Preliminary Groundwater Assessment of the Horse Heaven Hills

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Purpose:

This report is written to address the ground water regimen of a specific area as defined in this report and also to recommend interim management guidelines to assist in the decision-making process of the region, until a more comprehensive investigation can be completed and management regulations adopted.

Background:

Considerable interest has been expressed in the development of ground water for the irrigation of land in the Horse Heaven Hills. This interest alerted the region that possible ground water problems could exist in the future. The concern has prompted the region to evaluate potential aquifer recharge with respect to the total withdrawal from the system.

Scope of Report:

The area investigated for this report is generally located in southwestern Benton County and eastern Klickitat County (shown on Figure I), and consists of approximately 1400 square miles. The area ranges from the west boundary of R. 20 E.W.M. extending to the east boundary of R. 27 E.W.M., and from the north boundary of T. 7 N., south to the Columbia River.

Technical Investigation and Analysis:

The structure of the Horse Heaven Hills area allows the inflow of water into the interflow zones of the Priest Rapids basalt flows from the Satus Region along the ridge line from Pine Butte to the crossing of the Alderdale Road and the ridge in the northeast corner of T. 7 N., R. 22 E.W.M. The piezometric surface

appears to have a southeasterly gradient. The western boundary is either on the ridge between Wood Gulch and Rock Creek or in the Rock Creek drainage. The eastern boundary is less defined, however, it is presumed to be east of the Prosser-Paterson Highway. The southern boundary is comprised of the Anticlinal Ridges along the Columbia River which obstruct a majority of the flow from the aquifer and force most of these flows to discharge into the Columbia River through Artesian Coulee, which lies between Golgotha Butte and Canoe Ridge near the Klickitat and Benton County lines. Outflow along Artesian Coulee (submerged due to impoundment of the Columbia River) results in lower static water levels in wells along a depressed potentiometric surface extending five to six miles up Dead Canyon.

Alder Ridge in the southwest has a tendency to block outflow from the system into the Columbia River, resulting in higher static water levels than would normally be expected so close to the Columbia River. Characteristics of the McBride artesian wells in Sec. 29 and 30 of T. 5 N., R. 22 E.W.M. are an outstanding example of the high heads caused by the impoundment in the Alder Ridge area.

Wells in the area of the Andrews' ranch (Secs. 22, 15, 11, T. 6 N., R. 23 E.W.M.) are closer to the recharge area in the Satus and low enough in elevation to result in flowing conditions. The Andrews' well in Sec. 9 and 22 and the Feezell well in Section 16 T. 6 N., R. 23 E.W.M. appear to have a higher potentiometric surface (observable head with respect to sea level) than at the McBride wells.

The resulting lower heads in the eastern portion of the study area are due to the relatively unbounded condition in the east which causes a bleedoff of the

head. Other than some reported head declines in the area of the Andrews' well complex, no actual declines have been monitored to date.

An examination of the Horse Heaven artesian zone indicates a recharge area of about 800 square miles west of the Satus Creek Drainage and above a sea level elevation of 1000 feet (Figure I).

How come recharge occurs in the Satus area and not on the Horse Heaven area?

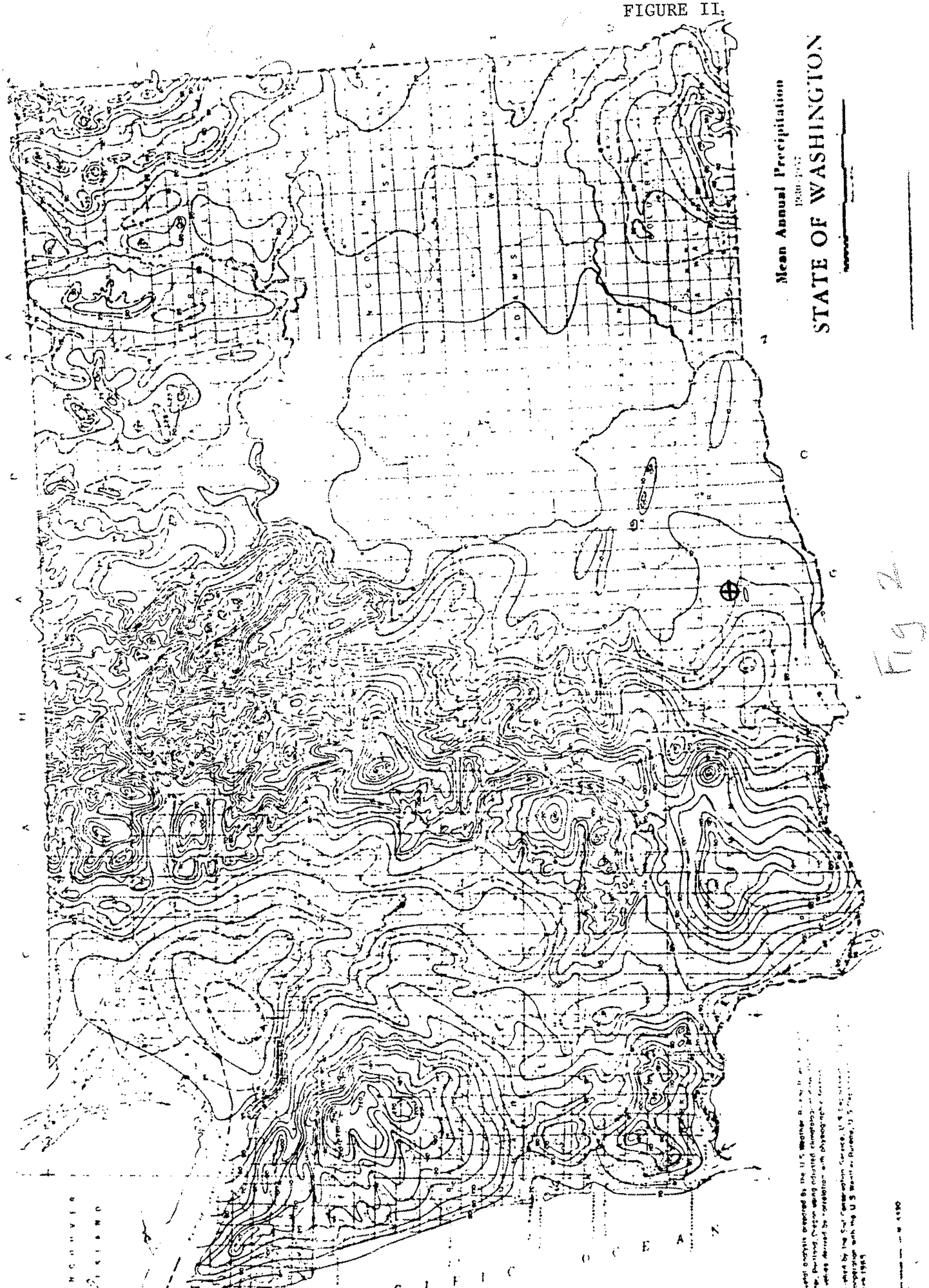
No additional recharge appears to be entering the highhead artesian system from either precipitation or return flows within the actual area of irrigation use.

In order to calculate recharge, parameters including precipitation, evapotranspiration, soil moisture retention, and runoff must be considered in addition to the area of recharge. Precipitation quantities were obtained from the U.S. Weather Bureau Mean Annual Precipitation Map of the State of Washington presented in Figure II. Examination of precipitation charts for the state indicates the average annual precipitation for the Satus Basin is about 15 inches. Having a recharge area and a precipitation figure, recharge to the artesian zone was then estimated using two methods. The first method was obtained from the Dead Canyon Study of June 1972 by Paul Eddy and Chuck Cline which used the product of the following: a) feet of precipitation at a depth of 6 inches remaining after evapotranspiration; b) area in acres; and c) the sum of specific retention and runoff factors taken from 1.00.

a. Assume 25% of the rainfall to be available below 6 inches of soil for recharge or 0.3 feet of precipitation.

b. 800 square miles x 640 acres per square mile or 512,000 acres.

FIGURE II.


Mean Annual Precipitation
STATE OF WASHINGTON
PACIFIC OCEAN
Fig 2

c. runoff factor plus the soil retention value = 0.40 + 0.10 = 0.50, or 0.5 for a recharge value

a x b x c = acre-feet of recharge

0.3 feet x 512,000 acres x 0.5 = 76,800 acre-feet. .125

An additional check was run using the product of:

a) precipitation 15 inches or 1.25 feet.

b) acres of recharge 512,000 acres.

c) recharge factor (assumed) 0.1

a x b x c = acre-feet of recharge

1.25 feet x 512,000 acres x .1 = 64,000 acre-feet. .10

Both values obtained for recharge (64,000 acre-feet and 76,800 acre-feet) appear to be reasonable estimates for the actual recharge into the Horse Heaven artesian zone.

Aquifer storage was considered using the following method:

500 square mile aquifer area

25 foot aquifer thickness

20% assumed effective porosity

= 1,600,000.00 acre-feet of storage 1/

1/ The porosity used in this report is extracted from Ground Water Hydrology and Hydraulics, 1977, Table 2-1; porosity of aquifer materials (adapted from Morris and Johnson, 1967), (Figure III). Also consideration must be given to the fact that the aquifer in its present condition is in a compressed state and if allowed to be overdrafted, the hydrostatic condition will change quite drastically.

Analysis of ground waters previously allocated through permits and certificates reveals the following:

	Acres	GPM	Acre-feet/year
Permits	22,010	139,300	78,584
Certificates	3,025	3,040	2,840
Sub-Total	25,035	142,340	81,424

The quantities requested in applications currently pending and the total potential demand against the aquifer system are as follows:

	Acres	GPM	Acre-feet/year
Applications	16,580	112,361	66,320
Total Demand	41,615	254,701	147,744

FIGURE III

Table 2-1. Porosity of Aquifer Materials
(Adapted from Morris & Johnson, 1967)

Aquifer Material	No. of Analysis	Range	Arithmetic Mean
Igneous Rocks			
Weathered granite	8	0.34-0.57	0.45
Weathered gabbro	4	0.42-0.45	0.43
Basalt	94	0.03-0.35	0.17
Sedimentary Materials			
Sandstone	65	0.14-0.49	0.34
Siltstone	7	0.21-0.41	0.35
Sand (fine)	243	0.26-0.53	0.43
Sand (coarse)	26	0.31-0.46	0.39
Gravel (fine)	38	0.25-0.38	0.34
Gravel (coarse)	15	0.24-0.36	0.28
Silt	281	0.34-0.61	0.46
Clay	74	0.34-0.57	0.42
Limestone	74	0.07-0.56	0.30
Metamorphic Rocks			
Schist	18	0.04-0.49	0.38

CONCLUSIONS:

The possible effect of additional withdrawals from the aquifer is calculated on a percentage increase as shown below:

Calculated Annual Recharge	76,800 acre-feet
Annual Withdrawals under Permits and Certificates	81,424 acre-feet
Present Annual Deficit	4,624 acre-feet or 6%

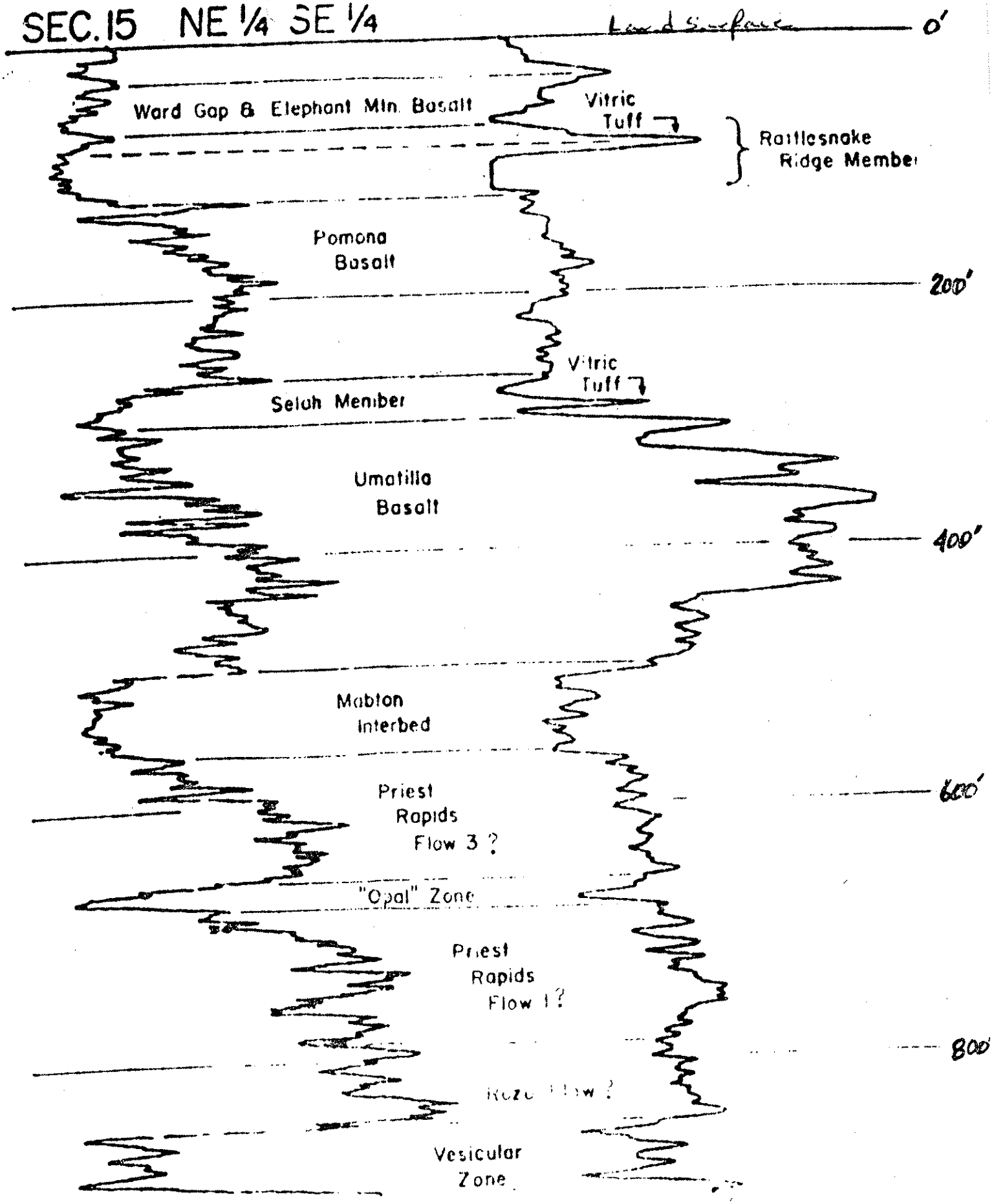
Considering the applications on file at the present time, and equating the potential influence these additional appropriations will have on the system if granted is shown by the number of permits according to their priority and requested acreage. Twenty applications are on file at the present time.

First Three permits	= 10% aquifer deficit
First Thirteen permits	= 20% aquifer deficit
All Twenty permits	= 87% aquifer deficit

These percentages are based upon 3.5 af./ac.

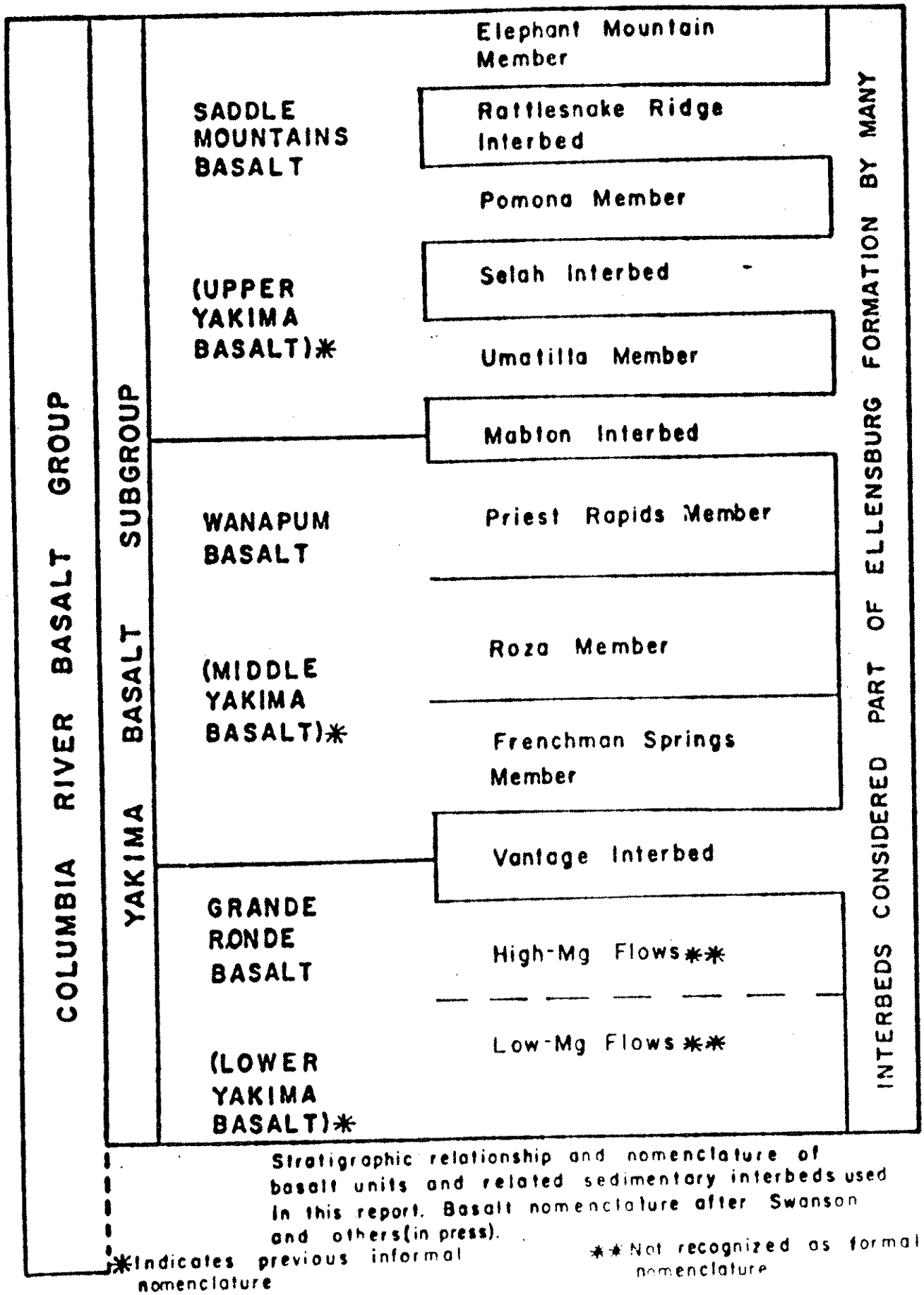
The data indicate at this time the basin is producing substantially well with no appreciable decline. However, it is the opinion of the writers that additional withdrawals will have an accelerated decline effect on the system. Also, information obtained from well logs and observed well tests indicate the best production is obtained from wells which are properly constructed to a depth penetrating the Priest Rapids Basalt Flows between 550 and 900 feet. Several of the wells in this area are drilled into the Priest Rapids aquifer and are producing high artesian heads occurring above land surface. (Stratigraphic correlations Figure IV and V.)

FIGURE IV



Stratigraphic correlations from ... by Anderson and Kiesler, 1972, ... slightly modified.

FIGURE V



Stratigraphic relationship and nomenclature of basalt units and related sedimentary interbeds used in this report. Basalt nomenclature after Swanson and others(in press).

*Indicates previous informal nomenclature

**Not recognized as formal nomenclature

The data presented in this report indicate that present allocations have reached a balance between recharge and withdrawal in the aquifers occurring above the Roza Basalt. It must be noted that the area of recharge and the products used to calculate the estimated quantity are strictly assumptions. Although the data are not confirmed, it is felt that it is the best information available at this time.

RECOMMENDATIONS:

After a thorough review of the data presented in this report, several conclusions have been formed as to the interim management program that should be immediately instituted. It is apparent from the available information that 1) additional research is required to form a more precise evaluation as to the existing water availability of this area; 2) additional appropriations of water from both aquifers above the Roza basalt should be curtailed until a more comprehensive study has been completed.

Exceptions to the above-mentioned closure may be made on a case-by-case basis for those applicants who wish to speculate on ground waters below the Roza aquifer which are presently not being appropriated. It is the writers' opinion that wells of this type should be considered under the following conditions:

1. The bore hole will be cased with steel casing and sealed with cement grout to a depth extending into the Frenchman Springs basalt member. (Figure VI). This type of well should be pressure grouted from the bottom of the casing to land surface.

2. After completion of the well, the owner will be responsible for furnishing the Department of Ecology with a complete suite of geophysical logs (logging

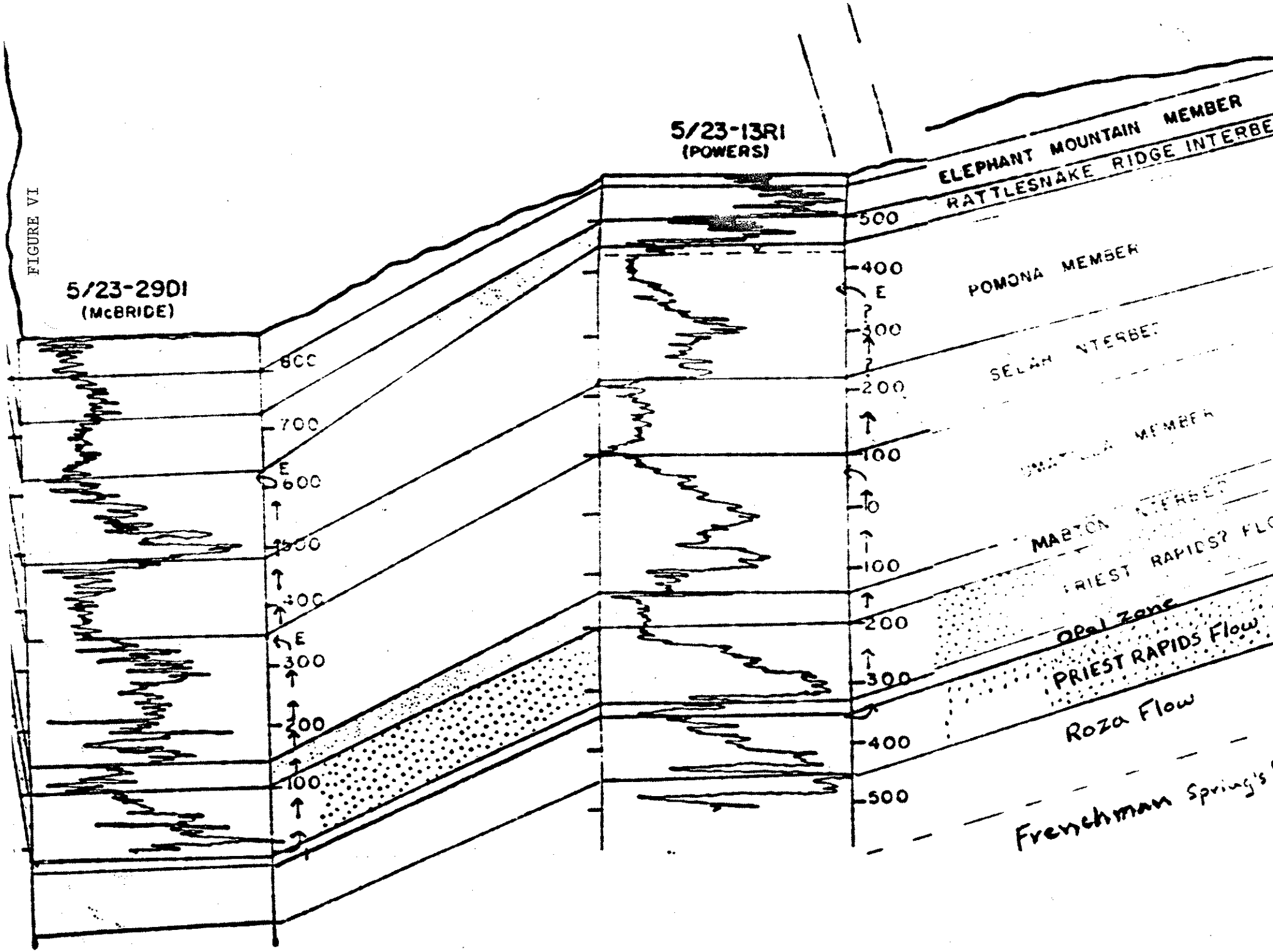
service available from Washington State University) and a video tape of the complete well bore to verify that the casing has been adequately sealed into the designated basalt flow.

3. A 72 hour constant rate drawdown aquifer test will be required and will conform to "Aquifer Test Procedures" WRIS Bulletin No. 30.

Consideration also should be given to spacing the additional wells drilled into the Frenchman Springs which will reduce future well interference problems.

In conclusion, we recognize the fact that our recommendations may reduce the landowner's ability to appropriate water in this area in the future, but it is our opinion that without such a program, ground water will decline at a rapid rate in the near future. We would also like to express the urgency of completing an indepth research program for this area within the next three years.

FIGURE VI


5/23-29D1
(McBRIDE)
5/23-13R1
(POWERS)
ELEPHANT MOUNTAIN MEMBER
RATTLESNAKE RIDGE INTERBE
POMONA MEMBER
SELAH INTERBED
MABTON INTERBED
PRIEST RAPIDS? FLO
Opal zone
PRIEST RAPIDS Flow
Roza Flow
Frenchman Spring's
800
700
600
500
400
300
200
100
0
E
?

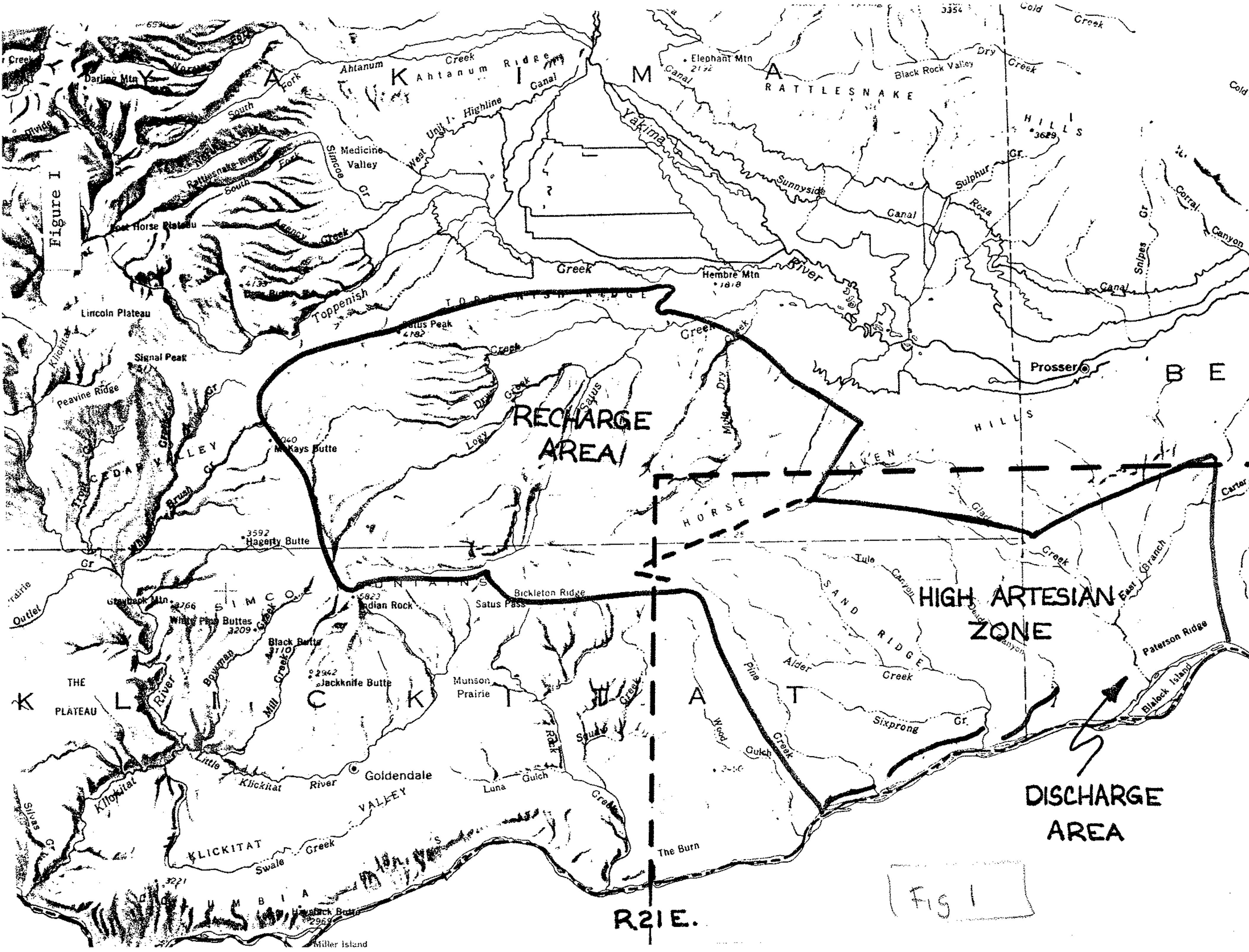
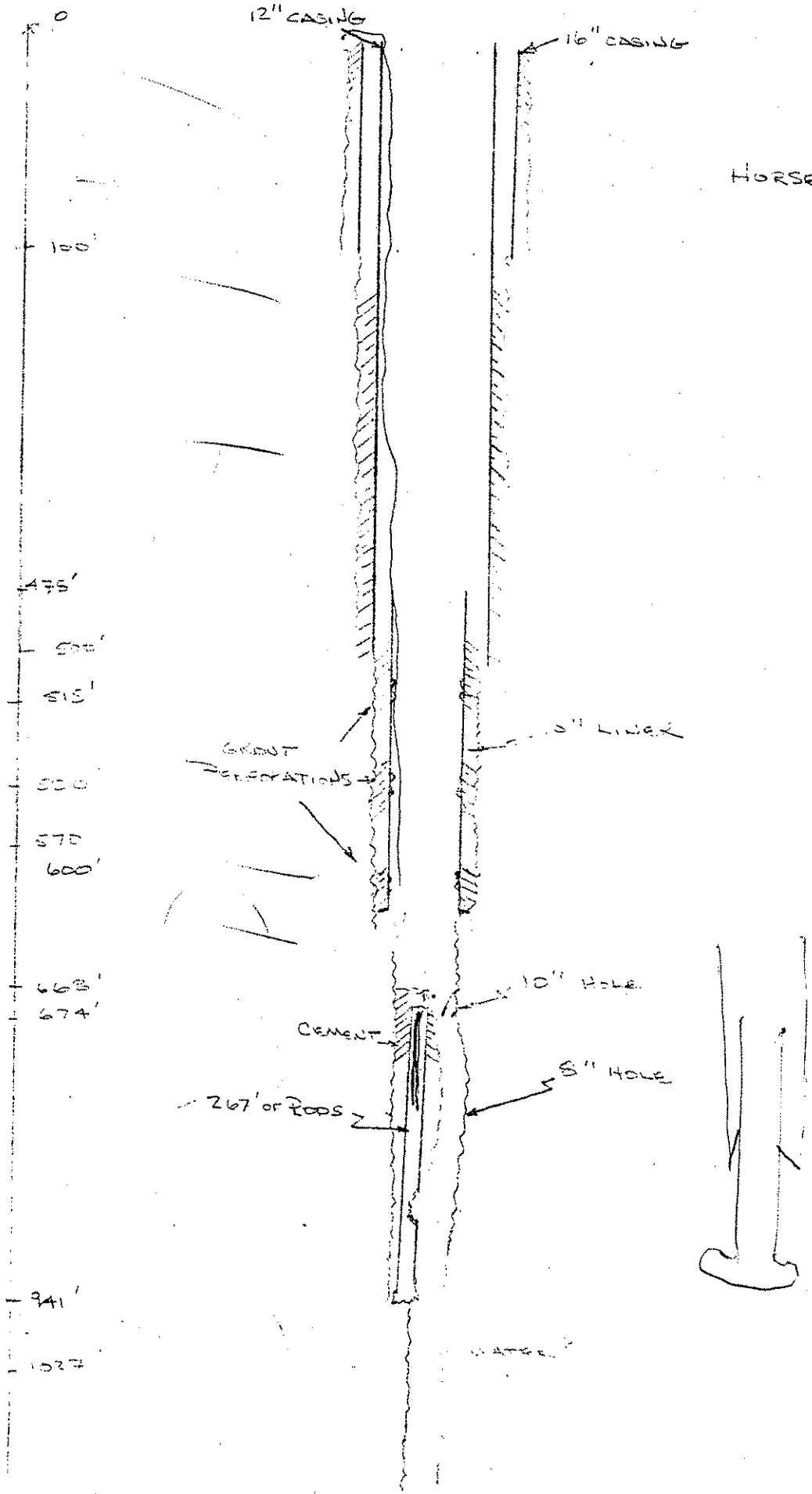


Figure I
RECHARGE AREA
HIGH ARTESIAN ZONE
DISCHARGE AREA
R21E.
Fig 1
Toppenish Ridge
Satus Peak
Satus Pass
Bickleton Ridge
Horse Heaven Hills
Sand Ridge
Paterson Ridge
Prosser
Goldendale
Klickitat Valley
Klickitat River
Yakima River
Rattlesnake Hills
Ahtanum Ridge
Simcoe Mountains
Lincoln Plateau
Signal Peak
Peavine Ridge
Cedar Valley
Hagerty Butte
Indian Rock
Munson Prairie
Mill Creek
Jackknife Butte
Black Butte
Blalock Island
Miller Island
The Burn
Columbia

12-20-78



HORSEHEAVEN HILLS

TEST-OBSERVATION
WELL #15