantity (gpm)	Total quantity (gpd)
1	Existing well at boat ramp	20	20	28,800
2	1, 2, 3, 4, 5, 6	20	40	57,600
3	14	26	66	95,000
4	8, 9, 19	50	116	167,000
5	12, 13, 15, 17, 18	26	142	204,000

Ecology of springs

The enclosure of springs and diversion of water would affect the flora of each developed site. Herbs and grasses are the most abundant plants growing near the springs. Some springs are surrounded by thickets of brush, but these thickets would be removed by the excavation for the enclosures. The enclosures probably would not collect all seepage and some moisture would be available to plants around the spring. Several small seeps, springs, and wet areas, not shown on figure 1, support brush and trees. The several scenic stands of pine do not depend upon spring water but are sustained by moisture in a sandstone bed that caps the hilltops.

Deer and game birds inhabit the area. Watering facilities can be built into the collection system for these animals, or the animals could use the undeveloped springs. It is assumed livestock will be excluded from the area and therefore will not pose a watering or pollution problem.

Chemical quality of water from the springs and reservoir

The four springs sampled in 1967 (Feltis, 1968a) were resampled and the water analyzed (table 3, in pocket). Also listed in table 3 are the results of chemical analyses of samples collected from three additional springs, the boat ramp water well, Bighorn Lake, and the Bighorn River near St. Xavier, Montana, which is about 0.4 mile downstream from Yellowtail Afterbay Dam. Stiff diagrams showing a comparison of the water from the several sources are on figure 2.

Water from the springs is a calcium magnesium bicarbonate type. The spring water meets the drinking water standards recommended by the U.S. Public Health Service (1962, p. 7).

A comparison of water from the boat-ramp well to reservoir water shows that the types are similar at a given time, but that the amounts of constituents change with time, according to the chemical quality of water in the reservoir. The water in the Bighorn River, which is essentially reservoir water, is a sodium calcium sulfate type at both high and low dissolved solids concentrations. The river and reservoir water sometimes contain sulfate in excess of 250 mg/l (milligrams per liter) and dissolved solids in excess of 500 mg/l (U.S. Public Health Service recommended maximum concentrations).

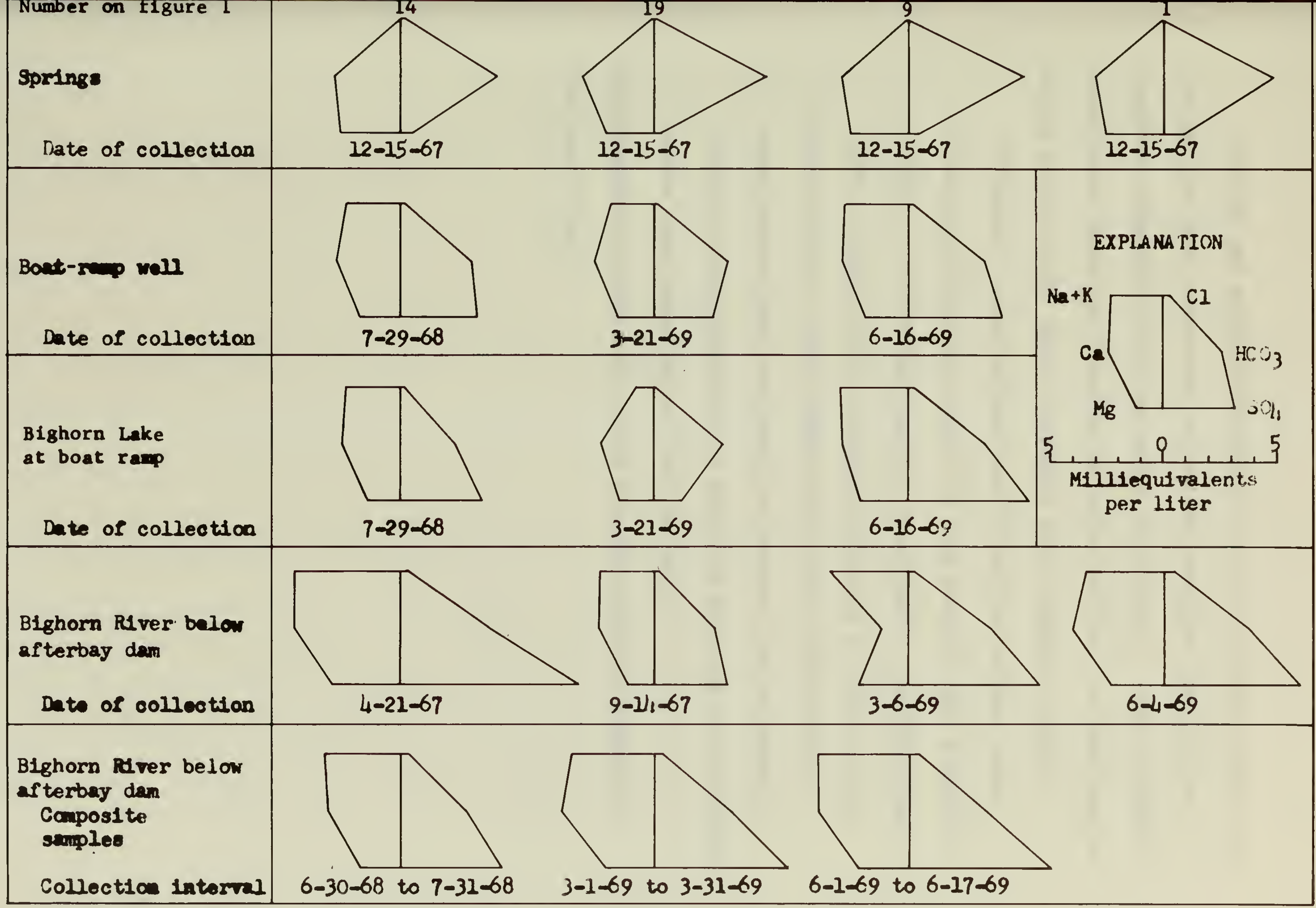

Figure 2.--Diagram showing chemical quality of water from springs near Box Canyon, boat-ramp well, Bighorn Lake, and Bighorn River, Bighorn Canyon National Recreation Area, Montana. (Analyses represented by patterns based on milliequivalents per liter.)

[illegible]

Although the Bighorn River water, at times, contains more than 250 mg/l sulfate, this water is used for municipal supplies by numerous communities above and below the reservoir. The following quote, which describes laxative effects of sulfate, is from page 34 of the Public Health Service Drinking Water Standards (1962).

> "***waters containing more than 750 mg/l of sulfate showed a laxative effect and those with less than 600 mg/l generally did not. If the water was high in magnesium, the effect was shown at lower sulfate concentrations than if other cations were dominant. Moore showed that laxative effects were experienced by the most sensitive persons, not accustomed to the water, when magnesium was about 200 mg/l and by the average person when magnesium was 500-1,000 mg/l."

The magnesium concentration in the reservoir water is generally less than 28 mg/l.

Sewage disposal

The National Park Service map, Pretty Eagle--Ok-A-Beh Developed Area Plan, drawing number 617, October 1968, shows a sewage lagoon in the N½ sec. 25, T. 6 S., R. 30 E. A sewage lagoon at this site (fig. 1) or anywhere else in sec. 25 could be a source of pollution to the recharge area of springs number 1-6, 8, 9, and 14 if the bottom leaks or if the lagoon overflows. The lagoon may be difficult to seal because the rocks underlying the site are fractured and would be conducive to leakage. To be certain that the springs are not contaminated by the lagoon, sewage should be piped by a 4-mile pipeline to the lagoon at Fort Smith.

If the 4-mile pipeline is not feasible, the sewage lagoon could be located in the draw draining into Box Canyon from the NW¼ sec. 30, T. 6 S., R. 31 E. Such a location, however, would preclude the use of springs number 12, 13, 15, 17, 18, and 19 (total discharge 38 gpm). Leakage from the lagoon might eventually reach the spring (SE¼NE¼NE¼ sec. 18, T. 6 S., R. 31 E.), which supplies Fort Smith.

Water-supply plans

The three basic water-supply systems that would serve the lodge, campground, and boat-ramp areas are:

1. The lodge, campground, and boat-ramp areas could be served by pumping water from Bighorn Lake to a treatment and storage tank. This would insure an unlimited supply of water as opposed to the spring supply, which may fluctuate in yield and might not be adequate in the future. This option would not require building and maintaining the spring collection system. An objection to use of reservoir water is that it does not always meet chemical quality standards of the U.S. Public Health Service. Sewage could be treated in a lagoon in sec. 30, T. 6 S., R. 31 E., or in sec. 25, T. 6 S., R. 30 E., if the location in sec. 25 can be chosen so as not to be unattractive with respect to the campground.
2. The Ok-A-Beh site could be served by the water well and the springs 1-6. About 20 gpm from each source would produce 40 gpm (57,600 gpd). An additional 26 gpm (37,400 gpd) could be added to the system by including spring number 14. The Pretty Eagle site could be served by water pumped from Bighorn Lake and treated; however, this water does not always meet chemical quality standards of the U.S. Public Health Service. Sewage could be treated in a lagoon in sec. 30, T. 6 S., R. 31 E., or piped to Fort Smith.

3. The lodge, campground, and boat-ramp areas could all be supplied from the springs and the well at the boat ramp. Mixing the poorer quality well water with the spring water would result in a supply that would meet recommended limits of the U.S. Public Health Service. This system would require construction of spring enclosures, two storage tanks, and pipelines. The quantity of water available is no more than 142 gpm (204,000 gpd). Sewage should be piped to Fort Smith through a 4-mile pipeline.

Conclusions

Based on discharge measurements of April 18, 1970, no more than 122 gpm (176,000 gpd) of water is available from springs. Development of the springs would require construction of spring enclosures and pipeline from the springs to storage tanks and from the tanks to service areas. The pumping lift from the boat-ramp area to a lodge storage tank, assuming a boat-ramp storage tank at about 3,800 feet, would be about 780 feet through a pipeline at least 1.8 miles long. The quantity of water available at the boat ramp, other than reservoir water, is limited. No record is available of dependability of spring-flow throughout the year or over a period of years. However, it is believed the discharge measurements are indicative of low flows.

The reservoir is the only source of an unlimited water supply. The lift from the reservoir at low-water stage of 3,585 feet to the storage tank near the lodge area would be about 1,000 feet. Normal reservoir pool level is 3,640 feet. If water is pumped from the reservoir, it is suggested it be pumped from Black Canyon (fig. 1) to take advantage of what is possibly better quality water that flows into Black Canyon from the Bighorn Mountains.

The quality of water from the springs is acceptable under standards suggested by the Public Health Service. The well water is the same type as reservoir water and would probably be the same as reservoir water after long-term pumping. The reservoir water sometimes exceeds the limits for sulfate and dissolved solids suggested by the Public Health Service; however, comparable water is used as municipal supplies by communities along the Bighorn River above and below Bighorn Lake.

References

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