SNAKE PLAIN AQUIFER

TECHNICAL REPORT

September 1985

IDAHO DEPARTMENT OF HEALTH AND WELFARE
IDAHO DEPARTMENT OF WATER RESOURCES

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DISCLAIMER

Preparation of this document was financed in part by the Environmental Protection Agency. The opinions, findings, and conclusions expressed in this document are those of the authors and not necessarily those of the Environmental Protection Agency.

INTRODUCTION

Background

The Safe Drinking Water Act (Public Law 93-523) allows the designation of an aquifer as a sole or principal source of drinking water if it is determined that, by contamination; it would create a significant public health hazard. In September 1982 The Hagerman Valley Citizens Alert, Inc. petitioned the U.S. Environmental Protection Agency (EPA) to designate the groundwater beneath the Snake Plain of Southeastern Idaho as a sole source aquifer. Subsequently a notice was made in the Federal Register on February 9, 1983. The notice announced receipt of the petition and requested public comment.

Designation of the aquifer as a sole source of drinking water would give EPA review authority to help insure certain Federally-funded or guaranteed projects that may have public health impacts on such aquifer are planned and designed "to assure that they will not so contaminate the aquifer". The Federal agencies affected by such designation are those which may provide a grant, contract, loan guarantee or other form of financial assistance. Those agencies are the Federal Highway Administration, Bureau of Reclamation, Economic Development Administration, Farmers Home Administration, Department of Housing and Urban Development, Soil Conservation Service, Veterans Administration, Federal Aviation Administration and the Small Business Administration. No other extraordinary control of contamination to the aquifer would be otherwise assured by such designation.

In cooperation with the EPA, the U.S. Geological Survey (USGS) prepared a summary report of Hydrologic, Demographic, and Land-Use Data for the Snake River Plain, Southeastern Idaho (Young and Jones, 1984). The purpose of the report was to provide information on the availability, condition, and uses of the groundwater in the Snake Plain. It was based on the available data from previous studies and was used by EPA in the sole source aquifer decision-making process. The boundaries of the aquifer are shown on Plate 1.

EPA's Region X office in Seattle, Washington, subsequently published a Support Document For the Designation of the Snake River Plain Aquifer as a Sole Source Aquifer (Marshall, 1984). It was the regional office's conclusion that the Snake Plain Aquifer is the principal source of drinking water for the eastern Snake Plain Basin. The office also determined that

SNAKE PLAIN AQUIFER AND DRAINAGE BASIN



PLATE 1

SOURCE: "WATER RESOURCES INVESTIGATIONS" USGS PUBL. 84-4001

the aquifer was susceptible to contamination and that such contamination, due to the limitations on alternative sources of drinking water, could result in a significant public health hazard. The office, therefore, recommended the designation of the aquifer as a sole source.

On August 20, 1984, Governor John Evans requested that EPA delay the designation of sole source for the aquifer, stating his belief that the State could best manage the aquifer. He cited the following in requesting the delay in sole source designation:1) the technical information and knowledge developed at the present time are insufficient to support the proposed administrative action, 2) the classification of the sole source designation would fail to recognize the need for a more balanced regulatory approach, coordinating both water quality and quantity issues, and 3) such designation would significantly inhibit the resolution of the Swan Falls water rights issue. In November, 1984, after meeting with Governor Evans and state officials, Ernesta Barnes, Regional Administrator for EPA, confirmed that the agency would forego such designation at that time. It was the EPA's belief that the state groundwater management program could go beyond the scope of protection that would be provided by sole source designation.

In February 1985, the EPA released additional funds under Section 106 of the Clean Water Act (Public Law 92-500). These funds were designated for use by states to "help develop a comprehensive groundwater protection plan". Although the funds could be used for both development and implementation of groundwater protection strategies, the Fiscal Year 1985 funds were to be used in the development of state groundwater protection action plans or strategies. Using a part of those funds and in cooperation with the Idaho Department of Water Resources, the Idaho Department of Health and Welfare's Division of Environment (IDHW-DOE) developed a work plan to formulate a management strategy for the Snake Plain Aquifer. The plan, accepted by the EPA on March 5, 1985, was to be completed by October 1, 1985. It includes the following elements:

1. Identify the unique characteristics of the aquifer.
2. Compile a summary of the existing water quality data.
3. Compile a summary of the potential groundwater quality problems.
4. Identify potential control mechanisms such as regulation development and State management to protect the aquifer water quality.
5. Develop a basic management strategy.
6. Identify potential problems in management or administration of the developed plan.

Report Purpose

This report provides the technical data gathered from the first three elements of the work plan, that is, the characterization of the aquifer and plain, summarization of existing water quality water data and identification of potential groundwater contamination problems. Such information has been summarized to assist in the development of a strategy to manage the water quality of the Snake Plain Aquifer.

Agency Involvement

The report has been prepared in cooperation with the following State and Federal agencies:

Idaho Department of Health and Welfare
Idaho Department of Water Resources
Idaho Department of Lands
Idaho Department of Agriculture
U.S. Geological Survey
U.S. Bureau of Land Management
U.S. Soil Conservation Service.

SNAKE PLAIN AND AQUIFER CHARACTERISTICS

HYDROLOGY

Hydrogeological Setting

The Snake Plain Aquifer is characterized by a succession of Quaternary basaltic lava flows, often separated by alluvial, volcaniclastic, or eolian interbeds. The total thickness of the sequence is largely unknown, but may locally exceed several thousand feet. A test well (INEL-1) drilled at the Idaho National Engineering Laboratory (INEL) in 1979 to a depth to 10,365 feet penetrated about 2500 feet of basaltic lava and sedimentary and volcaniclastic interbeds. The basalt flows themselves often have cindery, clinkery zones at their tops, which are capable of transmitting water freely. Interbeds of alluvial material, such as sand and gravel, also transmit water, but generally less freely than the cinder zones. Interbeds of fine-grained material, such as clays or windblown silt, often fill the voids which are present at the flow tops, greatly reducing the amount of water which can be transmitted. In fact, these zones typically prevent the downward percolation of water applied at the land surface, often creating perched water zones separate from the regional groundwater system. Older, less permeable rhyolitic rocks underlie the basalts and probably form the base of the Snake Plain Aquifer. In INEL-1, rhyolitic rocks extended from 2500 feet to the total of 10,365 feet.

The thickness of individual basalt flows generally ranges from 10 to 50 feet, and averages 20 to 25 feet (Mundorff et al., 1964). A well drilled to a depth of 200 to 300 feet below the water table will therefore encounter several water-bearing zones between the flows, each with often different water-bearing capabilities. Interbedded sediments, depending on their thickness, frequency of occurrence, and permeability can have a profound impact upon recharge to and discharge from the aquifer, can alter flow patterns and act upon introduced contaminants in a manner quite different from the basalts. Since their hydrologic characteristics vary considerably both laterally and vertically, sedimentary interbeds add greatly to the complexity of the hydrogeology of specific areas.

A case in point is the so-called "Mud Lake barrier", a generally northwest-trending linear feature in the subsurface south and east of Mud Lake. This "barrier" is a zone of significant interfingering of highly permeable basalts with sedimentary lake beds of low permeability. The lake beds act as a dam of barrier to water moving generally

southwestward, locally causing very steep groundwater gradients within the barrier area. At least two other "barriers", generally transverse to the axis of the plain, are known to exist, dividing the aquifer into several compartments. The nature of these barriers and their effect on groundwater flow should be the subjects of future study.

Interflow zones between successive basalt flows consist of pyroclastic and sedimentary materials. Where highly permeable they are the major avenues for horizontal movement of water within the aquifer. Where they consist of clay or other impermeable materials, they may act as confining layers, preventing the downward movement of water, creating a perched aquifer; or they may act as a "lid" on an underlying aquifer, confining it under pressure. The transmissivity of the aquifer (the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient) is generally high. Reported values of transmissivity range from 500,000 ft^2/day to as high as 13,000,000 ft^2/day (Lindholm, 1981), putting them among the highest known in the nation.

Depth to Water

Depth to water in the Snake Plain Aquifer ranges from less than 100 feet to more than 900 feet below land surface (Plate 2). As shown by Plate 2, depth to water is greatest in the central and northern parts of the aquifer. In areas near the western, southern and eastern margins of the aquifer, depth to water is generally less than 300 feet and is coincident in area with most of the development and water use. However, since perched aquifers often develop beneath irrigated tracts and are poorly defined, water levels in wells completed in these perched aquifers will often give very misleading values for depth to water. The basic depth and construction of the well must be known before one can be sure than depth to water is that of the regional groundwater system and not that of a localized, perched aquifer.

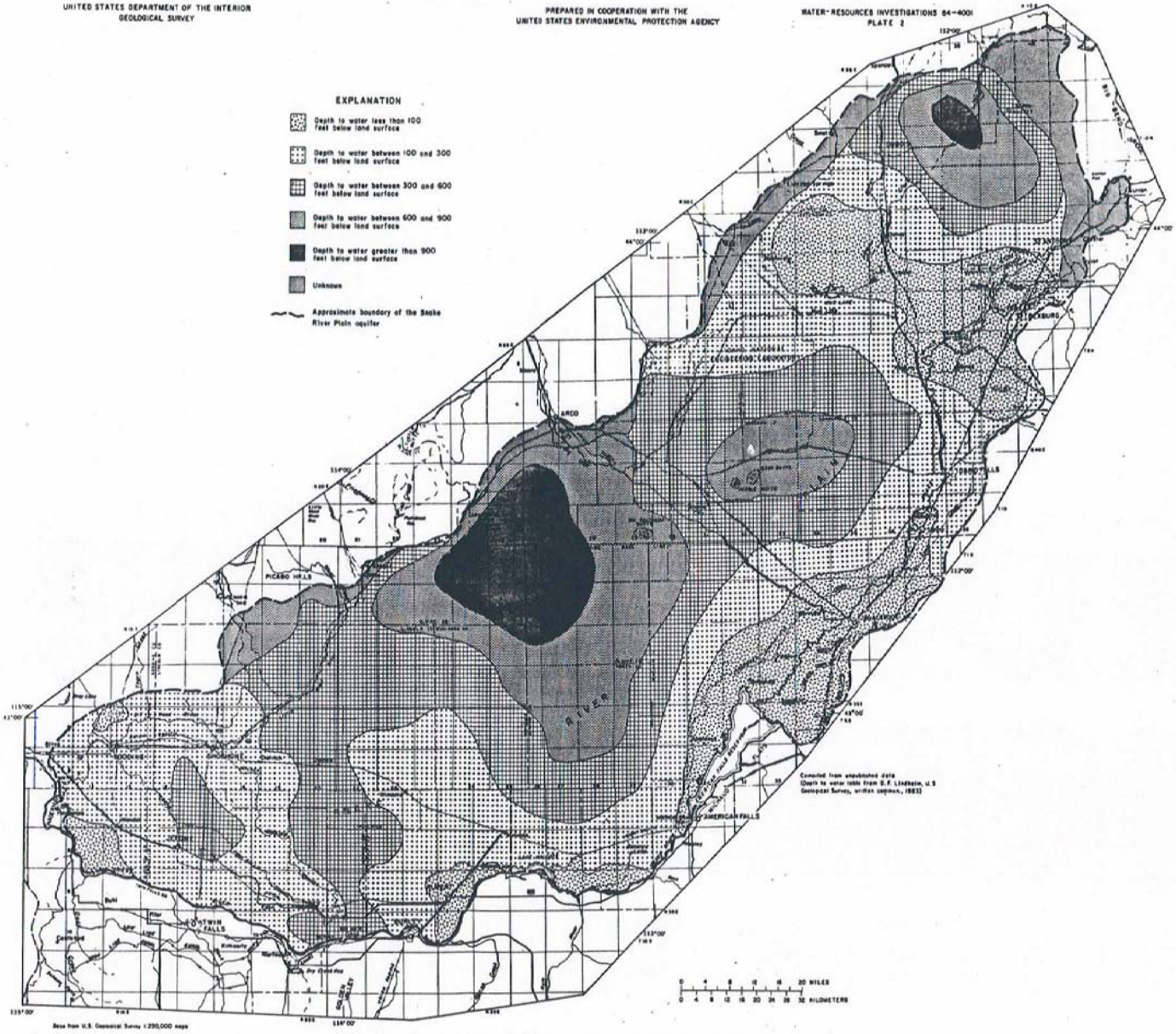
Groundwater Movement

The general direction of groundwater movement can be inferred from contours on the water surface (Plate 3). Movement is down the hydraulic gradient and roughly perpendicular to the water-level contours, from areas of recharge to areas of discharge. The position of the water surface in March 1980 is shown on Plate 3. Arrows on the plate show the general direction of groundwater movement.

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WATER-RESOURCES INVESTIGATIONS 84-4001
PLATE 2

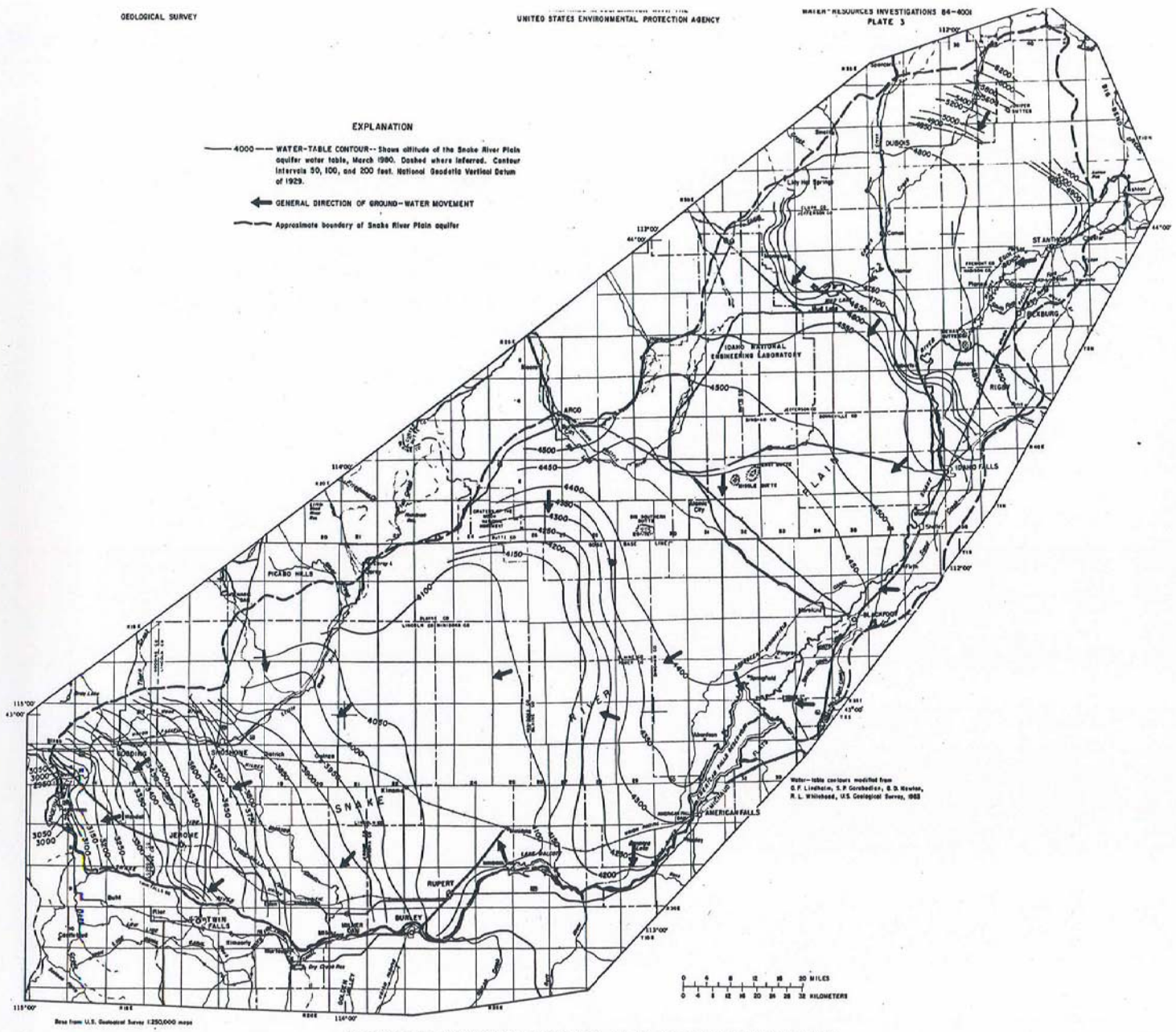


DEPTH TO WATER, MARCH 1980, IN THE SNAKE RIVER PLAIN AQUIFER

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WATER-RESOURCES INVESTIGATIONS 84-4001
PLATE 3



Base from U.S. Geological Survey 1:250,000 maps

Water-table contours modified from G.F. Lindholm, S.P. Garabedian, B.D. Newton, R.L. Whitehead, U.S. Geological Survey, 1983

WATER-TABLE CONTOURS, MARCH 1980, IN THE SNAKE RIVER PLAIN AQUIFER

The direction of groundwater movement can be significantly modified on a local basis by application of surface water, by drawdown due to heavy pumpage, local geologic conditions, and seasonal variations in recharge and discharge. Use of Plate 3, therefore, should be restricted to generally large areas. Site-specific studies and water table maps are more appropriate, and often required, before meaningful conclusions can be made regarding the fate of contaminants reaching the local groundwater system.

Water is often moves more easily laterally than vertically. Where the interbedded material consists of alluvial, eolian and pyroclastic material, its vertical and horizontal permeability depends upon such factors as sorting and stratification, compaction, and degree of cementation. All these factors can be highly variable, and can create an extremely complex structure within which groundwater moves. Water is frequently found to be stratified in water-bearing zones quite separate from one another. As Mundorff et al. (1964) put it:

> "The inability of water to move freely between superimposed water-bearing zones is demonstrated by the commonly observed, slight but significant, differences in water levels in successive zones."

This factor is important in its implications for groundwater contamination, and in the development of three-dimensional flow and solute-transport numerical models. Where the confining layers between successive water-bearing zones consist of massive, dense basalt, little vertical leakage of water, with or without dissolved contaminants, can take place. Where confining beds consist of silt to clay, however, appreciable vertical leakage can take place, especially when the areal extent of the confining layer is considered. Information on the areal distribution and hydrologic characteristics of these confining layers is virtually non-existent; without data concerning these layers, few conclusions can be drawn. In areas of recharge on the Plain, heads decrease with depth, causing downward movement of water. Some of the Plain is characterized by either little or no change in head with depth, or the head generally increase, tending to cause upward movement of water. Only in very few locations is the distribution of head with depth known, and then not through the entire saturated thickness of the aquifer. Upward or downward velocities of water under such conditions are essentially unknown but are probably low.

Calculated values of horizontal groundwater velocities in the aquifer are high. Assuming a saturated thickness of 1,000 feet, an average

water-table gradient of 5 feet per mile, a porosity of 0.5, and transmissivity values of 500,000 to 13,000,000 ft^2/day, calculated groundwater velocities range from .95 feet per day to 24.6 feet per day. It should be stressed that the calculated velocities are average velocities and are based on data from well tests under very localized conditions. According to Lohman (1972) the calculated velocity "...does not necessarily equal the actual velocity between any two points of the aquifer, which may range from less than, to more than this value, depending upon the flow path followed. Thus (the equation used to calculate average velocity) should not be used for predicting the velocity and distance of movement of, say, a contaminant in the groundwater."

This aspect of determining groundwater velocity is especially important to remember when considering contaminant movement in fractured media, such as basalt, due to the highly irregular fracture occurrence and orientation involved. Most mathematical analyses of dispersion of a contaminant assume the aquifer to be homogenous and isotropic, however, this assumption fails in fractured rock aquifers, especially on a local scale. It is simply not possible to know the fracture orientation, bulk fracture porosity, degree of vertical and horizontal connection of fractures and other parameters in sufficient detail to be able to predict with confidence the dispersion of a contaminant under these conditions. This is particularly true when the contaminant may have percolated down through a thick unsaturated zone before reaching the aquifer.

Water-Level Fluctuations

Groundwater levels fall in response to discharge from the aquifer and rise in response to recharge. Fluctuations are important on both short-term (minutes, days, months) and long-term (years) bases. Hydrographs of water-level fluctuations can reveal stresses on the aquifer and whether water in storage is increasing or decreasing over the long term.

The character of fluctuations in agricultural areas depends on whether groundwater or surface water is the principal source of water for irrigation. Where surface water is the source, groundwater levels start to rise after the beginning of an irrigation season as some of the applied water percolates to the saturated zone. A decline in water levels generally is observed shortly after the end of the season.

An area with mixed surface water/groundwater use may have a more complex pattern of water-level changes. Interpretation of the water-level hydrographs requires more knowledge of relative quantities and timing of application of surface and ground waters. However, the pattern of the dominant use in a particular area usually prevails. Many areas undergoing a shift from surface water to groundwater use may show a significant change in patterns over time.

Water levels in areas not influenced by irrigation are either relatively stable or start to rise in early spring in response to snowmelt. Water levels peak in late spring or early summer, then gradually decline The decline continues through fall and winter until spring snowmelt again recharges the aquifer.

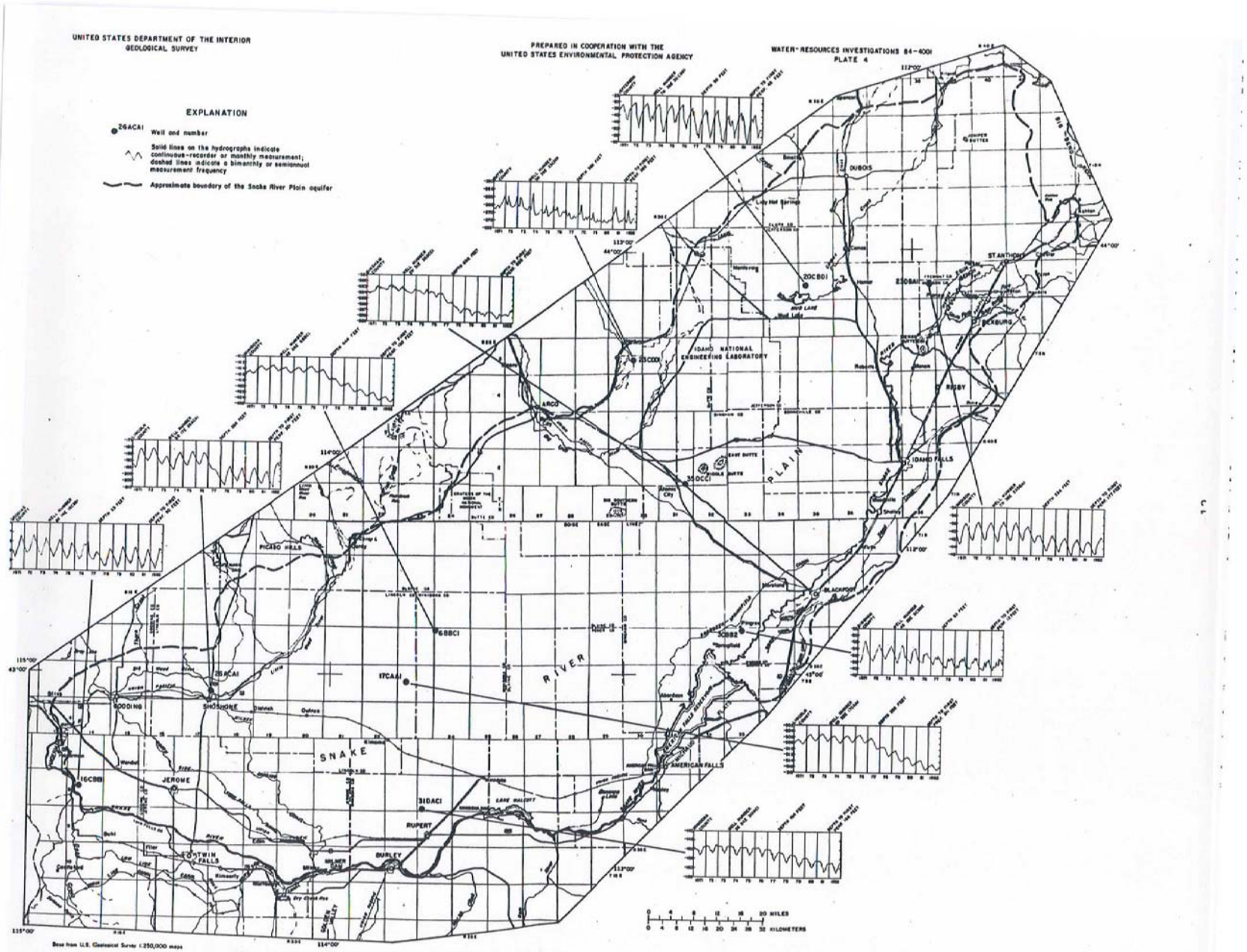
Hydrographs of water levels in 10 selected wells are shown on Plate 4. Water level fluctuations in the Snake Plain Aquifer generally reflect the source of irrigation water. Well 4S-33E-3DBB2 shows fluctuations typical of an area of surface water irrigation where canal losses and seepage from fields constitute the principal source of recharge. Well 8S-24E-31DAC1 shows fluctuations typical of an area of groundwater irrigation where water levels start to decline at the start of the pumping season.

In addition to repetition of seasonal fluctuations, hydrographs on Plate 4 show long-term (several years) trends. Generally, water levels in both surface and ground water irrigated areas show declines starting in the mid-1970's. These downward trends are probably the result of increasing groundwater withdrawals, reduced recharge from surface water owing to changes in irrigation practices, and two periods or reduced precipitation; or a combination of these factors.

Recharge to and Discharge from the Aquifer

Plate 5 shows locations and estimates of recharge to and discharge from the aquifer and contains a groundwater budget for 1980. The aquifer is recharged by percolation from surface water irrigation, inflow from tributary valleys (which includes both groundwater underflow and surface water), precipitation, and seepage losses from the Snake River.

Estimates of recharge from percolation of surface water irrigation, tributary valley inflow, and precipitation totaled 4,800,000, 1,411,000, and 760,000 acre-feet, respectively (S. P. Garabedian, U.S. Geological Survey, written communication, 1983). Estimates of recharge from

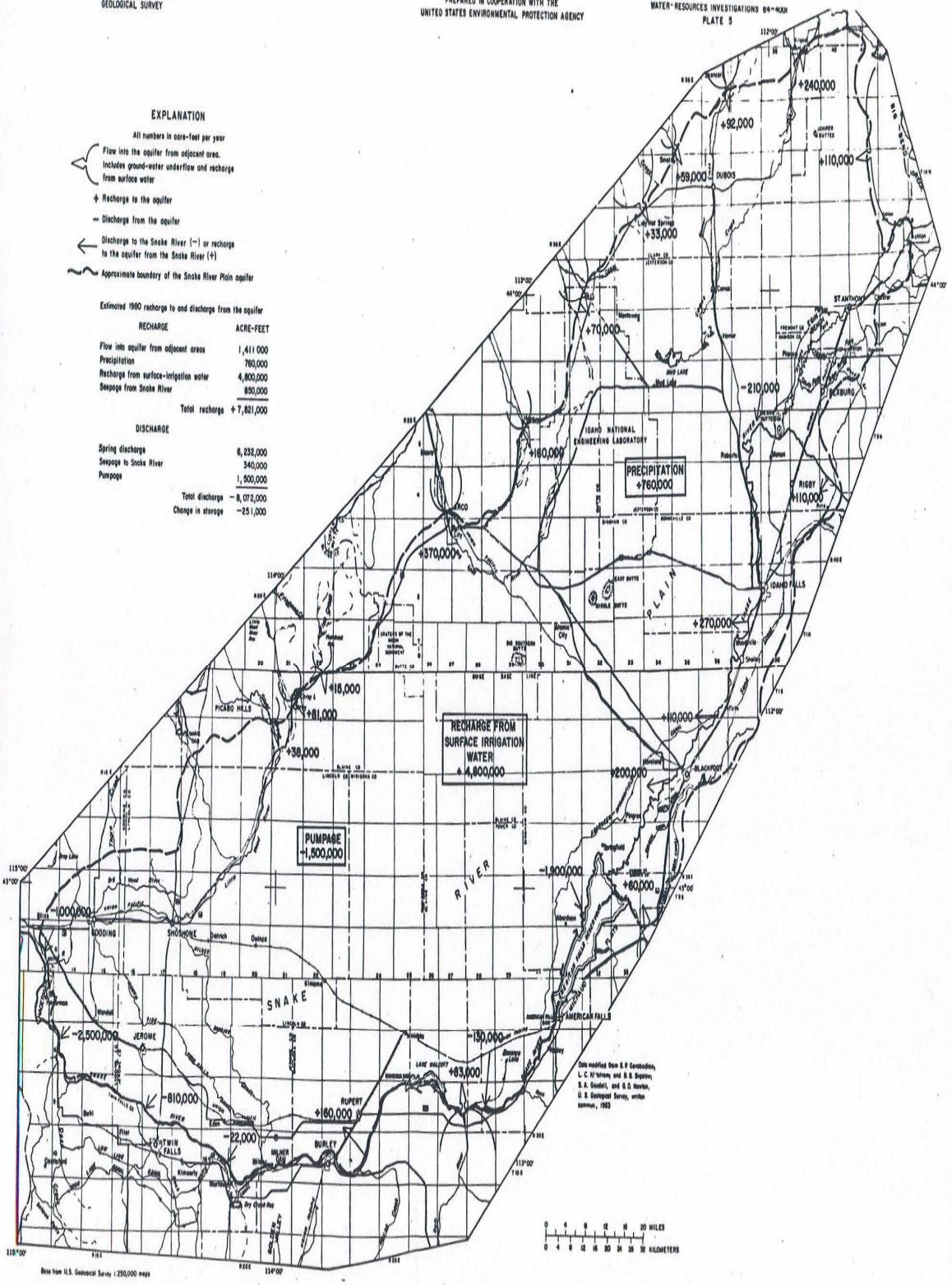


WATER-LEVEL HYDROGRAPHS AND LOCATIONS OF SELECTED WELLS, SNAKE RIVER PLAIN AQUIFER

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WATER-RESOURCES INVESTIGATIONS 84-4001
PLATE 5



ESTIMATED 1980 RECHARGE TO AND DISCHARGE FROM THE SNAKE RIVER PLAIN AQUIFER

seepage losses from the Snake River above Blackfoot totaled 850,000 acre feet (L. C. Kjelstrom, U.S. Geological Survey, written communication, 1983). Total recharge to the aquifer in 1980 was an estimated 7,820,000 acre-feet.

Discharge from the aquifer occurs as spring discharge, groundwater pumpage for irrigation, and seepage to the Snake River. Estimates of spring discharge and seepage to the Snake River totaled 6,232,000 and 340,000 acre-feet, respectively (L. C. Kjelstrom, U.S. Geological Survey, written communication, 1983). Groundwater pumpage for irrigation totaled 1,500,000 acre-feet (B. B. Bigelow, S. A. Goodell, and G. D. Newton, U.S. Geological Survey, written communication, 1983). Groundwater withdrawals for non-irrigation use are not included, because they, while unquantified, make up only a very small percentage of the whole.

An additional potential loss from the aquifer is groundwater evapotranspiration. However, depth to water in most parts of the aquifer is more than 50 feet and precludes any significant loss by this means.

Total discharge from the aquifer in 1980 was 8,072,000 acre-feet. The total recharge of 7,821,000 acre-feet subtracted from total discharge shows a reduction in storage of 251,000 acre-feet in 1980. Hydrographs on Plate 4, which indicate a general decline in water levels, also indicate a net loss in storage.

Spring Discharge

Springs issuing from the Snake Plain Aquifer occur singly, in clusters, and in continuous zones along the Snake River canyon between Milner and Bliss and along the Snake River near American Falls Reservoir between Blackfoot and Neeley. Continuous discharge data for Box Canyon and Blue Lakes Springs indicate that seasonal fluctuations in spring discharge coincides with the irrigation season. Hydrographs of discharge for Box Canyon and Blue Lakes Springs clearly show an increase in discharge shortly after the start of the irrigation season and a decrease in discharge shortly after the conclusion of the irrigation season. Only one measurement per year was available for the remaining springs. However, in 1980, several measurements were made at a number of springs and they show a similar increase in spring discharge corresponding with the irrigation season.

Hydrographs of annual discharge for the springs between Milner and Bliss and for springs near American Falls Reservoir for the period

1970-81 show a decrease in annual spring discharge starting in the mid-1970's, which is coincident with the declining water levels shown on Plate 4.

Groundwater/Surfacewater Relations

Plate 5 shows locations and quantities of groundwater discharge to the river and recharge to the aquifer from the river. Total exchanges of water between the aquifer and the Snake River in 1980 indicate a net recharge to the aquifer of 510,000 acre-feet.

Most of the water moving through the aquifer, as previously discussed, discharges to the Snake River as springs near American Falls Reservoir and between Milner and Bliss. However, the Snake River also loses to the groundwater system. Where the altitude of the water level is above the altitude of the river, groundwater discharges from the aquifer to the river. In areas where the altitude of the water level is below the altitude of the river, the aquifer is recharged by seepage from the river.

A continuing effort by state and federal agencies is being made to better define the complex interrelationships between the Snake River and the Snake Plain Aquifer. In some areas the relationship is relatively well known, in others the relationship is much more obscure. Lack of properly completed observation wells, unavoidable imprecision in gaging station values, inadequate knowledge of the subsurface geology and other factors make it difficult to precisely define reaches of gain to and loss from the aquifer.

The overall complexity of the Snake Plain Aquifer coupled with the uncertainty of its relationship to the Snake River in many areas makes it difficult to provide anything other than generalities in discussion of, for instance, the rate of contaminant movement from the point of contamination at land surface to its eventual discharge either in springs or by wells in areas of groundwater development.

Note: Although much of the above material was taken from USGS Water Resources Investigations Report 84-4001, which in turn was based on previous other publications listed in the Bibliography, much additional commentary was added by the Idaho Department of Water Resources. As a result, statements made and conclusions drawn are those of IDWR, and may or may not reflect the opinion of the USGS.

SOILS AND CLIMATE

Introduction

Soils and climate are important to the water quality of the Snake Plain Aquifer. Soils store much of the moisture from precipitation for plant growth thus reducing infiltration to groundwater. Soils are also media for the retention of nutrients and potential contaminants. Some potential contaminants are decomposed by the biological activity within the soil thus preventing their entry into the groundwater system. The kinds of parent materials from which soils form, interacting with climate, give rise to soil characteristics that are important to water movement and potential contaminant retention and decomposition. These characteristics are soil depth, slope, texture, drainage, permeability, pH, cation exchange capacity (CEC), and organic matter content. These characteristics are discussed in more detail later.

Climate

The climatic factors that are important are the amount of precipitation, temperature, and the period of precipitation. These factors affect the potential recharge by excess moisture, kinds of plants that grow, evapotranspiration and growing season.

The climate (Plate 6) is mainly semi-arid or Mediterranean that is borderline to Continental. A few small areas in the mountain foothills receive enough summer precipitation to be considered subhumid. The precipitation ranges from about 8 inches in the southwestern part of the area near Jerome and Hagerman to near 30 inches on the foothills north of St. Anthony and near Kilgore. Mountains on the west side of the plain create rain shadows that locally affect the distribution and amount of precipitation.

Precipitation comes as snow in late fall and winter and rain during the warmer months. The snow generally does not melt until early spring. The snowfall is reworked by wind forming drifts. The wind velocities and directions are fairly consistent from year to year as the snow drifts usually occur in about the same locations. This creates windswept areas with less effective moisture and snow drift areas with more effective moisture than the annual precipitation rate. On the basalt plains and lava beds, the snow accumulates in the cracks and fractures in the rock. Most

CLIMATIC ZONES; SNAKE PLAIN AQUIFER

EACH POLYGON REPRESENTS AN AREA OF SIMILAR ANNUAL PRECIPITATION (P) AND AVERAGE ANNUAL TEMPERATURE (T)



PLATE 6

SOURCE: "CONSUMPTIVE IRRIGATION REQUIREMENTS FOR CROPS IN IDAHO" BUTTLER & COREY, 1970

of the water from snow melt here goes directly into bedrock fractures where it can potentially move directly into the groundwater system.

The highest amount of rain comes in the spring. Rains that occur from mid-June through September usually wet the soil surfaces and contribute little to plant growth. During the summer there are isolated thunderstorms of various intensities.

Precipitation on the Snake Plain from near Hagerman to Idaho Falls ranges from about 8 to 12 inches. The soil is dry for more than one-half the time and only moist during winter and spring. The wetting front generally is less than 18 inches and the plants use all the moisture that the soil stores. In this area, irrigation is necessary for crop production. The potential for groundwater recharge from natural rainfall is low but excess irrigation water has a higher potential for recharge.

In the area from the Bennett Hills to near Arco and southwest of Big Southern Butte and in an area from about Ashton westerly to Dubois, the precipitation ranges from about 12 to as much as 20 inches. The wetting front in the soils may extend to a depth greater than 30 inches. Dryland agriculture is practical in parts of this area, however most farmed areas are irrigated. The potential for groundwater recharge from natural rainfall is low except in bedrock and lava areas. Excess irrigation water has a higher potential for groundwater recharge.

The average annual air temperature south of a line approximately between the east end of the Bennett Hills to Blackfoot ranges from about 45 to 50 degrees F. The frost free period ranges from about 110 days near Blackfoot to 150 days or more near Hagerman. As an example, the average annual temperature in the southern part of Minidoka County is 47.5 degrees F., the coldest month (January) has an average temperature of 24.5 degrees F. and the warmest month (July) has an average temperature of 71.5 degrees. North of this line the average annual air temperature is less than 45 degrees. The average annual air temperature at Idaho Falls is 44 degrees F., the coldest month (January) has an average temperature of 19.6 degrees F. and the warmest month (July) has an average air temperature of 68.9 degrees. The frost free period ranges for about 110 days at Blackfoot to less than 60 days near Kilgore. The major crop producing area in the northern Snake Plain, which is south of a line between Dubois and St. Anthony, has a frost free season of 70 to 110 days.

The air temperature affects the rate of transpiration of growing plants. The highest consumptive use of water is along the southern boundary of

the area and the lowest use is in the most northern part near Dubois and Kilgore.

The length of the growing season affects the amount of time plants will be actively using soil moisture. The total annual use of moisture is lower in the northern part because of both lower consumptive use and a shorter period of use.

Soil Formation

Soils are a product of an interaction between the kinds of parent materials from which they were formed and the climate under which they were developed. The major parent materials for soils in the Snake Plain Aquifer area are:

1) Alluvium along the drainageways. Adjacent to the streams, the material has been deposited fairly recently. Terraces along the major drainages were mostly deposited by melt water during glacial periods.

2) Wind deposited silts (loess) and windblown sands. These deposits are found mainly to the east of major drainageways. Their sources are assumed to be from melt water deposits during glacial periods. Some minor deposits may have occurred in a more recent period. The source of the sand deposits is: (a) sandy outwash; (b) wind reworking of the sand from the loess and deposition closer to the source; (c) sandy shorelines of glacial lakes of which the present Mud Lake is a remnant. Study of the Landsat scenes indicate the sand dunes between St. Anthony and Dubois had as their sources the Big Lost River valley near Arco, shoreline deposits of Mud Lake and possibly some outwash on the west side of the Snake Plain near the junction of Henry's Fork and the Teton River.

3) Basalt Plains. Basalt plains with a mantle of less than 10 inches to 5 or more feet of wind deposited silt (loess), sand, and some alluvium are common in the Snake Plain. There were many different flows of lava and wide time spans between flows. The most recent is near the Craters of the Moon National Monument. Thickness of the mantle on the basalt plains depends on the time for accumulation and proximity to the source of the mantle material. The thickness of the mantle and roughness of the basalt flow control the soil

depth and slopes on the basalt plains. The older basalt plains generally have the thickest mantle of material and the more strongly developed soils.

4) Old volcanoes. These are prevalent in much of the area. There are two major kinds of volcanoes. One is the low relief shield volcanoes associated with the basalt flows. Soils formed on these are like those on most of the basalt plains. The taller prominent volcanoes, "Big Southern Butte" and "Twin Buttes" are mainly rhyolitic. Soil formed mainly in thin loess and alluvium over pyroclastic materials and old lava flows. The slopes are greater on the rhyolitic volcanoes so there is a higher amount of runoff. The highly developed soils are on the stable slopes. On some active slopes, the soils are weakly developed.

5) Volcanic ash. Some soils formed in material that is mostly volcanic ash. The largest area of these soils is near the Craters of the Moon. Nearly all loess contains some volcanic ash.

The kind and amount of native vegetation are related to the kind of soils and the climates. In general the vegetation in the drier, warmer part is drought tolerant grasses and sagebrush. In this area Wyoming big sagebrush and bluebunch, wheatgrass, Thurber needlegrasses, and Sandburg bluegrass are typical for the moderately deep and deep soils. Where the climate is cooler and precipitation is higher, the typical native vegetation is mountain big sagebrush, bitterbrush, Idaho fescue, and bluebunch wheat-grass. In areas of shallow soils, soils with dense subsoils and soils on windswept areas, the native vegetation is typically low sagebrushes, Sandburg bluegrass, and bluebunch wheatgrass. Some of the lava flows are nearly barren of vegetation except for bitterbrush and some grasses growing in small pockets and cracks. The youngest lava has the least amount of vegetation. On the north side of some of the volcanoes and on some foothills there are Douglas fir, aspen, lodgepole pine with an understory of brush and grasses. The amount and kind of vegetation affect the amount of moisture that moves through the soil into the aquifer.

The sandy warm areas have native vegetation that is mainly basin big sagebrush, Indian ricegrass, and needle-and-thread. The cooler sandy areas have mountain big sagebrush with needle-and-thread, Idaho fescue, and Indian ricegrass. The density of vegetation in sandy areas is quite variable. The amount of groundwater recharge is related to the amount of moisture that goes through the soil prior to and during the growing season and the density of cover.

Soil Thickness and Slope

The soil depth and thickness of the soil column are important to water storage and contaminant retention and decomposition. Soils in the Snake Plain Aquifer range from very shallow (less than 10 inches) on some basalt plains to very deep in the alluvial, loess and sandy deposits. On the basalt plains the shallow soils are on lava ridges. Moderately deep and some deep and very deep soils are in pockets and low areas. In most of the other deposits the soils are very deep, however in some alluvial areas soils have loose stratified gravel and sand at depths of 20 to 40 inches. In these areas contaminants can more readily move into the aquifer. This is especially true where these soils also have a water table within 60 inches of land surface sometime during the year. Areas of various sizes of these soils occur along the drainage system from Kilgore to near Heyburn. Some soils are shallow or moderately deep to a dense layer high in silica and calcium (duripan). These duripans develop at maximum depth of the wetting front. Soils with duripans transmit very little water into the aquifer.

Soil slope affects the amount of water entering the aquifer. Steeper slopes cause precipitation to run off of the steeper areas and concentrate in basins and along toeslopes. On steep slopes little water moves through the soil into underlying aquifers. However on north and east facing slopes where there are large snowdrifts, the amount of water used by plants is less. Excess moisture, therefore, moves into the underlying bedrock cracks or pyroclastic materials and may then enter the groundwater system.

Soil Texture

Soil texture affects the amount of water, nutrients, and potential contaminants that the soil can store. It also affects the rate that water can enter and move through the soil.

The surface texture of soils on the Snake Plain ranges from sands to clay loam. Most of the area has silt loam surface soil. Areas with sandy surfaces are mainly west of Jerome and south of Gooding, northeast of Mud Lake and northwest of St. Anthony and along the terrace east of Heyburn to near American Falls. Some alluvial areas and the old lake bed near Mud Lake have more clay in the soil surface. These soils are mainly clay loam. The amount of surface and subsurface rock fragments (gravel and cobbles) ranges from near 50 percent along some stream channels and on the basalt

plains to none in the loess and wind deposited sands. The presences of rock fragments in the soil diminishes its storage capacity for water, nutrients and potential contaminants.

The texture of subsoils and substrata ranges from sands to heavy clay. Sandy textures are characteristic of soils developed from wind deposited sands and on the terraces along the Snake River and flood plains. Subsoils highest in clay are in the old Mud Lake bed and areas with soil material weathered from basalt. The clay content of these subsoils ranges from 35 to about 60%. In some small areas subsoils contain greater than 60% clay.

Moisture and Drainage

Most of the soils in the Snake Plain are well drained. Some areas of excessively drained soils are associated with the sand dunes northeast of Mud Lake and northwest of St. Anthony, sandy terraces along the Snake River and sandy areas west of Jerome. Some poorly drained soils with high water tables occur in small areas and include drainage ways and lake beds. These soils can be found in the Minidoka and Rupert area.and near the upper end of the American Falls Reservoir. In the plain, the water table ranges from near the surface to greater than several hundred feet. The basalt plains and loess areas generally have the deepest water tables.

The soil permeability (or rate that water moves through the soil) ranges from very rapid in sands and underlying gravels on terraces and flood plains to very slow for soil with high clay content or a duripan.

Soil pH and Cation Exchange Capacity

Soil pH and cation exchange capacity are important soil characteristics that affect the ability of soil to store nutrients and potential contaminants The soil pH ranges from strongly alkaline (pH 9.0) to medium acid (pH 5.6). The medium acid soils are of small acreage in the foothills where the native vegetation is forest. Soils in areas with 8 to 12 inches of precipitation have the highest pHs. These soils are generally high in lime (calcium carbonate), some contain sodium, and some have other salts. Generally these soils are leached free of lime to a depth of about 10 to 18 inches, however, some are calcareous to the surface. In areas of 12 to 20 inches of precipitation the soils are leached to depths of 18 to 30 inches and the surface and subsoils are neutral. The calcium carbonate is usually clay or fine silt size but it does not store nutrients as do clay particles. Some contaminants such as pesticides have rates of

decomposition which are dependent on the soil pH. Some break down faster in an acidic medium, others decompose most rapidly in alkaline soils. The mobility or availability of trace elements such as iron, zinc, and boron is controlled by soil pH. Soil pH is also important in determining the availability of phosphorus, an important plant nutrient.

The cation exchange capacity (CEC) of soils refers to the soil's capacity to store or release positively charged ions (cations). The CEC is determined by soil properties such as organic matter content, clay content, and kind of clay. Organic matter has the highest CEC, ranging up to 200 meq/100 grams. Montmorillonite clay also has a high cation exchange capacity (>90 meq/100 grams) (Nettleton and Bracher, 1983). Montmorillonitic clays are dominant in some of the soils in lake beds and in soils weathered from basalt. Some other clays have high cation exchange capacities. Kaolinitic clays have the lowest CECs. However, soils in the Plain are low in kaolinitic clays.

Cation exchange capacity for silts and sands is very low. Nutrients and potential contaminants are more likely to move through the soil with the soil water, resulting in a greater chance for entry into the aquifer. Soils that are high in organic matter and montmorillonitic clay have the highest CEC. These soils will store nutrients and certain contaminants the longest. Some potential contaminants have limited active lives. The longer they are stored in the soil, the more likely they are to decompose and not enter the aquifer.

Organic Matter

Soils in the Snake Plain generally contain 1 to 3 percent organic matter but range from practically none on the sand dunes to nearly 100 percent for the organic soils near the upper end of the American Falls Reservoir. Organic matter content of the soil is important to the control of surface water pollution, air pollution and subsurface water pollution. Organic matter itself, however, can be a contaminant where its content is extremely high. Water flowing through saturated organic soils can become high in suspended organic soils.

Organic matter in the surface soil tends to promote soil aggregation and improve soil tilth. Soils that have little if any soil aggregates or have very small aggregates are subject to wind erosion. Soils with good aggregation do not erode by water as easily, thus runoff water carries less soil. The infiltration of water into soils is generally greater if there is

good soil aggregation; this results in less runoff and more percolation into the soil.

Summary

The distribution and kinds of soils are important in predicting the potential for contaminants to enter the groundwater system. Based on the characteristics of major soils on the Snake Plain, the areas with highest potential for controlling the entry of contaminants into the aquifer are:

1) Loess soils that are very deep
2) Soils with limiting layers
3) Soils high in organic matter
4) Soils that receive much less rainfall than the plants can use
5) Soils with high amounts of montmorillonite in their subsoils
6) Soils high in all kinds of clays
7) Great depth to water table

Soils that have medium potential for controlling entry of contaminants into the aquifer are:

1) Shallow and moderately deep soils above bedrock.
2) Soils with a well developed subsoil but with less than 18 percent clay
3) Soils with moderate amounts of organic matter
4) Areas where vegetation uses most of the available precipitation
5) Areas of bedrock with moderate amounts of cracks that collect snow

Soils with the lowest potential for controlling the entry of contaminants into the aquifer are:

1) Soils with high water tables (less than 60 inches below land surface)
2) Soils which are very low in clay or silt and are mostly sandy
3) Areas where there is more soil moisture than the plants use
4) Areas of excess irrigation
5) Soils underlain with loose sand and gravel with no barrier between the soil and water table
6) Soils which are very low in organic matter
7) Areas of soil where there is run-in or ponding of water

Source of Data

The General Soils Map of the Snake Plain Aquifer (Plate 7) was developed based on information from the following sources: 1) General Soils Map – Idaho (U.S. Department of Agriculture, 1984); 2) published Idaho Soils Surveys for the areas of Bingham County , Bonneville County , Fort Hall , Jefferson County , Madison County , and Minidoka County; 3) unpublished ongoing Idaho soils surveys for the areas of Blaine County , Clark County , Fremont County , Jerome-Twin Falls County , and lower part of the Wood River (parts of Blaine, Gooding, Lincoln, and Minidoka Counties); 4) unpublished soils surveys conducted for BLM in the "Big Desert" Resource area (parts of Bingham, Blaine, Butte, and Minidoka Counties); 5) Landsat scenes band 5 and 7; 6) unpublished data (May, 1985) from the heavy metals project, National Soil Survey Laboratory, Lincoln, Nebraska; 7) unpublished physical and chemical data on 146 soil profiles from Idaho (1977-1983); and 8) consultation with Dr. Holzey, Dr. Nettleton, and Dr. Brasher of National Soil Survey Laboratory, Dr. Forsberg, University of Idaho and Glen Logan, SCS – Idaho Soil Correlator, 9) Idaho Soils Atlas.

The General Soils Map (Plate 7) does not show the kind of soil at a specific site but indicates the kind of soil that is most representative of an area. A more detailed map or on-site inspections are required to best evaluate the land use capabilities for a specific piece of land.

Soil Descriptions

The soils of the Snake Plain have been grouped by their climatic class, kinds of patent material and geomorphic position. (Refer to Appendix A for expanded, more detailed descriptions of each soil type.)

Cold, moist soils on terraces and flood plains

*1. Kilgore Variant-Hagenbarth-Alex Association
Very deep, well to somewhat poorly drained medium textured soils with slopes of 0 to 4 percent on terraces and flood plains. (Cryic-Xeric)

Cold, wet to dry soil on terraces and flood plains

2. Bannock-Heiseton-Fulmer Association
Very deep, well, moderately well, and poorly drained, medium and

GENERAL SOIL MAP, SNAKE PLAIN AQUIFER

GENERAL SOIL ASSOCIATIONS

COLD, MOIST SOILS ON TERRACES AND FLOOD PLAINS
1. KILGORE VARIANT-HAGENBARTH-ALEX ASSOCIATION

COOL, WET TO DRY SOILS ON TERRACES AND FLOOD PLAINS
2. BANNOCK-HEISETON-FULNER ASSOCIATION
3. TERRETON-LEVELTON ASSOCIATION
4. WHITEKNOB-TERRETON ASSOCIATION
5. LITTLEWOOD-BALLARD-ADRASON ASSOCIATION

WARM, WET TO DRY SOILS ON TERRACES AND FLOOD PLAINS
6. SNAKE-PHILBOH ASSOCIATION
7. DECLO-FELTHAM ASSOCIATION
8. PAULVILLE-DECLO ASSOCIATION
9. HOOSHOOH-DECKEA ASSOCIATION

COLD, MOIST SOILS ON BASALT PLAINS
11. YAMARIS-KAMARD ASSOCIATION

COOL, DRY SOILS ON BASALT PLAINS
12. MCCAREY-TENNO-ROCK OUTCROP ASSOCIATION
13. MALM-BONDFORM-ROCK OUTCROP ASSOCIATION
14. ORMSBY BUTTE-MATHERSON-DIXTON ASSOCIATION
15. MCBIGGAR-GOODZWOTON ASSOCIATION
16. MCET-BERENICETON-ROCK OUTCROP ASSOCIATION
17. PAHACHARI-POLATIS ASSOCIATION

WARM, DRY SOILS ON BASALT PLAINS
18. PORTNEUF-PORTINO-TREVINO ASSOCIATION
19. DEERHORN-RENFIELD ASSOCIATION
20. BIOLAKE-PAULVILLE ASSOCIATION
21. OOOOINO-POWER-ROCK OUTCROP ASSOCIATION
23. OOOOINO-HANKUB ASSOCIATION
24. PAULVILLE-MCCOY ASSOCIATION
25. PORTNEUF-NEWDOKA ASSOCIATION
26. KARCAL-YUTURE-CHILCOTTE ASSOCIATION
27. PORTINO-TREVINO-ROCK OUTCROP ASSOCIATION
28. VENINO-KEXO-BIOLAKE ASSOCIATION

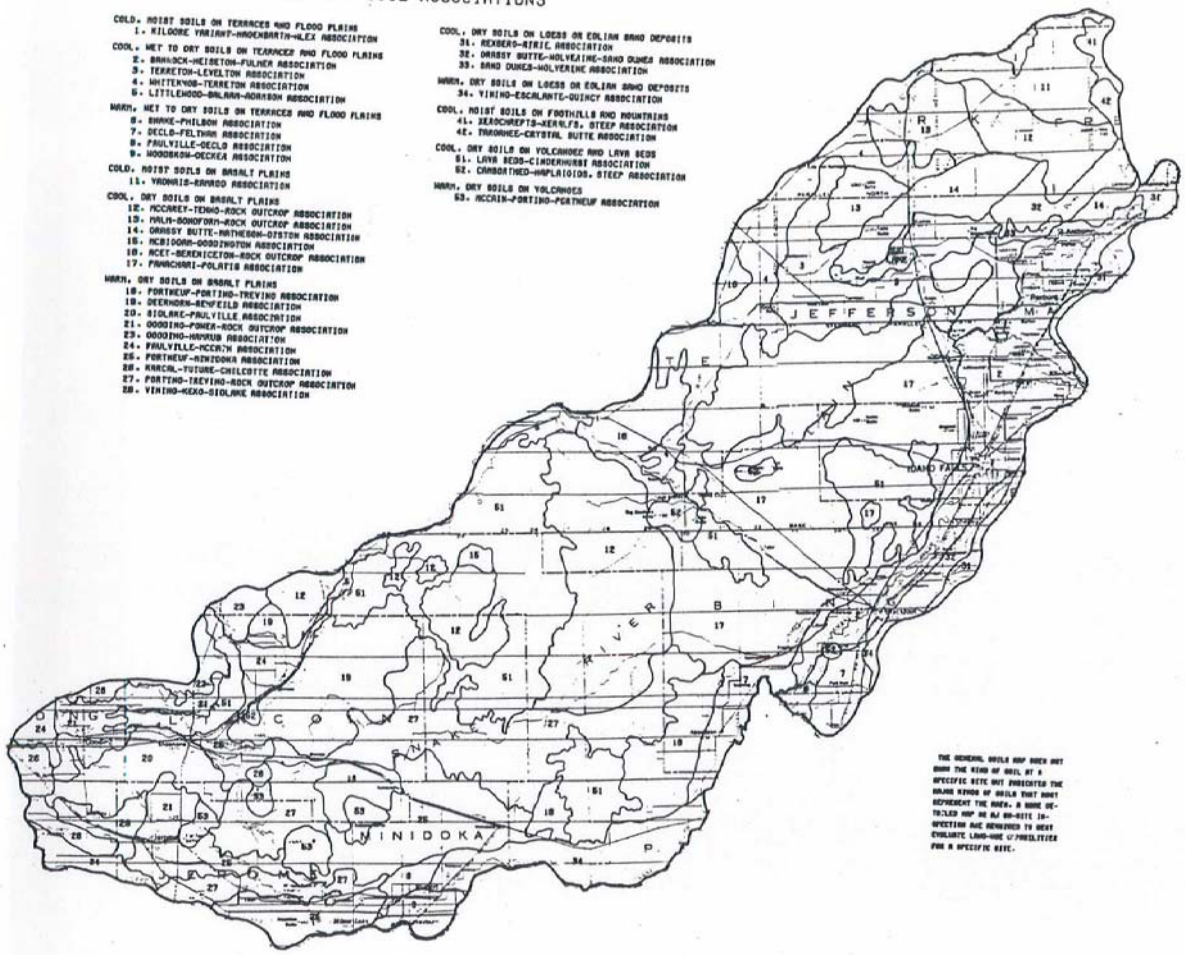
COOL, DRY SOILS ON LOESS OR EOLIAN SAND DEPOSITS
31. REXBERG-RIRIE ASSOCIATION
32. ORMSBY BUTTE-WOLVERINE-SAND DUNES ASSOCIATION
33. SAND DUNES-WOLVERINE ASSOCIATION

WARM, DRY SOILS ON LOESS OR EOLIAN SAND DEPOSITS
34. VINNO-ESCALANTE-QUINCY ASSOCIATION

COOL, MOIST SOILS ON FOOTHILLS AND MOUNTAINS
41. XERORTHENTS-XEROLLS, STEEP ASSOCIATION
42. TARGHEE-CRYSTAL BUTTE ASSOCIATION

COOL, DRY SOILS ON VOLCANOES AND LAVA BEDS
51. LAVA BEDS-CINDERHURST ASSOCIATION
52. CAMBORTHED-HAPLAQUOLS, STEEP ASSOCIATION

WARM, DRY SOILS ON VOLCANOES
53. MCCAIN-PORTINO-PORTNEUF ASSOCIATION



THE GENERAL SOILS MAP DOES NOT SHOW THE KIND OF SOIL AT A SPECIFIC SITE BUT INDICATES THE MAJOR KINDS OF SOILS THAT MOST REPRESENT THE AREA. A MORE DETAILED MAP OR AN ON-SITE INSPECTION ARE REQUIRED TO MEET EVALUATE LAND-USE ALTERNATIVES FOR A SPECIFIC SITE.

PLATE 7

SOURCE: PUBLISHED & UNPUBLISHED SOIL SURVEYS, IDAHO DIVISION OF ENVIRONMENT & U.S. SOIL CONSERVATION SERVICE, 1975

moderately coarse textured soils with slopes of 0 to 4 percent on terraces and flood plains. (Frigid-Aridic)

3. Terreton-Levelton Association
   Very deep, well drained and very poorly drained, moderately fine textured, and moderately coarse textured soils of 0 to 6 percent on old lakebeds and terraces. (Frigid-Aridic)

4. Whitenob-Terreton Association
   Very deep, well drained, medium and moderately coarse textured soils with slopes of 0 to 12 percent on alluvial fans, terraces, and lakebeds. (Frigid-Aridic)

*Numbers represent soil type on the General Soils Map shown in Plate 7.

5. Little Wood-Balaam-Adamson Association
   Very deep, well and somewhat excessively drained, medium and moderately coarse textured soils with slopes of 0 to 4 percent on terraces. (Frigid-Xeric)

Warm, wet to dry soils on terraces and flood plains

6. Snake-Philbon Association
   Very deep, well drained, medium and coarse textured soils with slopes of 0 to 10 percent on terraces. (Mesic-Aridic)

7. Declo-Feltham Association
   Very deep, well drained, medium and coarse textured soils with slopes of 0 to 10 percent on terraces. (Mesid-Aridic)

8. Paulville-Declo Association
   Very deep, well drained, medium textured soils with slopes of 0 to 20 percent on terraces. (Mesic-Aridic)

9. Woodskow-Decker Association
   Very deep, somewhat coarsely and moderately well drained, medium and moderately coarse textured soils with slopes of 0 to 2 percent on terraces. (Mesic-Aridic)

Cold, moist soils in basalt plains

11. Vadnais-Ramrod Association
Deep and moderately deep, well drained, medium textured soils with slopes of 1 to 12 percent on basalt plains. (Cryic – Xeric)

Cool, dry soils on basalt plains

12. McCarey-Tenno-Rock Outcrop Association
Moderately deep and shallow, well drained, medium textured soils and rock outcrops with slopes of 0 to 30 percent on basalt plains. (Frigid-Xeric)

13. Malm-Bondfarm-Rock Outcrop Association
Moderately deep and shallow, well drained, moderately coarse textured soils and rock outcrops with slopes of 2 to 20 percent on basalt plains. (Frigid-Aridic)

14. Grassy-Butte-Matheson-Dishton Association
Very deep to moderately deep, well and somewhat excessively

drained, moderately coarse and coarse textured soils with slopes of 0 to 20 percent on eolian sand covered basalt plains. (Frigid-Aridic)

15. McBiggam-Goodington Association
Very deep, well drained, medium textured soils with slopes of 2 to 20 percent on volcanic ash covered basalt plains. (Frigid-Aridic)

16. Aecet-Bereniceton-Rock Outcrop Association
Moderately deep and deep, well drained, moderately coarse textured soils and rock outcrops with slopes of 0 to 25 percent on basalt plains. (Frigid-Aridic)

17. Panchari-Polatis Association
Very deep and moderately deep, well drained medium textured soils on slopes of 0 to 12 percent on basalt plains. (Frigid-Aridic)

Warm, dry soils on basalt plains

18. Portneuf-Portino-Trevino Association
Very deep to shallow, well drained, medium textured soils with slopes of 0 to 25 percent on basalt plains. (Mesic-Aridic)

19. Deerhorn-Rehfield-Rock Outcrop Association
Moderately deep and deep, well drained, moderately coarse textured

soils and rock outcrop with slopes of 0 to 15 percent on basalt plains. (Mesic-Aridic)

20. Sidlake-Paulville-Rock Outcrop Association
Very deep and moderately deep, medium and moderately coarse textured soils and rock outcrops with slopes of 0 to 15 percent on basalt plains. (Mesic – Aridic)

21. Gooding-Power-Rock Outcrop Association
Deep and very deep, well drained, medium textured soils and rock outcrops with slopes of 0 to 25 percent on basalt plains. (Mesic-Aridic)

23. Gooding-Hamrub Association
Deep, well drained, medium textured soils with slopes of 0 to 20 percent on basalt plains. (Mesic-Aridic)

24. Paulville-McCain-Rock Outcrop
Very deep and moderately deep, well drained, medium textured soils and rock outcrops with slopes of 0 to 20 percent on basalt plains. (Mesic-Aridic)

25. Portneuf-Minidoka Association
Very deep and moderately deep, well drained, medium textured soils with slopes of 0 to 12 percent on loess covered basalt plains. (Mesic-Aridic)

26. Karcal-Yutrue-Chilcotte Association
Very deep and moderately deep, well drained, fine and medium textured soils with slopes of 0 to 12 percent on basalt plains. (Mesic-Aridic)

27. Portino-Trevino-Rock Outcrop Association
Moderately deep and shallow, well drained, medium textured soils and rock outcrops with slopes of 0 to 25 percent on basalt plains. (Mesic-Aridic)

28. Vining-Keko-Sidlake Association
Very deep to shallow, well drained, moderately coarse textured soils with slopes of 2 to 20 percent on loess mantled basalt plains. (Mesic-Aridic)

Cool, dry soils on loess or eolian sand deposits

31. Rexburg-Ririe Association
Very deep, well drained, medium textured soils with slopes of 0 to 25 percent on silty eolian deposits. (Frigid-Xeric)

32. Grassy Butte-Wolverine-Sand Dunes Association
Very deep, excessively drained, coarse textured soils and sand dunes with slopes of 0 to 30 percent on eolian sand covered plains. (Frigid-Aridic)

33. Sand Dunes-Wolverine Association
Very deep, excessively drained, coarse textured soils and sand dunes with slopes of 0 to 50 percent on eolian sand covered plains. (Frigid-Aridic)

Warm, dry soils on loess or eolian sand deposits

34. Vining-Escalante-Quincy Association
Moderately deep and very deep, well and excessively drained soils with slopes of 0 to 40 percent on terraces and eolian sand covered plains. (Mesic-Aridic)

Cool, moist soils on foothills and mountains

41. Xerochrepts-Xeralfs, Steep Association
Moderately deep, well drained, medium and moderately coarse textured soils with slopes of 15 to 60 percent on the sideslopes of the Island Park caldera. (Frigid-Xeric)

42. Targhee-Crystal Butte Association
Moderately deep and very deep, well drained, moderately coarse and medium textured soils with slopes of 15 to 40 percent on foothills and mountain slopes. (Cryic-Xeric)

Cool, dry soils on volcanoes and lava beds

51. Lava Beds-Cinderhurst Association
Very shallow, well drained, medium textured soils and lava beds with slopes of 1 to 30 percent on plains. (Frigid-Aridic)

52. Camborthids-Haplaigids, steep Association
Moderately deep, well drained, medium and moderately coarse

LAND USE; SNAKE PLAIN AQUIFER

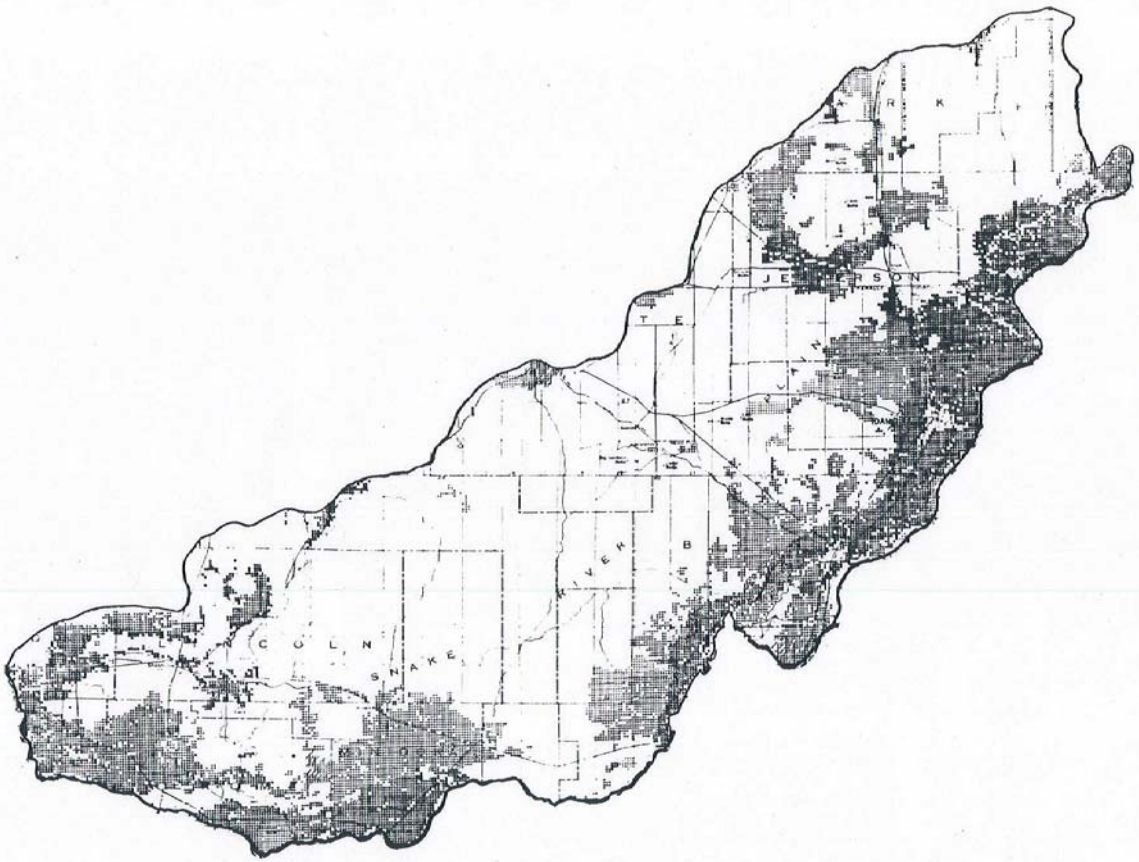


PLATE 8

SOURCE: "REGIONAL AQUIFER SYSTEM RESEARCH STUDY", IDAHO DEPARTMENT OF WATER RESOURCES, 1980

AN INDIVIDUAL SYMBOL REPRESENTS 160 ACRES OF THE INDICATED LAND USE

DRYLAND HORTICULTURE
IRRIGATED BY MIXED SOURCE
IRRIGATED BY GROUNDWATER
IRRIGATED BY SURFACE WATER

textured soils with slopes of 15 to 60 percent on sideslopes of old volcanoes. (Frigid-Aridic-Xeric)

Warm, dry soils on volcanoes

53. McCain-Portino-Portneuf Association
Deep and moderately deep, well drained, medium textured soils with slopes of 5 to 20 percent on old shield volcanoes. (Mesic-Aridic)

LAND AND GROUNDWATER USE

The Snake Plain Aquifer as shown on Plate 8 covers approximately 9,600 square miles. Land uses above the aquifer include urban, agricultural, industrial, and transportation activities. Groundwater use plays an important role on the Plain in relation to these land use activities.

The governing jurisdictions within the boundaries of the aquifer include all of part of 14 counties, a part of the Fort Hall Indian Reservation, and most of the Idaho National Engineering Laboratory. Forty incorporated cities of which 11 are urban (see Table 1) and numerous communities are also included. Of the estimated population of 201,694 within the plain approximately 46% or 93,224 live within urban cities. An additional 17,609 people live within 29 rural cities. The total population within the incorporated cities of the Snake Plain accounts for 57% of the total population of the area.

Agricultural activity is the dominant land use within the Snake Plain Aquifer. Approximately 3514 square miles or 37% of the Plain is in agricultural use. Groundwater irrigates approximately 1396 square miles and surface water irrigates about 1819 square miles. The remaining 299 square miles of agricultural land is either dry land agriculture or the source of irrigation water is mixed or unknown. The leading agricultural products within the counties of the Snake Plain Aquifer include potatoes, cattle and calves, and wheat. Some of the other agricultural products of the area include corn, sugar beets, milk, cheese, barley, alfalfa hay, oats, red clover and Kentucky Bluegrass seed, dry beans, hogs and pigs, sheep and lambs, and dry edible peas.

Since agriculture is the main activity on the Snake Plain, the major industrial activity is food processing. This involves mainly potato processing and also includes meat packing and sugar processing. However, one of the single largest employers in the area is the Idaho National Engineering Laboratory (INEL). This facility builds, operates, and tests various types of nuclear reactors. The reactors are built primarily to develop peace time uses of atomic energy. Fifty-two reactors have been constructed to date, of which 17 are still operable. The INEL site covers about 890 square miles which lie mostly within the boundaries of the aquifer (Plate 8).

The major transportation systems found in the area of the Snake Plain Aquifer include U.S. and State highways, interstate highways, and a railroad network. This includes about 175 miles of interstate and 664

miles of U.S. and State highways. Two major lines of the Union Pacific Railroad serve the area. The line from American Falls to Bliss (about 116 miles) has a freight traffic flow greater than 20 million gross tons per year. The line from Chubbuck to Spencer (about 104 miles) has a flow of 5-20 million gross tons per year of freight traffic.

Table 1
Snake River Plain Governing Jurisdictions

Counties[1]

1. Bannock
2. Bingham
3. Blaine
4. Bonneville
5. Butte
6. Clark
7. Fremont
8. Gooding
9. Jefferson
10. Jerome
11. Lincoln
12. Madison
13. Minidoka
14. Power

[1]Includes all of parts of these counties.

Cities and Population

1. Aberdeen 1,528
2. Acequia 100
3. Ammon* 4,669
4. Arco 1,241
5. Ashton 1,219
6. Atomic City 34
7. Basalt 414
8. Blackfoot* 10,065
9. Butte City 93
10. Dietrich 101
11. Dubois 413
12. Eden 355
13. Firth 460
14. Gooding* 2,949
15. Hammer 93
16. Hazelton 496
17. Heyburn* 2,889
18. Idaho Falls* 39,590
19. Iona 1,072
20. Jerome* 6,891
21. Lewisville 502
22. Menan 605
23. Minidoka 101
24. Mud Lake 243
25. Newdale 329
26. Parker 262
27. Paul 940
28. Rexburg* 11,559
29. Richfield 357
30. Rigby* 2,624
31. Ririe 495
32. Roberts 466
33. Rupert* 5,476
34. Shelley* 3,300
35. Shoshone 1,242
36. St. Anthony* 3,212
37. Sugar City 1,022
38. Teton 559
39. Ucon 833
40. Wendell 1,974

*Urban Cities – based upon 1980 census. Census Bureau defines urban as incorporated cities of 2,500 persons or more.

Other

1. Fort Hall Indian Reservation
2. Idaho National Engineering Laboratory

The major use of groundwater within the Snake Plain is irrigated agriculture. According to a U.S. Geological Survey report, an estimated 1.5 million acre/feet of groundwater was pumped from the Snake Plain Aquifer in 1980 (Bigelow et al., 1984). Estimated groundwater use in 1980 from industrial activities was 50,000 acre/feet and domestic water use was 35,220 acre/feet (Solley et al., 1983). Domestic water supplies are drawn entirely from groundwater and were determined by using 231 gallons/day/person for 93,224 urban residents and 98 gallons/day/person for 108,470 rural residents. Therefore, of the 1,585,220 acre/feet pumped from the aquifer, 95%, 3%, and 2% are used for agriculture, industry, and domestic water supplies respectively.

Groundwater pumpage is concentrated in the Mud Lake and Minidoka project areas. Irrigators in the Mud Lake area consume less power per acre-foot of pumpage than those in other intensely pumped areas. Low power consumption per unit pumpage occurs because lifts are low and many wells discharge to gravity irrigation systems (Bigelow et al., 1984).

According to the U.S. Geological Survey's Snake River Plain RASA (Regional Aquifer-Systems Analysis) study, total annual groundwater recharge under current conditions is about 8 million acre-feet in the Snake Plain Aquifer (Kjelstrom, 1984). On the basis of these estimates, 1980 groundwater pumpage was equal to about one-fifth of annual (1980) recharge to the groundwater system.

WATER QUALITY

Introduction

The chemical characteristics of the Snake Plain Aquifer are determined by the characteristic s of the water that recharges it. The major recharges are from excess irrigation water, seepage from streams, underflow from tributary basins and precipitation (Yee and Souza, 1984). Low (1985) indicated that most inorganic solutes are derived from tributary drainage in the north and east of the eastern Snake Plain. Only 2 to 5 percent of the total recharge water to the aquifer is from precipitation (Lewis and Goodell, 1985).

The following factors have been determined to have an effect on the chemical characteristics of the aquifer's water (Parliman, 1983):

1. Geochemical properties such as solubility and exchange characteristics of aquifer materials
2. Contact time of water with aquifer materials
3. Mineral composition of aquifer materials
4. Relative proximity of sampling sites to source of groundwater recharge .
5. Influences of man's activities.

There is a very complex association with each of these components and that complexity of distribution has been noted laterally in the aquifer and with depth (Dyer and Young, 1971). The Snake Plain Aquifer water is characterized as being of the calcium-magnesium bicarbonate type with moderate concentrations of sodium, silica, sulfate and chloride (Lewis and Goldstein, 1982, p. 44).

According to Yee and Souza (1984) water quality data for the Snake Plain Aquifer are sparse and only general statements can be made regarding the areal distribution of constituents, with very few data available to describe temporal variations. The shortcomings of the groundwater quality data base for Idaho in general are cited as:

1. Multi-aquifer sample inadequacy
2. Constituent coverage limitations,
3. Baseline-data deficiencies
4. Data-base nonuniformity.

The water that passes through the two major geological features, the basalt of the Snake River Group and the Quaternary sediments, is similar.

The total dissolved solids average less than 250 mg/L. This low level indicates that dissolution of minerals within the aquifer is very low. About 50 percent of total cations are calcium and 80 percent of the total anions are bicarbonate.

Data Analysis Review

Data on groundwater quality are very diverse, having different characteristics of space, time and quality (Naidu et al., 1985). As can be seen from the preceding section, this is indeed the case with the Snake Plain Aquifer. The reliability of groundwater analysis is affected by the following general factors:

1. Spatial variability in the aquifer
2. Temporal variability in the aquifer
3. Monitoring well construction and location
4. Sampling integrity
5. Accuracy and precision of analytical techniques

Errors in the choice, application and interpretation of analytical techniques are common (Naidu et al., 1985). The standard deviation of a specific test method, even if followed by two or more laboratories, will be different for those laboratories.

Three major problems confound the statistical analysis of groundwater data:

1. The lack of information which may result in missed values in time or in space and the lack of synoptically sampled data sets for comparison.
2. The difficulty of taking complex aquifer information into account in a statistical analysis.
3. The problem of satisfying the assumptions of the statistical tests used.

By restricting data analysis to a specific data provider and reviewing sampling sites with the largest number of test data , the results of statistical tests become more valid. Additionally, the decision on the validity of the data reviewed will depend a large part upon the analyst's judgment and knowledge.

The review and integration of data from all known sources into a single composite summary is, therefore, significantly beyond the scope of this

report. However, to determine the impacts of man on the aquifer's water quality five major aquifer constituents are considered as important for in-depth review:

1. Chloride and total dissolved solids
2. Safe Drinking Water Act Primary Parameters
3. Bacteriological quality
4. Organic chemicals
5. Radionuclides

Chloride and Total Dissolved Solids

Total dissolved solids, that is the total amount of dissolved ions in the water, is the result of both aquifer lithology and of land use activities. The criterion for total dissolved solids is significant for waters intended for agricultural, industrial or public drinking use. Constituents such as sodium, calcium and magnesium can limit use for irrigation or steam generation. Total dissolved solids greater than 500 milligrams per liter (mg/L) and chloride above 250 mg/L are not recommended for drinking water.

Dyer and Young (1971) reviewed the analysis of samples collected from 194 irrigation wells and 29 springs in conjunction with a groundwater pumpage inventory of the Snake Plain Aquifer. Many of the sites were sampled twice but no seasonal variation was detected among the dissolved constituents.

An indication of total dissolved solids can be made with the specific conductance test. In the Snake Plain Aquifer, specific conductance is approximately twice the total dissolved solids. Specific conductance was greater than 300 micromhos per centimeter along the eastern and southern margins of the Plain. Five samples from areas that were irrigated showed specific conductance in excess of 1000 micromhos per centimeter. The central Plain had specific conductance values of less than 300 micromhos per centimeter.

Chloride is the result of dissolution from aquifer rock or land-use. Highest chloride concentrations were noted in areas of intensive irrigation. Chloride ranged from 7 to 325 mg/L, with chloride at 10 to 160 mg/L in heavily irrigated areas (Low 1985).

Five areas were identified with high dissolved solids and chlorides: northwest of Rupert, north of American Falls Reservoir, west of American Falls Reservoir, north of Lake Walcott and near Monteview northwest of

Mud Lake. Although the cause of the higher values was not known, it was noted that these areas have intensive irrigation and are underlain by permeable sediments. However, the samples were all primarily collected from areas irrigated by groundwater and may not accurately reflect the quality of the total water recharged to the aquifer.

Low (1985) summarized USGS data on the complete Snake Plain Aquifer, including the western portion from Bliss to Weiser. Total dissolved solids and chloride were the two constituents considered. Their concentrations are shown in Plates 9 and 10.

Temporal changes were not obvious (Parliman, 1983, Low, 1985). Areal changes were noted most significantly in irrigated areas. It is concluded that the water in the part of the aquifer sampled for the studies was generally of good chemical quality and suitable for most uses.

Safe Drinking Water Act Primary Parameters

The Safe Drinking Water Act of 1976 established requirements for the chemical and bacteriological analysis of all public drinking waters on a routine, regular basis. Primary parameters required to be analyzed are arsenic, barium, cadmium, chromium, fluoride, lead, mercury, selenium, nitrate and silver. Their limits are listed in Table 2.

Since it is the water provided to the public as drinking water that is of greatest significance, it is only reasonable to look at that data. All previous discussion has been from wells other than drinking water wells. The data selected for review in this section were taken from drinking water monitoring reports provided to the Department of Health and Welfare from public water systems in municipalities located in the Plain. The Bureau of Laboratories established a rigorous quality assurance/quality control program in 1977 as a result of requirements of the Safe Drinking Water Act. All laboratories state-wide that provided analytical results must follow the same quality control practices and participate in routine reviews and round-robin sample testing. Therefore, test results prior to 1977 were excluded from review.

The Safe Drinking Water Act, however, requires heavy metals testing on drinking waters only every three years. That restricted the number of individual samples from any given well to no more than three since 1977.

DISSOLVED SOLIDS: SNAKE PLAIN AQUIFER

DISSOLVED SOLIDS CONCENTRATION.
SUM OF CONSTITUENTS,
IN MILLIGRAMS PER LITER

<200 LESS THAN 200
200-400 200 TO 400
>400 GREATER THAN 400

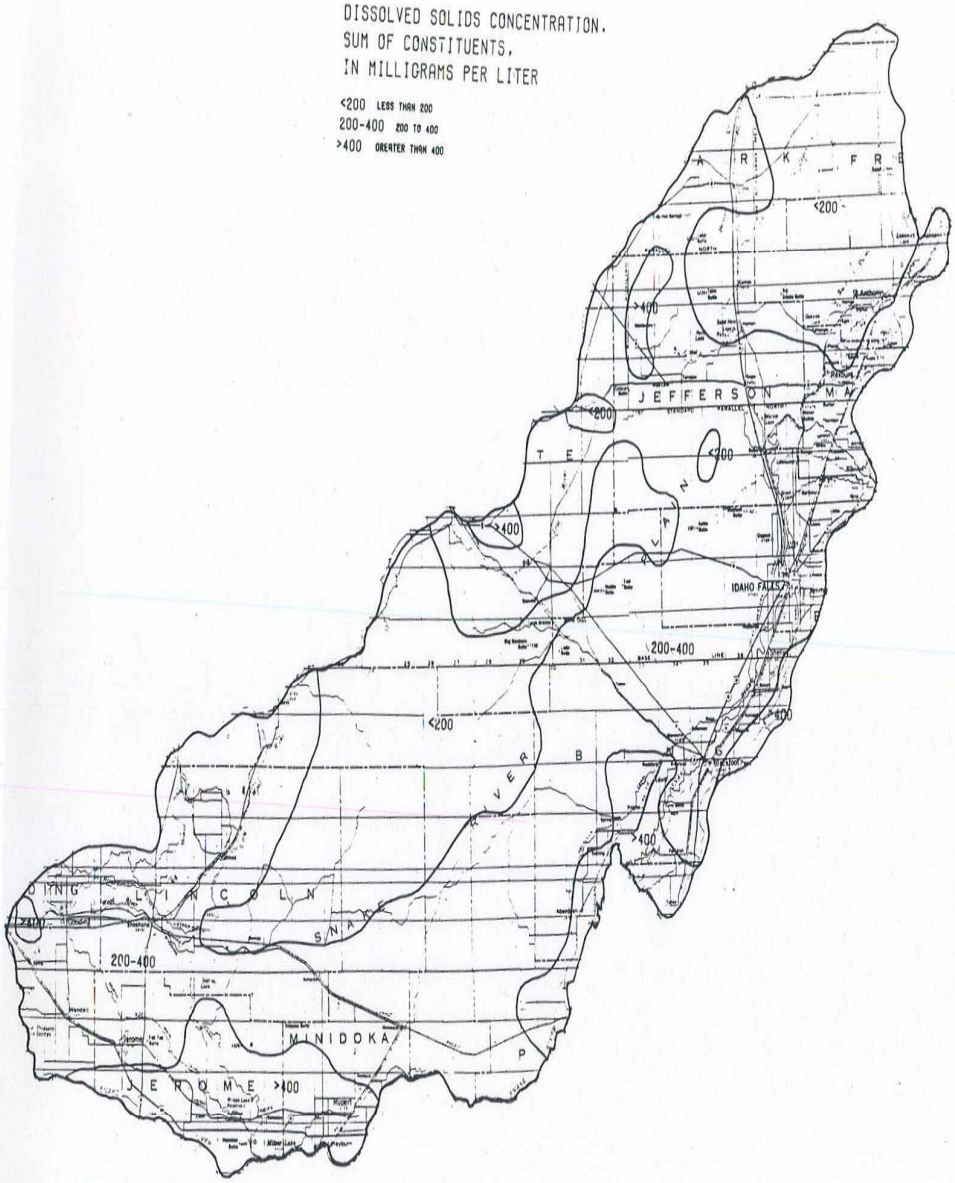


PLATE 9

SOURCE: 'SOLUTE DISTRIBUTION IN GROUND AND SURFACE WATER..' LOW, USGS PUBL. OFR 85-104

CHLORIDE; SNAKE PLAIN AQUIFER

CHLORIDE CONCENTRATION
IN MILLIGRAMS PER LITER

<20 LESS THAN 20
20-50 20 TO 50
>50 GREATER THAN 50



PLATE 10

SOURCE: "SOLUTE DISTRIBUTION IN GROUND AND SURFACE WATER..." LOW. USGS PUBL. OFR 86-104

Table 2
Primary Drinking Water Standards

Substance	Maximum Allowable Concentrations mg/l	Degrees Celsius
Arsenic	0.050	
Barium	1.000	
Cadmium	0.010	
Chromium	0.050	
Cyanide	0.200	
Fluoride*		
	2.400	Up to 12.0
	2.200	12.1 – 14.6
	2.000	14.7 – 17.6
	1.800	17.7 – 21.4
	1.600	21.5 – 26.1
	1.400	26.3 – 32.5
Lead	0.050	
Mercury	0.002	
Nitrate (as N)	10.000	
Selenium	0.010	
Silver	0.050	

*As determined by the average annual maximum daily air temperature for the area where the water is to be used.

Only one instance of a violation of the drinking water standards for the primary parameters was noted. That violation was for naturally-occurring fluoride in Newdale. No discernible trends were noted in the data. Drinking water quality of the aquifer with regards to the ten primary parameters is currently good.

Parliman carried out an investigation from August to December 1979 of groundwater from 165 wells on the eastern tip of the Snake Plain Aquifer from (Parliman, 1983). Pre-1979 data were compiled from 189 wells. Fluoride, nitrate, sulfate and dissolved iron were shown to exceed EPA drinking water standards in only a few samples. It was concluded that the groundwater quality was acceptable for most uses, including drinking water and agricultural uses. Comparison of 34 previously sampled wells with the investigation's analyses showed relatively minor changes.

Bacteriological Quality

Two data searches were performed in order to determine bacteriological quality of the aquifer water. The databases that were searched are: 1)STORET, a federal database used by, among others, the Environmental Protection Agency, Geological Survey and Bureau of Reclamation; and 2) the Idaho Department of Health and Welfare's Municipal Drinking Water Database in CONDOR.

Data from STORET were limited to those wells with five or more analyses. The results for fecal coliform from 47 wells showed a range of <1 colony per 100 milliliters to 25.6 colonies/milliliters. The mean was 2.0/100 milliliters. Although the levels of fecal coliform are low, the results do show a low level of bacterial contamination of the aquifer.

The CONDOR file showed 7 violations for total coliform bacteria out of 870 samples from 25 municipalities. Bacteria which yield positive total coliform tests may come from the distribution system of public water supplies. Therefore, this look at municipal water quality may not accurately reflect the aquifer's bacterial quality.

Both the regional field offices of the Department of Health and Welfare and the local Health Districts routinely receive complaints of suspected contaminated water form private well owners. Confirmed bacterial contamination has been reported near or in Paul, Groveland, Collins and Blackfoot. A survey by District Seven Health Department in 1980 showed contamination of private wells from septic tanks in the Idaho Falls area.

Organic Chemicals

Data on the concentrations of organic constituents in the groundwater in the Snake Plain Aquifer are virtually nonexistent at this time. Monitoring of drinking water for organic compounds is limited to six pesticides for which maximum contaminant levels have been established. These are endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP. However, only 2,4-D is commonly used. These analyses are only conducted on groundwater used for drinking "if the Department (of Health and Welfare) determines that there is a likelihood" of occurrence of contamination. For these reasons, the state's drinking water database contains no data on background levels of naturally occurring or synthetic organic compounds. Similarly, the U.S. Geological Survey's large water quality database, WATSTORE, does not contain any useful data on organic compounds.

Several brief organics surveys have been conducted in Idaho but the number of sampling locations in the Snake Plain is too small to evaluate general water quality. Sampling was conducted in 1984 for trihalomethanes at about 35 sites throughout the state. Only four sites, all in Idaho Falls, were located within the Snake Plain. No trihalomethanes were detected.

Idaho also participated in a 1981 nationwide groundwater survey which was designed to provide a cursory assessment of the occurrence of volatile organic compounds in drinking water (Westrick et al., 1984). Groundwater at 945 sites throughout the country was sampled; 14 sites were in Idaho. Only two of these sites were in the Snake Plain; these were Idaho Falls and Fort Hall. None of the 33 compounds analyzed were detected in significant quantities at the Snake Plain sites. Several organic constituents were detected in low concentration at other sites in the state.

Other brief organics surveys include a single sampling by the U.S. Geological Survey of 14 wells at the Idaho National Engineering Laboratory in 1980. Analyses for volatile and semivolatile organics did not reveal the presence of hazardous organic contaminants in amounts considered to be significant (>10 parts per billion). Numerous synthetic organic compounds were tentatively identified at lower concentrations (Leenheer and Bagby, 1982).

Groundwater monitoring for pesticides that are presently being used is nonexistent with one minor exception. Three brief surveys were conducted by EPA for aldicarb, an herbicide used extensively on potatoes. These efforts were in response to the detection of aldicarb in groundwater on Long Island, New York. No aldicarb was detected in the Snake Plain Aquifer at levels above the detection limit of 1 part per billion. Our present lack of information on other potential problems of pesticide occurrence in groundwater is discussed in a later section.

Most sampling of groundwater for organic compounds occurs at sites of known groundwater quality problems such as petroleum spills. These data are useful in documenting the extent and severity of known contamination but contribute little to our understanding of ambient levels of organics in groundwater.

It is well known that groundwater in other states has been locally contaminated with a wide variety of organic compounds from domestic, industrial and agricultural uses. Compounds such as pentachlorophenal, used in pest control and processing of wood products, are frequently found

in Idaho at concentrations of low parts per trillion. Our present lack of data on organics in groundwater prohibits an understanding of whether these compounds are truly ubiquitous. The rate at which organic concentrations in groundwater may be changing over time is hampered by inadequate data.

Radionuclides

Radionuclides in groundwater are of two types: 1) naturally occurring isotopes leached from soil and bedrock and 2) man-made isotopes from activities using radioactive materials. In monitoring groundwater for radionuclides, two aggregate parameters are usually measured. These are gross alpha activity and gross beta activity. These parameters actually represent the sum of several commonly occurring isotopes. As a broad generalization, gross alpha activity is primarily a measure of natural radionuclides and gross beta activity is representative of man-made isotopes. The Idaho drinking water standards for these parameters and several other common isotopes are shown in Table 3.

Table 3
Drinking Water Standards for Selected Radionuclides[1]
pCi/L[(2)]

Source	Radionuclide	Standard
Natural	Gross alpha activity (including radium 226, excluding radon and uranium	15
Natural	Combined radium 226 and radium 228	5
Man-made	Gross beta activity	50
Man-made	Tritium	20,000
Man-made	Strontium 90	8
Natural	Uranium	10-20 (proposed Federal Standards)
Natural	Radon	2000 (proposed Federal Standards)

[1] Idaho Department of Health and Welfare
[2] pCi/L = picocurie per liter. One picocurie of a radioactive substance is equal to 2.2 nuclear disintegrations per minute.

Several data bases containing radionuclide data on Snake Plain groundwater were reviewed to determine compliance with the standards. In 1981, EPA's Office of Radiation Programs sampled as part of a nationwide survey 69 Idaho community water supplies utilizing groundwater. Thirty-two sites were within the Snake Plain. An additional 11 sites were just outside the boundary of the plain. No sites within the Snake Plain were found to be in violation of any of the actual or proposed standards shown in Table 3. An area near the plain, the Twin Falls/Kimberly region, was found to have slightly elevated levels of natural radioactive constituents.

Radionuclide data from the U.S. Geological Survey's water quality data-base WATSTORE were also retrieved. These data were from groundwater sampling conducted from the 1930s to the present. All together, 126 wells were sampled at least once for some of the parameters shown in Table 3. (This does not include sampling at the Idaho National Engineering Laboratory which will be discussed separately.) Most of the analyses were for gross beta activity and tritium. No violations were found. Based on these two limited surveys, the groundwater in the Snake Plain Aquifer is concluded to contain no known contamination by natural or man-made radionuclides at levels that represent a danger to public health.

The major source of man-made radionuclides is the Idaho National Engineering Laboratory. This facility, which is operated by the U.S. Department of Energy, builds and tests nuclear reactors and generates wastes in which at least 56 different radionuclides have been detected (State of Idaho, 1979). Some radioactive waste has been injected into the aquifer through deep wells. The major waste disposal well is 600 feet deep and was utilized from 1953 through 1984. To monitor the movement of the wastes in the aquifer, the U.S. Geological Survey has operated an extensive monitoring network of more than 100 wells since the facility was established. The major isotopes that have been detected in the groundwater are tritium, strontium 90, and iodine 129 (Lewis and Goldstein, 1982; Humphrey and Tingey, 1978; State of Idaho, 1979). Near the injection well, tritium has been measured at levels that are 10 times the drinking water standards (Lewis and Goldstein, 1982) and strontium 90 at levels of three times the standards (State of Idaho, 1979). However, through extensive and ongoing groundwater modeling programs conducted by U.S. Geological Survey and others, it is clear that the plumes of contamination are presently localized in the vicinity of the sources. Tritium has moved 7.6 miles (as of 1982) and strontium 90 and iodine 129 have migrated less than 2 miles (1979) from the point of injection. No groundwater contamination from this facility has been detected off of the site.

Special studies on various isotopes have been conducted periodically throughout the life of the facility. One of interest investigated the occurrence of plutonium and americium in on-site and off-site wells (Polzer et al., 1976). Isotope activities were found to be one to two million times lower than federal and state guidelines in the vicinity of the injection well. Analyses in perched groundwater near the point of injection detected tritium (at levels equal to the drinking water standard, Humphrey and Tingey, 1978) and other isotopes such as chromium and cobalt (Barraclough and Jensen, 1976). Plutonium, americium and other isotopes were detected at depths up to 250 feet in the soil (Humphrey and Tingey, 1978) near disposal site.

Summary

As summarized by the U.S. Environmental Protection Agency (Marshall, 1984) the water quality of the Snake Plain Aquifer is generally good. There are local areas that exceed drinking water standards for fluoride, nitrate, chloride, total dissolved solids and coliform bacteria.

The U.S. Geological Survey, in conjunction with the Department of Health and Welfare and the Department of Water Resources, has proposed a state-wide monitoring program that would continue to examine groundwater on a more precise, routine basis. Such a program would mitigate those statistical problems as noted in this report and would continue surveillance of the aquifer's water quality.

POTENTIAL CONTAMINANT SOURCES

The following activities have been identified as potential sources of contamination to the Snake Plain Aquifer:

1. Land spreading of industrial and municipal wastewater treatment plant sludge and septage
2. Land-applied wastewaters
3. Injection wells
4. Well drilling and abandonment
5. Radioactive materials sources, such as from INEL or natural occurrence
6. Surface run-off from urban areas and transportation routes
7. Feedlots and dairies
8. Petroleum handling and storage
9. Oil and gas pipelines
10. Mining and oil and gas drilling
11. Landfills and hazardous waste disposal sites
12. Pits, ponds and lagoons
13. Pesticides
14. Septic tank systems
15. Hazardous substances point sources
16. Geothermal wells
17. Fertilizer application

Each of these activities is reviewed as to the magnitude of its impact, including the number of wells contaminated, the probable or possible mechanism of contamination, and the regulatory authority (or lack thereof) to deal with the contaminant or the activity. The locations of some major contaminant sources are shown on Plate 11.

POTENTIAL CONTAMINANT SOURCES

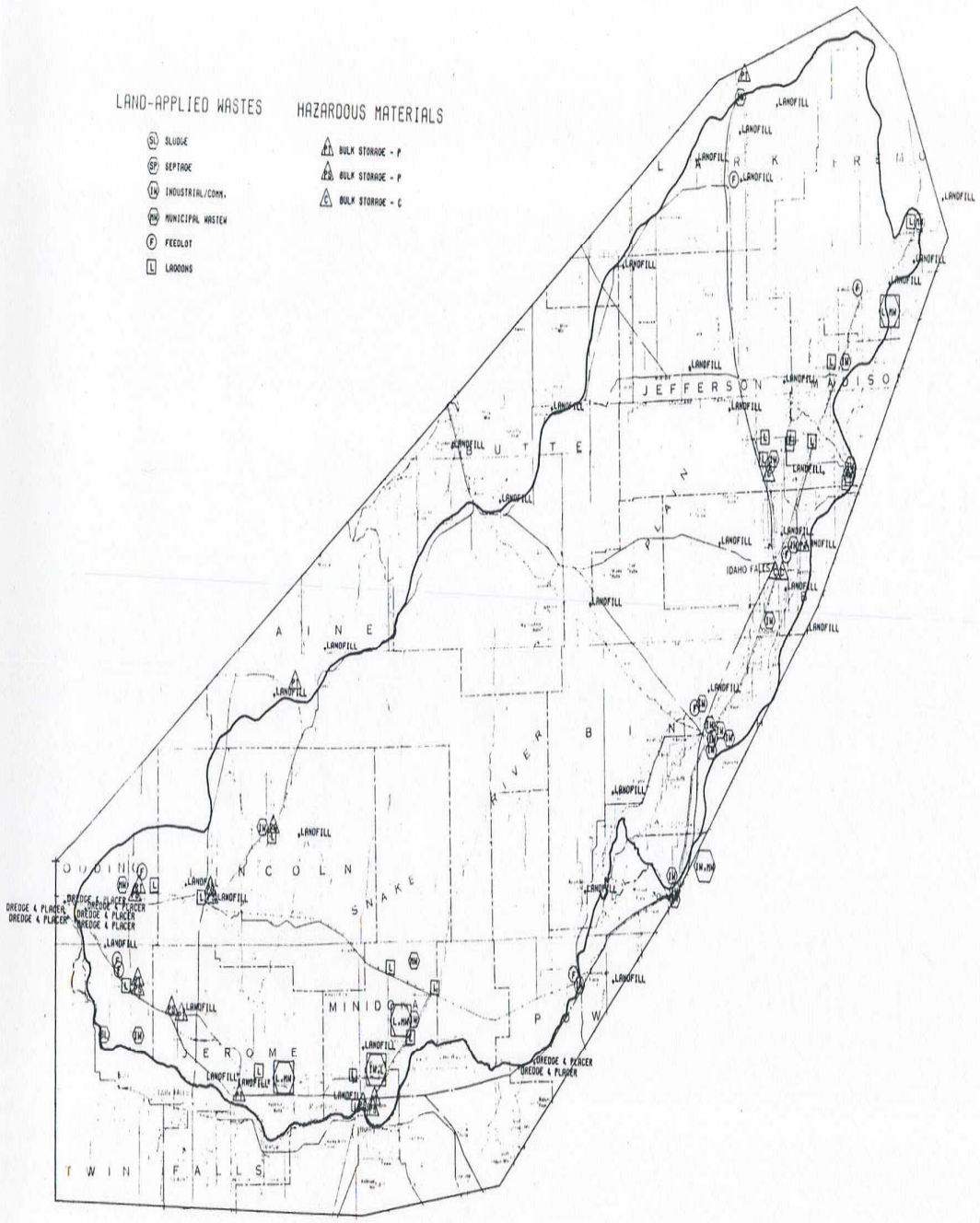


PLATE 11

SOURCE: IDAHO DIVISION OF ENVIRONMENT, FIELD OFFICE DATA, 1985

LAND SPREADING: SEPTAGE AND SLUDGE

The contents of septic tanks are referred to as septage. Sources of septage include household or domestic waste (46%), industrial or commercial sources (40%), chemical toilets (14%) and livestock (1.5%). Some characteristics of septage are listed in Table 4.

Table 4
Characteristics of Septage[1]

Parameter	Mean Value, mg/L
Total Solids	24,500
Biochemical Oxygen Demand	4,610
Chemical Oxygen Demand	29,500
Total Nitrogen	588
Total Phosphorus	232
Grease	6,705
Arsenic	0.16
Cadmium	0.15
Chromium	0.85
Copper	8.5
Mercury	0.1
Lead	6.2
Total coliform, per 100 ml	$10^7 - 10^9$

[1]IDHW-DOE Unpublished Background Report for Proposed Septage Regulations

Good maintenance practices for septic tanks dictate that those tanks be pumped when the sludge that collects in them exceeds 40% of the liquid volume of the tank. Standard practice, however, is not to pump the tank until a failure, such as backing up of sewage into the house, occurs. A survey of septage disposal practices in Idaho conducted by the Division of Environment in 1979 indicated that 75% of septage pumped was from failing or malfunctioning septic tank drainfield systems. That survey also revealed the following disposal practices in Idaho and over the Snake Plain aquifer (Table 5).

Table 5
Septage Quantities Disposed on the Snake Plain and Statewide

Category of Disposal Site	Septage, gallons		Percent of Total	
	Statewide	Snake Plain	Statewide	Snake Plain
Sewage Treatment Plants	5,840,000	515,000	56	25[1]
Landfills	1,438,000	1,547,000	14	75[1]
Private Septage Systems	2,025,000	(2)	20	(2)
Home Owners Property	710,000	(2)	7	(2)
Taken Out of State	300,000	0	3	0

(1) Estimated from reported gallons of septage pumped
(2) Unknown;not reported in the 1979 DOE Septage Survey

The report suggests that the values in Table 5 should be considered as minimum. 60% of septic tank pumpers surveyed indicated that they had problems in disposing of their septage due to lack of near-by approved disposal sites.

The known affected sites in the Snake Plain for septage disposal are landfills at Ohio Gulch, Gooding, Shoshone, Jerome, Fort Hall, Jefferson, Madison and Idaho Falls. Using the figures from Table 4 and Table 5, the estimated potential contaminant load from septage on the Snake Plain can be calculated (Table 6).

Table 6
Estimated Contaminant Quantities from Septage
On the Snake Plain

Parameter	Pounds per Year
Biochemical Oxygen Demand	79,250
Chemical Oxygen Demand	507,600
Total Nitrogen	10,100
Total Phosphorus	4,000
Arsenic	2.8
Cadmium	2.6
Chromium	12.4
Copper	150
Mercury	1.7
Lead	100

Sludge is produced from two sources in southern Idaho: as a product of the aerobic digestion of sewage and from the raceways of fish farms

Approximately 60% of the sludge produced in Idaho is disposed of by land spreading; two-thirds of that on agricultural land. The remainder is disposed of in sanitary land fills. No quantities or locations for disposal of fish farm raceway sludge are available. Producers of wastewater treatment plant sludge on the Snake Plain are listed below in Table 7.

Table 7
Sludge Quantities Disposed on the Snake Plain

Generator	Quantity, Tons/Year	Method of Disposal
Aberdeen	0.21	Farmland
Blackfoot	6.20	Farmland
Gooding	- - . - -	Landfill
Heyburn	- - . - -	Farmland
Idaho Falls	- - . - -	Farmland
Jerome	0.74	Landfill

- - Information not available.

Wastewater treatment plant sludge is variable in its composition. The characteristics of sludge produced by the plants listed in Table 8 is unknown. However, assuming typical characteristics the quantities of some constituents can be estimated (Table 8).

Table 8
Estimated Pollutant Quantities from Sludge Disposal on the Snake Plain

Parameter	Typical Characteristics	Estimated Quantity, Year
Organic Matter	45 – 60 %	9.5 – 12.5 tons
Total Nitrogen	1.6 – 6.6 % (35-100 lb/T)	730 – 2100 lbs.
Total Phosphorus	1.5 – 3 % (30-60 lb/T)	630 – 1250 lbs.
Total Potassium	0.27 – 0.8 % (4-16 lb/T)	80 – 320 lbs.

Crops grown on land that receives sludge are sensitive to zinc, copper, lead, nickel, and cadmium. Since nitrogen loading is the limiting factor for sludge application on land, it is believed that those sludges applied over the Snake Plain would not exceed maximum recommended limits for those metals. However, the quantity of those metals in sludges disposed on the Plain is not known nor can they be estimated.

Septage and sludge are not known to be creating contamination in the Snake Plain Aquifer. Outside of monitoring beneath landfills no attempts are known to have been made to monitor for such contamination.

Guidelines were developed in 1979 by the Idaho Department of Health and Welfare for the application of both septage and sludge. Septage is regulated under Title 1, Chapter 15, Regulations Governing the Cleaning of Septic Tanks. The effective date of those regulations is March 1980. Their enforcement is promulgated to the Health Districts.

LAND-APPLIED WASTEWATERS

Wastewaters from industry and municipal waste treatment plants are commonly applied to land through flood or sprinkler irrigation. This technique, if properly designed, operated and maintained, can be a cost-effective and viable method of wastewater renovation. Waste treatment is accomplished through organic decomposition and chemical, physical and adsorptive reactions in the soil-plant matrix. There are many complex factors and relationships which may control the effectiveness of land application systems. Some of the more common include the hydraulic capability of the soil to accept the wastewater, nitrogen loading and the anticipated crop's ability to utilize that nitrogen, the specific crop's tolerance to the heavy metals in the waste, soil salinity, organic loading and solute concentration. Should inefficient plant-soil mechanisms be present to accommodate these waste components, contamination of the groundwater may occur.

A survey is currently underway by the Department of Health and Welfare's Division of Environment to inventory all land-applied wastewater facilities and determine the exact quantities of pollutants in wastewater applied on land state-wide. Results of that survey to date for the Snake Plain are summarized in Table 9.

Table 9
Sources of Land-Applied Wastewaters on the Snake Plain

Location	Type of Wastewater	COD,lbs/acre/year
Amalgamated Sugar, Paul	Sugar Process Water	400,000
Blincoe Meat Packing, Gooding	Packing Plant	Unknown
Wards Cheese, Richfield	Whey	Unknown
Kraft Foods, Rupert	Whey	Unknown
Kraft Foods, Carey	Whey	Unknown
Rupert STP[1]	Municipal	Unknown
Wendell STP[1]	Municipal	Unknown
Gooding STP[1]	Municipal	Unknown
American Potato, Blackfoot	Potato Processing	25,400
Idaho Supreme, Firth	Potato Processing	1,070,000
Kraft Foods, Blackfoot	Whey	Unknown
Non-pariel, Blackfoot	Potato Processing	Unknown
R.T. French, Shelley	Potato Processing	22,500
J.R. Simplot, Aberdeen	Potato Processing	55,000
Nelson-Ricks, Rexburg	Unknown	Unknown
American Potato, Rexburg	Potato Processing	72,000

(Continued)

Location	Type of Wastewater	COD,lbs/acre/year
Prolda, Ririe	Potato Processing	Unknown
Idaho Fresh Pack, Lewisville	Potato Processing	Unknown
Golden Valley Packers, Roberts	Unknown	Unknown
Ashton STP[1]	Municipal	Unknown

[1]Sewage Treatment Plant

The largest producers of land-applied wastes are the food processors. However, the actual quantity of land-applied wastes from these sources is not known. Therefore, estimated quantities of pollutants that may be received by the Snake Plain can not be calculated. Williams et al. (1969) estimated that the amount of industrial wastewater produced in the Snake River Basin was equal to the population equivalent of 6.4 million people in 1967.

The chemical characteristics of land-applied wastes have been poorly assessed in Idaho. Table 10 provides a summary of known levels of some of these constituents.

Table 10
Characteristics of Selected Wastewaters[1]

Wastewater	Parameter, mg/L				
	Biochemical Oxygen Demand	Chemical Oxygen Demand	Total Suspended Solids	Total Kjeldhal-Nitrogen	Nitrate-Nitrogen
Potato Waste	2200–4600	1500–15,000	1,500–3,000	128	3
Whey	800–8,000	2500–61,000	800–4,000	80–145	40
Municipal	5–35	15–100	5-30	-	-

[1]Data from IDHW-DOE Field Offices

Land-applied wastewaters are suspected of contributing to groundwater contamination in the Snake Plain. Limited purification has been noted in wastewaters moving through fractured basalt zones to the aquifer (McNabb et al., 1977). Both the perched groundwater and the confined aquifer were contaminated by bacteria.

A current study being conducted by the U.S. Geological Survey in the Groveland-Collins area of Blackfoot is aimed at assessing the impacts of land-applied potato processing wastes to that area's groundwaters. Conclusions are not yet available from that study. Suspected contamination of groundwater in the Paul area associated with sugar beet process water is also under investigation. Soluble organics, are, however, recognized as a major potential source of pollution especially as organics often enhance the dissolution of metals in the waste and soil (Sanks and Asano, 1976)

There are no regulations controlling the application of wastewaters to land. Although guidelines were adopted in May, 1983. These guidelines, intended to be updated every three years, provide for site selection criteria, wastewater characteristics consideration, pretreatment requirements, loading rates and management considerations. The effects of soluble organics are not addressed in the Guidelines. As of September 1985 the Division of Environment was revising the land applied waste guidelines and developing regulations.

INJECTION WELLS

The Department of Water Resources is charged with administering the Idaho Injection Well program under Title 42, Chapter 39 of the Idaho Code. Under this program, all injection wells are placed into one of five classes according to the source of the injected fluids and the proximity of the injection formation to drinking water supplies. Class I through III wells generally inject hazardous or otherwise poor quality fluids into formations not containing drinking water sources. These classes of wells are not currently used in Idaho and are not authorized for construction or use under the current program. Class IV contains wells that inject hazardous or radioactive wastes into or above a formation containing a drinking water source. Both the Idaho Code and the state injection well regulations (IDWR, 1984) explicitly prohibit the construction or use of Class IV wells. Injection wells not included in Classes I through IV are Class V. This class contains all known injection wells in Idaho.

All injection wells authorized for construction and use within the area overlying the Snake Plain aquifer are Class V and are within the following subclasses:

Class V(a) – Injection wells greater than 18 feet in vertical depth that inject nonhazardous or nonradioactive wastewater into or above a drinking water source.

Class V(c) – Injection wells greater than 18 feet in vertical depth that return groundwater to the subsurface after the water has passed through a closed-loop heat exchange unit.

Class V(e) – Shallow injection wells (less than or equal to 18 feet in vertical depth) that inject nonhazardous or nonradioactive fluids.

The Department of Water Resources has inventoried a total of 914 injection wells within the boundaries of the Snake Plain aquifer (Table 11). Of the 631 active Class V(a) wells, 501 are used for the disposal of irrigation tailwater, 146 for street and highway drainage and four for domestic waste disposal. Irrigation tailwater disposal wells are concentrated in Lincoln, Jerome, Minidoka, Jefferson, Bonneville, and Bingham counties (Plate 12). Most of the deep street and highway drainage wells are used within the cities of Idaho Falls (48), Gooding (36), Shoshone (40) and Wendell (17). The four domestic waste disposal wells are under conditional permits requiring timely abandonment.

Table 11
Inventoried Injection Wells within the Boundaries of the Snake Plain Aquifer by Subclass and Status

Well Class	Active	Abandoned	Total
V(a)	723	39	762
V(c)	8	0	8
Total Deep Wells	731	39	770
V(e)	142	2	144
TOTAL WELLS	873	41	914

The impact of Class V(a) wells used for disposal of irrigation tailwater and street and highway runoff on the quality of groundwater was the focus of numerous investigations (Whitehead, 1974; Graham , 1977; Graham et al., 1977; Graham, 1979). These studies determined that the following constituents posed a risk to domestic groundwater supplies:

(1) Suspended sediment , as measured by turbidity – Irrigation and street drainage wells.

(2) Total and fecal coliform bacteria – Irrigation and street drainage wells.

(3) Total lead – Street drainage wells.

Pesticide use and concentrations in irrigation tailwater influent to irrigation wells in the Snake Plain area was investigated by Campbell (1982). Constituents most frequently encountered in irrigation tailwater were 2,4-D, PCP, PCNB and dicamba. However, none were found to exceed drinking water standards or health criteria.

Class V(a) wells authorized for continued use are conditionally permitted to require compliance with effluent quality standards and locational criteria (Rule 8, Construction and Use of Injection Wells, Rules and Regulations). These standards require that the injected fluids meet drinking water standards at the well head except for those constituents that are either nonpersistent or attenuated by filtration or sorption. Irrigation disposal wells are usually brought into compliance by requiring the installation of properly designed settling ponds and limiting livestock use within the drainage area. Filtration may be required to remove total lead from street runoff until leaded gasoline is phased out of production.

Shallow injection wells (Class V(e)) are authorized without permit provided that required inventory information is submitted to the Department of Water Resources and use of the wells does not cause contamination of a drinking water source. Of the 142 active shallow wells, 135 are used for street and highway drainage, five for disposal of irrigation tailwater, and two for domestic waste disposal. The major operators of shallow street and highway drainage wells are the cities of Idaho Falls, Shoshone, and Sugar City and Madison County.

The Department of Water Resources recently completed an assessment of shallow injection wells in Idaho (Campbell, 1985). Based on data collected for the Rathdrum Prairie and Boise Valley, the author concluded that there was no evidence of measurable degradation in groundwater quality resulting from the use of shallow wells.



PLATE 12

SOURCE: INJECTION WELL STUDIES, IDAHO DEPARTMENT OF WATER RESOURCES, 1996

WELL DRILLING

Well drilling for municipal, irrigation, rural-domestic, livestock, and industrial use has been, and continues to be, an important activity with potential to damage water quality in the Snake Plain Aquifer. Approximately 1500 to 2000 well logs from the Snake Plain are received from drillers by the Idaho Department of Water Resources each year. This figure is known to be low, because not all required logs have been submitted. The figure does, however, provide an order of magnitude for the number of wells drilled for all purposes. Included are small numbers of wells drilled for geothermal and drainage purposes.

Well drilling activities themselves have very low potential for contamination of the aquifer. The two most common types of drill rigs, the cable-tool and hydraulic rotary, typically use only natural materials such as water and bentonite in the drilling process. Under some conditions, however, other activities used to condition the drilling fluid may be used which are potentially less benign. In the air-rotary method of drilling, special soaps or surfactants are used to help remove drill cuttings from the borehole. Spills of diesel fuel, gasoline, thread lubricating compound, and other materials are commonly used around drill rigs could be accidentally introduced into the borehole or in the unsealed annular space around the casing, creating local contamination.

The greatest potential for groundwater contamination due to well drilling is from improper well construction. Drillers frequently fail to place an adequate surface seal around the uppermost casing down to a suitable confining layer. Other typical shortcomings involve failure to isolate deep warm water zones from shallower cold water aquifers, failure to isolate deeper artesian zones from overlying unconfined aquifers, and improper perforation of casing, promoting free commingling of water from several aquifers.

Rules and regulations regarding the proper construction of water, geothermal and injection wells are administered by the Department of Water Resources. General guidelines for well construction, distance to potential sources of contamination, and requirements for public drinking water supplies are given in Rules and Regulations for Public Drinking Water Supplies administered by the Department of Health and Welfare. Other controls on well drilling are contained in the licensure requirements for well-drilling contractors and operators which are administered by the Department of Water Resources.

RADIOACTIVE MATERIALS SOURCES

As mentioned in the section on radionuclide data, radioactive substances are of two types: man-made and naturally occurring. Naturally occurring radionuclides result from the decay of parent isotopes found in soil and bedrock. Thorium and uranium are the primary materials that decay into a variety of other natural radionuclides such as radium, lead, radon and polonium. Natural levels of these materials are relatively low in the basalt of the Snake Plain. No areas in the Plain have been found to have groundwater with elevated levels of natural radionuclides.

The Idaho Hazardous Materials Bureau is responsible for the licensing of individuals and facilities that use radionuclides. Records maintained by the Bureau show that there are presently 32 facilities (excluding the Idaho National Engineering Laboratory) that are licensed for use of radioactive materials in the Snake Plain. These activities are summarized in Table 12.

Table 12
Facilities in the Snake Plain Licensed to Use Radioactive Materials

Facilities	Number of Facilities	Isotopes Used
Academic	1	Fission products
Medical	6	Technetium 99 & others
Industrial (mainly food processing)	25	Cesium 137, Americium 241, Iridium 192, Cobalt 60, Nickel 63, Radium 226
Idaho National Engineering Laboratory	--	Tritium, Strontium 90, Iodine 129, Plutonium isotopes, Americium 241, Chromium 51 and others

Procedures for the handling and disposal of radionuclides at these facilities (excluding INEL) are also established by the Hazardous Materials Bureau. Disposal practices used on the Plain include: 1) allowing short-lived isotopes to decay to background levels and 2) returning waste materials to the radionuclide manufacturer for disposal. Disposal by methods other than these is not permitted.

By far the largest generator and disposer of radioactive materials is the Idaho National Engineering Laboratory (INEL) which is operated and

regulated by the U.S. Department of Energy. This 890 square mile facility was established in 1949 to build and test nuclear reactors. In addition to the radioactive wastes generated by these activities, INEL accepts and stores radioactive wastes from other sites.

INEL is located in the southwest corner of Butte County. This area is an important site of natural groundwater recharge to the Snake Plain Aquifer. The Big Lost River and other streams bring considerable surface water onto the site. This water moves quickly and directly into the aquifer.

Radioactive waste was disposed to the aquifer in several injection wells from 1952 through 1984. The depth of the major well at the Idaho Chemical Processing Plant is 600 feet. Radioactive wastes have also been disposed in shallow percolation ponds. The ponds and well wastes infiltrate into the ground, form perched bodies of water and then percolate downward to the Snake Plain Aquifer (Barraclough and Jensen, 1976). In 1984, use of the injection wells was eliminated and waste disposal was transferred to the percolation ponds. Most of the radioactivity from the wastes is removed prior to disposal so that input of radionuclides to the environment is minimized.

The primary radionuclide released to the environment is tritium. Monitoring data for this isotope are summarized in the preceding section on water quality. Although the most abundant isotope, tritium poses a minimal potential health hazard because its half-life is relatively short (12.3 years). Monitoring and modeling for several decades support the conclusion that tritium will decay to acceptable drinking standards before the groundwater flow carries the isotope off of the site (Lewis and Goldstein, 1982).

The greatest danger is from environmentally mobile isotopes with longer half-lives. Iodine 129 (half-life = 16,400,000 years) is one such element. Monitoring has shown that this isotope is presently localized around the point of injection (State of Idaho, 1979).

SURFACE RUN-OFF

Surface run-off is generated from street and parking drainage. It is the water derived from snow, rain, ice, street cleaning, urban irrigation and other water sources associated with ground or paved areas in urban areas (Abegglen, 1970, Robert and Bozeman, 1982). The components of run-off and their contaminant parameters are shown in Tables 13 and 14.

Table 13
Some Components of Run-off

Domestic garbage	Animal and bird fecal matter
Eroded soil	Construction debris
Road surface material	Air pollution fallout
Leaves and lawn litter	Fertilizers
Salt and de-icers	Insecticides/herbicides

Table 14
Some Contaminant Concentrations of Run-off Water[1]

Parameter	mg/L
Total suspended solids	233 – 161,000
BOD_5	11 – 4260
Nutrients (P, NO_3, NH_3)	< 5 – 2250
Iron	6.1 – 2790
Lead	0.25 – 64.6
Zinc	0.14 – 37.5
PCB	0.00019 – 0.0002
DDT, DDD and Dieldrin	Detected

[1]Robert and Bozeman, 1982

The best index of the soluble pollutants in run-off is the Biochemical Oxygen Demand (BOD_5). Run-off may represent 20 to 80 percent of the BOD entering receiving streams (Carr et al., 1983). Although PCB's are found in run-off they are relatively insoluble. Some pesticides, on the other hand, are more soluble, and thus may be able to reach groundwaters.

Several factors may add to or mitigate the pollutant potential of run-off: the septic accumulation in catch basins, solubility of solid

components of the run-off, precipitation frequency and intensity, frequency of street washing and nature of the receiving soils.

The most common method of disposal of parking lot run-off in the Plain is through shallow disposal trenches ("French drains") or pits. These are often constructed in very porous subsoil to assure percolation of the run-off. Run-off from highways and roadways is generally to surface barrow ditches and catchments basins, where the run-off then percolates underground or evaporates.

The Spokane Water Quality Management 208 Office that manages the Rathdrum Prairie-Spokane Aquifer in eastern Washington completed a report in 1984 that clearly showed that activities in urbanized areas were causing degradation of that aquifer's water quality. Although it has been concluded that run-off may be a significant source of groundwater pollution, no instances of such pollution are documented in the Snake Plain Aquifer, nor has monitoring for degradation by this specific activity been carried out.

Idaho has no regulation or statute regulating run-off other than requirements for some shallow injection wells (see Injection Wells). Local Highways Districts and the Idaho Department of Transportation exercise some control over run-off, but that is in regard to prevention of flooding and destruction of highway appurtenances.

Feedlots and dairies are common over the aquifer. Preliminary inventory data developed as a result of the U.S. Environment Protection Agency's aerial flyover of the Snake Plain showed between 550-600 such operations. These are principally located over the southern and south western portion of the plain with major concentrations located in Jerome and Gooding counties.

Groundwater contamination of the aquifer from feedlots and dairy operations is not well documented. The potential for aquifer contamination from feedlots is believed to be much less than dairies because of their respective water use and management. Feedlot operations generate substantially less wastewater than dairies. Dairy operations, depending on their size, water use, and disposal of wastewaters have a much higher potential for contaminating the aquifer. It is common practice for large dairies to generate 5,000 to 10,000 gallons of wastewater daily. Current dairy wastewater disposal practices include the use of total containment ponds, storage ponds and land application when weather permits, year long land application, and discharge to canals, drains, or other surface waters. Leaking storage ponds and discharges to unlined canals and drains are considered potential sources of contamination of the aquifer by excess nitrates and bacteria.

Cases of confirmed well contamination from feedlot and dairy operations have been documented. Contaminated wells are generally shallow and located in such a manner that they intercept runoff or filtrate from ponds or corral areas. Methemoglobenemia, a temporary blood disorder in some infants, results from ingestion of high levels of nitrates. The most recent case of this disorder in an infant was the result of water ingested from a shallow well within 50' of a hog lot in Nebraska (Young, 1984).

The overall scope and significance of aquifer contamination from feedlot and dairy operations has not been determined and currently very little information on groundwater impacts is available. The refinement of inventory data will allow for an estimate of animal wastewater volumes that are discharged over the aquifer. Additional studies need to be conducted to determine the extent of contamination from these sources.

Animal wastewater management practices are critical to the adequate removal and control of nitrates and bacteria generated by feedlot

and dairy operations. Adequate facilities and properly operated land application systems are necessary to ensure minimum impacts on the aquifer.

Some regulatory authority for controlling animal wastes is within existing Idaho Department of Health and Welfare Water Quality Standards and Wastewater Treatment Requirements. The authority is limited to sections under general water quality standards, land application of wastewaters, and hazardous and deleterious materials storage. No specific regulatory authority exists to control feedlot or dairy wastewaters. The Department of Health and Welfare will be developing specific regulations and technical guidance to assist in the management program.

Limited resources do not allow for the implementation of a proper management or regulatory program to control feedlot or dairy discharges. The U.S. Environmental Protection Agency is in the process of developing a general permit for larger feedlot and dairy operations but the permit will only address source discharges and not groundwater contamination.

PETROLEUM HANDLING AND STORAGE

Petroleum storage and handling on the Snake Plain represents one of the greatest potential sources of contamination of groundwater. Activities involving petroleum are diverse. The severity of impact on groundwater and the adequacy of regulatory authorities vary widely. To facilitate a discussion of the potential for petroleum activities to contaminate groundwater, the activities have been divided into the following categories:

1. Large bulk storage facilities
2. Small storage tanks
3. Pipelines
4. Transportation
5. Various handling procedures such as tank filling

Eight large bulk storage facilities have been identified on the Snake Plain, the locations of which are shown in Plate 11 . At least seven similar facilities are located just outside the aquifer boundary. The number of small storage tanks at service stations and on farms is not known and no reliable estimates are available at this time. Storage tanks can be located above or below ground. Underground storage tanks pose the greatest threat to groundwater. Corrosion of buried tanks or associated piping results in leaks that may remain undetected until groundwater contamination has occurred.

There are no major petroleum transmission pipelines within the boundary of the aquifer. However, over 100 miles of the Chevron pipeline from Salt Lake City to Boise convey refined petroleum along the southern boundary of the aquifer. Most of this distance is traversed by dual 8 inch lines. The pipeline is buried slightly beneath the soil surface. The statutory minimum is 36 inches below the soil surface (CFR 195.248). Two types of problems are associated with the pipeline. In spite of the requirements for cathodic protection, periodic pressure testing and frequent surveillance, breaks do occur. Secondly, surface activities such as construction and grading of roads have ruptured the pipeline due to its shallow cover.

Above ground transportation of petroleum involves the entire extent of the road network over the aquifer. Most commonly, losses of petroleum are due to highway accidents involving tanker trucks. The final category, petroleum handling, includes the numerous procedures for filling of tanks and transferring of petroleum between storage facilities. Carelessness and human error are the most frequent causes of petroleum spills of this type.

To evaluate the potential for groundwater contamination from these various petroleum related activities, the Idaho Water Quality Bureau conducted a statewide study on petroleum spills in 1984. Eighty-nine uncontrolled releases of petroleum to the environment were documented to have occurred during the preceding 10 years. Sixty-five percent of these spills resulted in confirmed contamination of shallow groundwater. The majority of the remaining 35% were sites where groundwater contamination was not investigated due to a remote location or a spill of small volume.

Only one of the sties where groundwater contamination was confirmed falls within the Snake River Aquifer boundary (Arco). Three additional spill sites at which groundwater contamination was not confirmed also occurred within the boundary. However, if the area of interest is expanded by 15-20 miles around the aquifer boundary, a different picture emerges. Twenty three incidents of confirmed groundwater contamination and 10 other petroleum spills were documented in this extended area. These 33 spills represent almost 40% of the total number of incidents reported to the state during the 10 year period. The majority of these incidents occurred in Twin Falls and Buhl.

The elucidate the potential for each of the five previously defined petroleum activities to cause environmental contamination, the 33 spills were grouped according to activity as shown in Table 15.

Table 15
Number of Incidents of Groundwater Contamination from Petroleum[1]

Petroleum Storage		
	Large Facilities	2
	Small storage tanks	14
Pipelines		
	Breaks	4
	Ruptures due to surface activities	4
Transportation accidents		5
Handling procedures		4
	TOTAL	33

[1]Idaho Division of Environment unpublished data, includes suspected and confirmed groundwater contamination incidents

The volume of petroleum released in these incidents varies according to the cause of the release. Spills from tank truck accidents and those associated with tank filling and other transportation operations are generally on the order of only a couple hundred gallons. Spills from pipeline breaks or rupture can be very large, ranging up to 250,000 gallons. Releases of petroleum from bulk storage facilities can also be considerable. The ability to detect a leak at a storage facility soon after it begins is often hampered by inadequate monitoring and record keeping. Preventive measures such as tank testing and replacement of aging tanks are also practiced to a limited extent. In the case of the 16 incidents involving petroleum storage in this survey, most releases were less than 1000 gallons. However, many of the largest spills documented in the statewide survey resulted from leaks from storage tanks. The volumes lost ranged up to 3 million gallons.

The exact number of wells contaminated by petroleum spills in and around the Snake Plain is not known. As previously mentioned, two thirds of the documented spills did, however, result in contamination of groundwater. The contamination was generally confined to shallow water which is not frequently used for drinking. While fortunate, the restriction of the contamination to shallow zones should not be interpreted as cause to minimize the hazard associated with subsurface petroleum contamination. Petroleum that migrates on the surface of shallow groundwater can result in explosive vapors in sewers and basements. When drinking water does become contaminated, the levels of human tolerance are quite low. Petroleum can be tasted and smelled in water at concentrations less than 1 part per billion (Ineson and Packham, 1967). Soluble constituents in petroleum such as benzene and toluene are very mobile and have health criteria limits of less than 1 part per billion. Petroleum exhibits a strong affinity for binding to soil, rendering conventional cleanup and recovery techniques incapable of retrieving more than 20-30% of the quantity lost (American Petroleum Institute, 1972). Contamination is therefore persistent long after the source of the petroleum has been abated. Based on all of these factors, petroleum represents one of the most hazardous potential contaminants of groundwater in the Snake Plain Aquifer.

It can be seen from Table 15 that the majority of the petroleum releases have resulted from storage tanks, most of which were underground. While it is recognized that this is a small data set on which to make generalizations, it is supportive of a growing state and nationwide awareness of the threat of underground storage tanks to groundwater. Underground storage tanks, including large bulk storage facilities and smaller tanks at service stations and farms, are one of the most severe potential sources of contamination in the aquifer.

The regulatory framework to address this problem is presently inadequate. Many tanks that were installed in the late 1950s and 1960s are presently reaching their maximum life expectancy of 20 to 25 years. Acidic soils and soils with high moisture contents accelerate corrosion so that even relatively new bare steel tanks may develop leaks. Groundwater monitoring and keeping accurate records of receipts and sales of stored fuels for materials balance monitoring are two of the best ways to detect a leak before major environmental damage results. These activities are often conducted with insufficient frequency and accuracy to achieve early leak detection. There are no requirements in Idaho for periodic tank pressure testing or replacement of tanks which have been in service for longer than their design life. All of these regulatory inadequacies result in the present regulatory approach being primarily one of response to contamination as opposed to prevention and early detection.

When a leak is detected, often through groundwater or soil contamination or the presence of surface vapors, the authorities for spill response are fragmented. The Idaho State Fire Marshall can require the testing of a suspected tank under the Uniform Fire Code Section 79.605. Response to groundwater and drinking water contamination is the responsibility of the Idaho Division of Environment under the Idaho Environmental Protection and Health Act of 1972.

A major new piece of legislation to address this problem was enacted as Subtitle I of the 1984 Amendments to the Federal Resource Conservation and Recovery Act (RCRA). Congressional budget appropriations will provide the Division of Environment with funds to implement an underground storage tank regulatory program as required under the Act. The first step will be the required notification of the Division by all tank owners of the location and age of underground tanks. This must be completed by May 1986. Some means to limit leaks from new underground storage tanks is mandatory as of May 1985. Examples include cathodic protection, double walled tanks, fiberglass tanks or coated steel tanks. The Division will also be developing regulations for new tank installation and for testing and monitoring of tanks in use. This major new program will greatly strengthen the authorities for prevention and early detection of leaks.

OIL AND GAS PIPELINES

There are no pipelines for the transmission of bulk petroleum within the Snake Plain boundary. A major pipeline from Salt Lake to Spokane runs along the outside of the southern boundary of the aquifer. Problems associated with this pipeline and the potential for adverse groundwater impacts are discussed in the section of petroleum.

Transmission lines for natural gas are located in urban areas throughout the Snake Plain. However, a leak or rupture of a natural gas line would have no impact on groundwater. The gas would be expected to diffuse upward through the soil and be lost to the atmosphere.

For these reasons oil and gas pipelines are not considered to be potential sources of contamination to groundwater in the Snake Plain Aquifer.

MINING AND OIL AND GAS DRILLING

Mining activities is minimal within the boundary of the Snake Plain. Only 8 dredge and placer mining sites were identified in Idaho Department of Lands' records. The locations of these sites are shown in Plate 11. Because these are small surface operations, their impact on groundwater quality is expected to be negligible. Mining is therefore one of the least significant potential contamination sources evaluated in this study.

Department of Lands' records show only one oil and gas drilling site within the Plain. Oil and gas drilling is therefore not considered as a potential source of contamination to the Snake Plain Aquifer.

LANDFILLS AND HAZARDOUS WASTE SITES

Landfills within the Snake Plain receive a variety of wastes: domestic, agricultural, small industry, fish and municipal waste treatment sludge, and septage. Any waste deposited in a landfill that is soluble in rainwater has the potential to migrate from the disposal site through the soil mantle to the underlying aquifer. Although the chemical characteristics of the waste-carrying liquid or leachate that may move from a landfill will vary with the nature of the contaminants in the landfill, a typical leachate may have the constituents in Table 16.

Table 16
Typical Characteristics of Landfill Leachate

Parameter	National Leachates[1], mg/L	Idaho Leachates[2], mg/L
Alkalinity	-	74 - 13,600
Ammonia	-	0.28 - 480
Biochemical Oxygen Demand	9 - 54,610	to 14,000
Chemical Oxygen Demand	<1 - 89,520	-
Chloride	<1 - 2,800	106 - 1020
Copper	<1 - 9.9	0.09 - 40
Hardness	<1 - 22,800	168 - 4800
Iron	<1 – 5,500	2 - 995
Lead	<1 - 5.0	.01 - 100
Phosphate	<1 - 154	to .031
Potassium	2.8 – 3,770	to 325
Sodium	<1 - 7,700	25 - 550

[1]EPA, 1977
[2]Bureau of Hazardous Materials

There are 34 landfills in the Plain. The majority are owned and maintained by the counties. There are no hazardous waste sites (RCRA Storage, Treatment and Disposal Facilities). The landfills in the Plain are summarized in Table 17 along with the quantities of refuse they receive.

Table 17
Summary of Landfills in the Snake Plain

Landfill	Area, Acres	Tons per Day	Years in Use
Gooding County	40	31	8-12
Jerome County	120	30	18-20
Eden Hazelton	20	8	10
Shoshone	40	5	20+
Richfield	20	3	14-18
Carey Mod	20	4	8-12
Carey BLM	20	<1	?
Minico	200	35	8-12
Cassia County[1]	2	50	3-5
Fort Hall	360	150	13-17
Power County	15	35	9-13
Aberdeen	40	5	5
Atomic City	10	2	15-20
Goshin Bulky Waste	24	3	5
MacDonaldsville	40	100	9-13
Springfield Bulky	40	2	5
Arco	40	15	15
Howe	40	1	8
INEL	-	-	Several
Heilson Pit	6	20	2
Hemmert Avenue	41	100	1
Clark County, Dubois	10-20	2	8-20
Clark County, Spencer	5	1	8-20
Clark County, Kilgore	5-10	1	8-20
Clark County, Birch Creek	10	1	8-20
Clark County, Small	5-10	1	8-20
Clark County, Reno Point	5-10	1	8-20
St. Anthony	200	20	20+
Falls River	70	0	0
Jefferson County, Rigby	30	30	15
Jefferson County, Mud Lake	30	4	12
Roberts Old Dump	42	5	8-10
Roberts New Dump	80	5	1
New Madison	140	40	1

[1]Energy Recovery Incinerator

The total estimated waste deposited in Snake Plain landfills annually is about 260,000 tons (710 tons/day X 365).

In 1981 a National Open Dump Inventory was sponsored by the U.S. Environmental Protection Agency. Idaho carried out actual site inspections of its facilities. Maximum Contaminant Levels (MCLs) of contaminants

where not exceeded in the Snake Plain wells nearest to inventoried landfills. There are no documented impacts by landfills on wells in the aquifer. However, there is no routine or regular groundwater monitoring program associated with landfills in the Snake Plain.

Regulatory authority for landfills is contained in Idaho Code 31-4401 to 31-4416. The Solid Waste Regulations are outdated with respect to the state-of-the-art in landfill management and regulation. Although the regulatory powers are broad in scope, the regulations lack specificity in the Standards section with regard to groundwater monitoring and groundwater pollution. There are no current sources of funding dedicated to revising these regulations.

PITS, PONDS AND LAGOONS

This category includes a diverse array of activities keeping all involving storage of wastes or waters in artificial or natural pits, ponds, or lagoons. Such activities include:

1. Animal waste contaminants
2. Surface run-off, including urban, transportation route or agricultural sources.
3. Chemical storage
4. Municipal and industrial wastewater treatment
5. Livestock rearing, including aquaculture, and duck ponds

Feedlots and dairies and surface run-off are discussed elsewhere in this report. Little is known about groundwater impacts from livestock rearing or chemical storage.

Other than containment ponds or lagoons for feedlots and dairies, municipal and industrial wastewater treatment lagoons offer the most significant potential source of groundwater contamination over the aquifer from this activity group. Although such contamination has been documented elsewhere, no known groundwater problems have been reported from lagoons on the aquifer. Lagoons are constructed to provide for minimum infiltration of wastewater. Current guidelines require less than ¼ inch per day.

Those communities using lagoons, either for total containment or as pre-treatment prior to discharge to land or streams are shown in Table 18.

Table 18
Communities Using Lagoons on the Snake Plain

Arco	Inkom	Ririe
Ashton	Mud Lake	Roberts
Basalt	Paul	Rupert
Eden	Rexburg	Shelley
Firth	Rigby	St. Anthony
		Wendell

Regulations concerning wastewater treatment lagoons are found in the Idaho Water Quality and Wastewater Treatment Standards. There are no

groundwater quality-related regulations or guidelines concerning surface run-off containment, livestock-rearing ponds or chemical storage. Large feedlots and dairies that discharge to surface waters may be required to meet provisions of the Clean Water Act. However, that is in relation to surface water protection only. The Division of Environment has adopted guidelines for chemical storage in ponds.

PESTICIDES

For this report, the discussion of the use of pesticides on the Snake Plain is restricted to the use of insecticides and herbicides. These are the two major types of pesticides and their use on the Snake Plain greatly exceeds that of all other types of pesticides such as fungicides and rodenticides.

To evaluate the magnitude of pesticide use in the Plain, the following use categories were distinguished. These categories are listed in order of quantity of chemicals used and acreage to which the products are applied.

1) Agricultural use on crop lands
2) Grasshopper spraying
3) Roadside weed control
4) Rangeland weed control
5) Power line corridors and railroad rights-of-way
6) Private residential use

The diverse list of pesticide uses and the even more extensive list of individuals involved in applying these chemicals (land owners, commercial applicators, federal, state, and local governments, industries) make the compilation of pesticide use data a very difficult task. No one agency tracks the quantity of pest control products sold and the areas in which they are applied. After an extensive search, no reliable estimates of total pesticide use were found to be readily available.

Agricultural pesticide use is extensive in the Snake Plain. The products used are dependent on the crops that are grown. Table 19 gives the major crops grown in the study area based on 1984 data compiled by the Idaho Crop and Livestock Reporting Service (U.S. Department of Agriculture, 1984) and Larson (1983). The total acreage planted in these crops is over 2 million acres.

Table 19
Major Crops Grown on the Snake Plain

Crop	Number of Counties in Snake Plain where Grown	Number of Acres Planted in these Counties, 1984
Wheat (winter & spring)	All	640,300
Barley	All	461,600
Alfalfa	All	430,000
Potatoes	All	269,200
Beans (dry & seed)	8	125,000
Sugar Beets	8	72,800
Corn	10	53,100
Oats	All	20,300

While a relatively small number of crops dominate agricultural production in the Snake Plain, a large variety of pesticides are applied to this land. Pesticides can be applied by spraying on the crop, mixing with the irrigation water or applying directly on or in the soil. Table 20 illustrates the complexity of agricultural use of pesticides.

Table 20
Pesticides Used on Crops on the Snake Plain

Wheat	Barley	Alfalfa	Potatoes	Beans	Sugar Beets	Corn	Oats
Atrazine	Dicamba	Carbofuran	Aldicarb	Chlorothalonil	Aldicarb	Atrazine	Methomyl
Dicamba	Dinoseb	Hexazinone	Carbofuran	DCPA	Carbofuran	Carbofuran	Dicamba
Picloram	Picloram	Pronamide	DCPA	Methomyl	Cycloate	Dicamba	Picloram
Disulfoton	Disulfoton	Terbacil	Dinoseb	Alachlor	Disulfoton	Alachlor	
Diuron	Metribuzin	Diuron	Metolachlor	Bentazon	Methomyl	Metolachlor	
Metribuzin	Methomyl	Propham	Chlorothalonil	Aldicarb		Disulfoton	
Cyanazine		Dinoseb	Disulfoton			Diuron	
Methomyl		Metribuzin	Oxamyl			Methomyl	
		Methomyl	Metribuzin			Butylate	
			Methomyl				
			Maleic hydrazide				

The products listed are only those that are used in Idaho and have been found by the EPA to have the potential to reach groundwater under normal agricultural use elsewhere in the U.S. (Cohen et al., 1984). The list does not include all products used on a given crop and is not arranged in order of

quantity of use. Only product names are given. Often a product will be marketed under one or more trade names by the chemical manufacturer(s).

No reliable data are readily available on which to base an estimate of the quantities of these products which are actually used. The Idaho Pesticide Bureau and the Bureau of Water Quality are presently conducting a survey of pesticide use to provide such an estimate.

Grasshopper spraying is listed as the second major category of pesticide use in the Snake Plain. Annual aerial spraying varies considerably. In 1979 and 1984 less than 1 million acres were sprayed throughout the state. In 1985, an estimated 2.5 to 3 million acres were sprayed in the Snake Plain alone. No spraying occurred in 1980-1983. The spraying occurs over a short period of time (4-6 weeks). Malathion is the major insecticide that is used and is generally sprayed at the rate of 8 ounces per acre.

The third category of pesticide use, roadside weed control, is similar to agricultural spraying in that use estimates are unavailable. Many government and private entities are involved in the spraying. Based on data from the Idaho Pesticide Bureau, the primary products used for control of roadside weeds are 2,4-D, atrazine, dicamba, and Tordon.

Weed control on rangeland and along power line and railroad rights-of-way is minor compared to the preceding pesticide uses. Bureau of Land Management projections show only an average of 5200 acres of rangeland are proposed to be sprayed annually between 1985 and 1990 (BLM, 1985). Common herbicides such as Tordon, Banvel (dicamba), Roundup and 2,4-D, will be used. The final category, residential use, is the most difficult to quantify because of the number of individuals involved. Quantities of pesticides sold are not tabulated by a central authority so that sales data cannot be used to estimate usage.

Various pesticide handling procedures and their associated problems may also impact groundwater quality. These handling and use practices will be addressed:

1) Normal agricultural use
2) Disposal of: a) containers; b) applicators' tank rinsate solutions
3) Irrigation runoff
4) Spills and misuse
5) Bulk storage

The rates of application of pesticides for agricultural (and all other) uses are addressed by very specific regulations and are required to be detailed on pesticide container labels. These rates have been determined on the basis of quantities necessary to achieve desired pest control performance. Each chemical has a characteristic length of time for which it will persist in a particular soil and a characteristic mobility in that soil. This time is based on its water solubility and ability to adsorb to soil particles. The tendency for a pesticide to degrade, volatilize or be otherwise removed from the surface soil is expressed in terms of its half-life ($t_{1/2}$). Table 21 shows the relative persistence of many common products.

Table 21
Persistence of Common Pesticides

NON-PERSISTENT $t_{1/2}$ < 20 days	MODERATELY PERSISTENT $t_{1/2}$ 20 – 100 days		PERSISTENT $t_{1/2}$ > 100 days
2,4-D	Atrazine	Phorate	Trifluralin
2,4,5-TP	Simazine	Carbofuran	Bromacil
Dicamba	Terbacil	Carbaryl	Picloram
Dalapon	Linuron	Aldrin	Paraquat
Methyl Parathion	TCA	Dieldrin	DDT
Malathion	Glyphosate	Endrin	Chlordane
Captan	Parathion	Heptachlor	Lindane
	Diazinon	PCP	
	Fonofos		

Rao and Davidson, 1980

In spite of limitations on rates of application of pesticides based on environmental persistence and mobility, recent groundwater monitoring studies in other states have shown that some pesticides have leached in significant quantities into groundwater. This leaching occurs even under normal and accepted agricultural practices (Cohen et al., 1984). The potential for groundwater contamination is dependent on soil structure, soil chemistry and depth to groundwater. An assessment of the likelihood of groundwater contamination by pesticides from agricultural practices in the Snake Plain has not been conducted at this time.

As will be discussed in a later section, groundwater monitoring data are grossly inadequate to determine whether or not a problem exists. As agricultural practices are continually modified to minimize surface runoff and loss of surface soil and nutrients, the potential for vertical movement

of pesticides to groundwater becomes more likely. New low or no till conservation practices are increasing in Idaho. Associated with these new tillage methods is a need for increased application of pesticides. For these reasons, further monitoring is necessary.

The disposal of pesticide waste products represents another area of concern. Waste products include pesticide containers, excess spray and the wash water generated by pesticide applicators. In 1982, the South Central District Health Department surveyed all of the pesticide waste disposal practices occurring in that district (Alred, 1982). Portions of five of the counties that were studied fall within the area of interest of this report (Blaine, Gooding, Jerome, Lincoln, and Minidoka). For proper disposal, most pesticide containers are required to be triple rinsed, punctured or crushed to prevent reuse, and disposed at an approved landfill. Landfills in Gooding, Jerome, and Lincoln counties were reported to be lax in adherence to these requirements. Clandestine dumping of containers that were partially full of pesticides was reported to have occurred at the Gooding County sanitary landfill.

This study also documented a problem with the disposal of dilute pesticide solutions generated during the routine washing of the tanks on spray planes. Ideally, reuse of the solutions for dilution of bulk materials or reduction of volume using lined evaporation ponds is desirable. However, most aerial applicators do not have access to the necessary facilities to abide by these practices. The South Central District Health Department found indiscriminant disposal occurring at airports in Gooding and Jerome. Use of a shallow injection well for rinsate disposal at the American Falls airport was terminated as a result of high concentrations of pesticides in the well and nearby water well.

The Idaho Hazardous Materials Bureau has proposed to undertake site investigations for pesticide contamination at six airports in the Snake Plain. Improving the facilities available for rinsate disposal has been identified as a high priority by the Idaho Water Quality Bureau as well. Regulations for the disposal of pesticide rinsate are presently under development.

Another major practice involving pesticides is the use of injection wells for irrigation runoff. The use of the injection wells is extensive in the Snake Plain and is described further in the section on injection wells. Irrigation runoff water can potentially accumulate significant quantities of pesticides. An investigation was undertaken by the Idaho Department of Water Resources (Campbell, 1982) to determine whether significant

concentrations of pesticides were being recharged into the subsurface environment via injection wells. One hundred and six samples of influent were collected in Minidoka County and Idaho Falls and were analyzed for 95 pesticides and breakdown products. Eighteen were found in detectable amounts, although none were present in excess of drinking water standards or proposed water quality criteria. Additional investigations are advisable to determine whether significant quantities of some pesticides are building up in soils and groundwater that receive these wastes.

At this time the only documented cases of significant contamination of well water by pesticides are situations in which spills or misuse of the product have taken place. The spills have occurred directly into the well so the problem was localized and short-lived (Brokopp, 1981a). Surface spills that occur during transportation and handling have resulted in no known groundwater contamination.

One last pesticide handling practice has been found to be significant in the Snake Plain. This is the storage of pesticides in bulk quantities. The locations of eight such facilities are shown in Plate 11. No problems with these facilities have been documented. To address the potential hazard associated with leaks, those facilities that are underground will be required to be in compliance with the Section 1 1984 RCRA Amendments dealing with underground storage tanks.

Although pesticide usage is extensive in the Snake Plain, groundwater monitoring data to detect potential problems are virtually nonexistent. Furthermore, when monitoring of public water supplies drawing on groundwater does occur, it is only for those pesticides for which there are drinking water standards (toxaphene, endrin, lindane, methoxychlor, 2, 4-D, and 2,4,5 TP). Only one of these chemicals, 2,4-D, is presently used to a considerable extent; four of the six have been banned from use on crops. No violations of the standards for these six products have been found in the Snake Plain.

Routine monitoring for the vast array of pesticides presently being used does not occur and drinking water standards for most pesticides do not exist. The U.S. Geological Survey water quality database, WATSTORE, does not contain pesticide data for groundwater. Neither do the various agricultural agencies in the state monitor groundwater for pesticides.

Only one product appears to have received attention with respect to possible contamination of groundwater in the Snake Plain. After

groundwater was found to be contaminated with aldicarb (trade name Temik) used on potatoes on Long Island, New York, several brief investigations were conducted in Idaho. The product's manufacturer, Union Carbide, analyzed several groundwater samples from Bingham and Fremont counties in 1979. Samples from Bingham and Minidoka counties and from Twin Falls were taken by EPA in the same year. A study was carried out near Rupert for the same purpose (Brokopp, 1981b). Altogether about 300 samples were analyzed for aldicarb and none were found to contain the chemical at levels above the analytical detection limit of 1 part per billion.

The regulatory aspects of pesticide use and handling are reasonably well developed however the potential groundwater impacts are not regulated.At this time, no contamination of groundwater in the Snake Plain Aquifer can be attributed to pesticides. This fortunate statement is however, made primarily on the basis of a lack of information.

SEPTIC TANK SYSTEMS

Approximately 48% of the population (96,451) on the aquifer dispose of their sewage through septic tank drainfield systems. The actual number of such systems is not known but is estimated at 38,274 (2.52 persons/dwelling). The highest density of septic tank drainfield systems is in the Moreland area of Blackfoot. The general distribution of the systems is higher along the southern and southeastern one-quarter of the aquifer.

Septic tank drainfield systems are known to be serious potential sources of bacterial and nitrate contamination to groundwaters (Scalf and Dunlap, 1977, Canter and Knox, 1984, ASAE 1977, 1982, 1984). They are ranked as one of the most serious potential hazards to groundwater in the Northwest (EPA 1980). Nitrate will accumulate below drainfields and may persist for years. Migration of nitrate from drainfields to groundwater has been documented in Idaho (Mink et al., 1972, Jones and Lustig, 1977, SWDHD 1977).

Within the Snake Plain, no confirmed instances of groundwater contamination from septic tank drainfields have been documented. However high nitrates in private wells at 12 to 30 mg/L have been reported in the Paul and Moreland areas. Whether the high levels are the result of septic tanks or land applied wastewaters is currently undetermined.

An estimated 5 million gallons of septic tank effluent is discharged daily to the soil beneath the Snake Plain. The estimated daily accumulation of nitrogen from septic tank effluent in the soil and groundwater beneath the aquifer is 1670 pounds. The composition of that effluent is shown in Table 22.

Table 22
Characteristics of Septic Tank Effluent

Parameter	Concentration (mg/L) Range	Mean
Suspended Solids[1]	39 – 155	88
Biochemical Oxygen Demand[1]	120 – 240	155
Chemical Oxygen Demand[1]	200 – 327	276
Total Nitrogen[1]	36 – 45	40
Total Coliform, per 100 ml[2]	$1.6 \times 10^4 - 2.4 \times 10^6$	1.8×10^5

[1] EPA, 1980
[2] Scalf and Dunlap, 1977

The depth and characteristics of unsaturated soils below septic tank drainfields are critical to the adequate removal of human pathogens, such as bacteria and viruses. Current Idaho regulations require at least four (4) feet of unsaturated soil below a septic tank drainfield and a limiting layer such as fractured bedrock and basalt or groundwater.

The regulatory authority to control septic tank drainfield systems is delegated to the Health Districts. District V in Twin Falls, District VI in Pocatello and District VII in Idaho Falls administer the installation of such systems through issuance of installation permits and licensing of septic tank system installers. The Districts provide for final inspection of installed systems prior to covering.

The Rules and Regulations for Individual and Subsurface Sewage Disposal Systems of 1978 are currently being revised. Those revisions will be effective in October 1985. The new rules will provide for a Technical Guidance Committee to review new or alternative forms of on-site sewage disposal practices and to maintain a Technical Guidance Manual for assisting the Health Districts in providing for the best management practices for individual and subsurface sewage disposal. The new rules will require the following separations from limiting layers (Table 23).

Table 23
Recommended Effective Soil Depths

Soil Group	Soil Type	Depth below drainfield to: Groundwater	Fractured Rock (feet)	Impermeable Layer
A	Medium Sand Fine Sand Loamy Sand	6	6	4
B	Sandy Loam Loam Silt Loam	4	4	4
C	Silt Clay Loam Sandy or Silty Clay Loam	3	3	4

All other soil types, such as coarse sands and clays will be excluded as potential sites for installation of septic tank drainfields.

The current regulations and the revisions do not address nitrogen loading rates or minimum lot sizes for individual septic tank systems.

HAZARDOUS SUBSTANCES

Before a discussion of the potential impact of hazardous substances on groundwater quality in the Snake Plain Aquifer can be undertaken, it is necessary to understand the regulatory framework by which activities involving hazardous substances are governed. The following list addresses this complicated area in a succinct manner.

1. Clean Water Act of 1972. Regulates hazardous substances in industrial discharges.

2. Toxic Substances Control Act; Federal Insecticide, Fungicide and Rodenticide Act; Hazardous Materials Transportation Act. Regulate hazardous substances while in use by industry.

3. Resource Conservation and Recovery Act of 1976 and 1984 Amendments. Ensures that the ultimate disposition of hazardous waste materials from any process use of spill occurs in an environmentally sound fashion.

4. Idaho Hazardous Waste Management Act of 1983. State statute which closely parallels the federal Resource Conservation and Recovery Act.

5. Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Addresses abandoned sites or closed facilities where hazardous wastes have been handled in the past and active uncontrolled waste sites. This is the enabling legislation for Superfund.

The major piece of legislation that offers protection to groundwater from contamination by hazardous substances is the Resource Conservation and Recovery Act (RCRA) and the parallel state authority. This statute is very powerful and broad in scope. Groundwater protection is specifically addressed. For these reasons, the majority of this discussion will detail the implementation of RCRA in the Snake Plain.

RCRA governs the generation, treatment, storage, transportation, and disposal of hazardous wastes. Hazardous wastes are defined on the basis of ignitability, corrosivity, reactivity and toxicity. Subpart D of Part 261 of the EPA regulations mandated by RCRA lists approximately 400 substances for which "cradle-to-grave" tracking is required.

The U.S. EPA and the Idaho Division of Environment's Hazardous Materials Bureau are charged with enforcement of these regulations. Permits are required to treat, store and dispose of hazardous wastes. Plans for land disposal of hazardous wastes must specifically address the protection of groundwater. For all land disposal facilities, groundwater monitoring is required. Monitoring is required for up to 30 years after the closure of a disposal facility to ensure that no contamination occurs.

At present, there is only one site in the Snake Plain at which groundwater contamination has occurred and remedial provisions under RCRA are being enforced. This site is the former Utah Power and Light pole treating facility in Idaho Falls. An extensive groundwater monitoring and cleanup program is underway.

A major provision within RCRA for addressing potential groundwater contamination is the State Hazardous Waste Site Inventory Program mandated by Section 3012. This program, which is implemented through Superfund, involves the compilation of a list of sites at which hazardous wastes have at any time been stored or disposed. The Emergency and Remedial Response Information System (ERRIS) List, as it is called, forms the foundation for further investigation of potential hazardous waste problems. As site investigations occur, determinations of no hazard to the public or the environment result in removal from the list. A determination of a significant potential problem results in further investigation. Action under RCRA or CERCLA (Superfund), depending on ownership and financial solvency, may ensue.

At this time, the Idaho Hazardous Materials Bureau has identified 22 ERRIS sites within the Snake Plain. A summary of the sites by county is shown in Table 24.

Table 24
ERRIS Site in the Snake Plain

County	No. of Sites
Bingham	5
Bonneville	3
Butte	3
Fremont	1
Gooding	1
Jefferson	3
Jerome	2
Madison	2
Minidoka	2
TOTAL	22

Based on findings of no significant problems during preliminary investigations by the Hazardous Materials Bureau, the state has requested that EPA remove 10 sites from the list. Five additional sites have been given low priority for subsequent investigation, one site medium priority and one site was classified as being of high priority for further work. Remedial measures are already underway at one other site (Utah Power and Light). No sites are presently receiving Superfund money; neither have any sites in the Plain been recommended for Superfund cleanup at this time.

The sites on the ERRIS investigation list fall into four major categories as shown in Table 25.

Table 25
Types of ERRIS Sites

Type	No. of Sites
Unauthorized solid waste disposal	8
Pesticide rinsate disposal at airports	6
Pole treatment facilities	4
All other types of sites (mines, landfills)	4

After initial investigations, all of the unauthorized dump sites were found to pose no significant threat to public health or the environment, including groundwater. All 8 sites have been recommended by the state for removal from the ERRIS list.

Of the remaining categories, only pesticide rinsate disposal sites and pole treatment facilities are subjects of concern for groundwater protection. Problems with present practices for the disposal of pesticide rinsate solutions are addressed in the section on pesticides. Further investigations are being conducted on the environmental fate of pesticides disposed at these sites.

Pole treatment facilities use organic solutions of creosote and pentachlorophenol to process telephone poles, fence posts and railroad ties. Because of the quantities of these solutions used and the need for maneuvering unwieldy poles in and around the dipping tanks, these sites must employ carefully designed procedures to minimize any threat to the environment. At this time only the aforementioned site in Idaho Falls has been documented as having soil and groundwater contamination. Further precautionary investigation of the other sites on the list has been recommended.

The regulatory authority for dealing with the handling of hazardous wastes over the Snake Plain Aquifer is well developed and its implementation is being strengthened as the Idaho Hazardous Materials Bureau prepares to assume primacy (state control) of the RCRA program. A system of permits is clearly established through the detailed RCRA regulations. However, the inclusion by the 1984 RCRA amendments of generators of small quantities of hazardous wastes will test the capabilities of the responsible agencies to enforce the statute. This factor, coupled with the moderate to high health risk associated with the chemicals involved, results in a moderate threat to groundwater quality in the Snake Plain Aquifer.

GEOTHERMAL WELLS

To date, there are no producing geothermal wells within the boundaries of the Snake Plain Aquifer. Hot springs activity along the margins of the Plain suggests geothermal potential, and several wells along the margins have been drilled that have produced thermal waters. None of these wells are considered a direct threat to the Snake Plain Aquifer due to generally good water quality and adequate construction. In virtually all cases, other than the heat itself, fluoride has been the only water quality parameter that has exceeded the limits of drinking water standards.

The Idaho Department of Water Resources is the state agency responsible for administering rules and regulations regarding the permitting, construction and abandonment of exploratory and production geothermal wells.

FERTILIZER APPLICATION

The major agricultural practice that can potentially impact groundwater quality is the application of fertilizers and pesticides to land overlying the aquifer. The use of pesticides on the more than 2 million acres of agricultural land in the Snake Plain is discussed in a separate section. This portion will address the use of fertilizers on the Plain.

Table 26 shows the quantities of fertilizer materials that are estimated to have been applied on the Snake Plain annually between 1978 and 1983. The data are derived from statewide total quantities compiled in 1984 Idaho Agricultural Statistics and estimates by the Idaho Department of Agriculture to determine portions used on the Plain.

Table 26
Estimated Commercial Fertilizer Materials Used on the Snake Plain

	tons/year
Nitrogen materials	120,000
Phosphate materials	21,600
Potash materials	10,725
Secondary and micronutrients	6,000

Clearly the greatest application is of nitrogen materials. At present, the degree to which the nitrogen compounds pass through the soil and enter groundwater is not known. Monitoring to document this potential groundwater impact does not occur. The situation is complicated further by the fact that elevated levels of nitrate-nitrogen can reach groundwater from septic tanks. Where wells produce drinking water with high nitrate levels, it is sometimes difficult to discern the source.

At this time, there are no instances in which the application of fertilizers has clearly impacted groundwater in the Snake Plain. A few isolated sites have been adversely impacted in areas outside the Plain such as Mountain Home. However, because our knowledge of the impacts of fertilizer application is limited, this contaminant source should be considered as being of moderate concern for groundwater contamination.

RATING AND RANKING THE POTENTIAL CONTAMINANT SOURCES

Rating the Contaminants

Two major mechanisms which are associated with the potential of contamination to the Snake Plain Aquifer have been identified. The first of these is how well a potential contaminant is regulated ($RS_{Regulatory}$). It considers the degree of regulation affecting the contaminant, the level of monitoring that is being carried out for the contaminant and violations of Maximum Contaminant Levels (MCLs). The second is the actual risk of exposure to the contaminant (RS_{Risk}) and is based on the population at risk and the toxicity, quantity, mobility and persistence of the contaminant.

A third factor influencing the potential for contamination is the nature of the aquifer and the overlying soils and geology. This aspect was not considered in the general rating scheme because these characteristics must be considered as constant in a regional rating system.

The factors that make up each of the two variable mechanisms are summarized below:

1. Regulatory Factors:

    a. The regulatory effort in effect for the particular contaminant.
    b. The occurrence of violations of Maximum Contaminant Levels (MCLs) or level of effort to monitor for such violations.

2. Risk Factors:

    a. The toxicity of the contaminant.
    b. The population at risk.
    c. The quantity of the contaminant over the aquifer.
    d. The chemical mobility and persistence of the contaminant..

Each factor is rated 1 through 3 based on the guidelines in Table 27.

Table 27
Guidelines for Rating Factors

	1	2	3
Regulations	Regulations with permits	Regulations or guidelines	No Regulations
Violations/Monitoring	No MCL violations with monitoring	Some MCL violations No monitoring	Numerous MCL violations
Toxicity	No harm	Reversible harm	Irreversible harm or death
Population	Low density <20/mi^2	Moderate density 20-100/mi^2	High density >100/mi^2
Quantity pounds or gallons	Pounds or gallons	1000's of pounds or gallons	Millions of gallons
Mobility/Persistence	Totally contained, Low persistence	Some mobility, Moderate persistence	Extremely mobile, Very persistence

The lack of monitoring for a contaminant is considered as important as the determination that some violations of maximum contaminant levels exist. Such a lack of data shows where there are additional monitoring needs. The toxicity index is based on Sax (1974, 1984).

Each of the factors has been considered just as important as each of the other factors in the rating scheme of used. However, the total rating scores (RS_{Total}) of the contaminant was determined from the following formula (Canter and Knox, 1985):

$$RS_{Total} = \sqrt{\frac{RS_{Regulatory}^2 + RS_{Risk}^2}{2}} \quad X \quad 100$$

The formula is a simple application of the Pythagorean Theorem and provides for emphasis on the most heavily weighted mechanism. For instance, if the risk of a compound was very high, but there was good regulatory control available, the total rating score would reflect more strongly the risk from the compound. The formula makes a vector addition of the two mechanisms after normalizing them a common denominator. This means combining them gives added weight to the rating score that is

higher. The raw rating score is then multiplied by 100 to provide a significant whole number.

Ranking the Contaminants

After a rating value was applied to each of the factors the total rating score was then calculated. Results of those calculations, along with a summary of the individual factor rating scores, are shown in Table 28. The highest rating score represents the contaminant with the greatest potential pollution capability over the aquifer. The lowest possible total rating score is 100, the highest is 300. The contaminants have been ranked in Table 28 in priority order, based on their rating score. The highest rating score indicates the contaminant with the most severe contamination potential.

Table 28
Summary of Rating and Ranking Potential Contaminants

		Factor Ratings						
Rank No.	Contaminant	Regulations	Violations	Toxicity	Population	Quantity	Mobility	Total Rating Score
1	Petroleum	3	2.8	3	3	3	3	295
2	Feedlots/dairies	3	2.5	2	2	2	2	243
2	Landfills	2	2	3	2	3	3	243
4	Land Application	2	3	2	2	3	2	240
5	Haz. Materials	1	2	3	3	3	3	237
6	Pesticides	2.5	2	3	2	2	2	225
7	Land Spreading	2	2.5	2	2	2	2	215
7	Surface run-off	3	1	2	3	2	2	215
7	Pits/ponds	2.5	2	2	2	2	2	215
7	Ag practices	3	1.5	2	2	2	2	215
11	Radioactivity	1	2	3	1	2	3	194
12	Septic tanks	1	2.5	2	2	2	2	191
12	Well drilling	2	2	2	2	1	2	190
14	Injection Wells	1	2	2	2	2	2	177
14	Mining	1	2	2	2	2	2	177
16	Geothermal	1.5	1.5	2	2	1	2	150

The regulation or statute that may affect each potential contaminant source or the lack of such a specific law or guidance has been listed in each section. General authority to protect groundwater quality is given in the Department of Health and Welfare's Water Quality Standards and Wastewater Treatment Regulations. However, these may not clearly address specific contaminant sources, such as surface run-off. An addendum to those regulations, Groundwater Quality Standards, is therefore

currently being proposed. The regulatory activity for each of the potential contaminant sources is listed in Table 29.

Table 29
Summary of Water Quality Regulatory Activity
of Potential Contaminant Sources

Potential Contaminant Sources	Current Status of Regulatory Activity
Land spreading of septage	Regulations
Land spreading of sludge	Guidelines
Land applied wastewaters	Guidelines
Injection wells	Regulations with permits
Well drilling	Regulations
Radioactive materials	Regulations
Surface run-off	None
Feedlots and dairies	NPDES permit for large operations
Bulk storage of petroleum	RCRA and others
Oil and gas pipelines	None
Mining	General Water Quality Standards
Landfills/hazardous waste sites	Regulations
Pits, ponds and lagoons	Regulations for lagoons
Pesticides	Guidelines
Septic tank systems	Regulations with permits
Hazardous substances	Regulations
Geothermal wells	Regulations
Fertilizer application	None

SUMMARY

The Snake Plain Aquifer is influence by a complex set of activities on the Plain. This report provides the technical information to help understand how these activities may affect groundwater quality in the aquifer. Included is the general characterization of the Aquifer and Plain, a review of existing water quality data, and the identification of potential water quality problems. This information will be used to assist in the development of a strategy to manage the water quality of the Snake Plain Aquifer. Conclusions derived from this report regarding water quality management of the aquifer can be found in the strategy which will be completed by the fall of 1985 by the Idaho Department of Health and Welfare and Department of Water Resources.

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GLOSSARY

Adsorption – a process of collecting soluble substances in a solution onto an interface, such as soil or rock particles.

Aggregate Soil – many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are man-caused aggregates produced mainly by tillage.

Alluvial – pertaining to or composed of alluvium (unconsolidated sand, silt, clay, gravel or similar material), deposited by a stream or running water.

Alluvium – material, such as sand, gravel, or silt transported and deposited on land by moving water.

Amorphous Clay – a clay that lacks crystalline form.

Aquifer - a geologic formation, group of formations or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Arid Climate – a climate that lacks sufficient moisture for crop production without irrigation.

Aridic – soil moisture class. Soils too dry for common plant growth for more than 50 percent of the time during the growing season.

Basalt – an extrusive, usually dark-colored igneous rock with a fine-grained texture. Often dense to highly fractured and jointed. Composes the bulk of the Snake Plain Aquifer.

Bedrock – the solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Biochemical Oxygen Demand (BOD_5) – the amount of dissolved oxygen, measured in milligrams per liter, required by microorganisms in the chemical breakdown of organic matter.

Bulk Density – the mass of dry soil per unit volume.

Cation Exchange Capacity – the total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.

Chemical Oxygen Demand (COD) – the total amount of dissolved oxygen, measured in milligrams per liter, required to oxidize organic matter in water.

Clay – mineral soil particles less than 0.002 millimeter in diameter.

Clinker – rough, jagged pyroclastic fragments that resemble the clinker or slag of a furnace.

Coarse Fragments – mineral or rock particles 2 millimeters to 10 inches in diameter.

Cobblestone – a rounded or partly rounded fragment of rock 3 to 10 inches in diameter.

Cryic – soil temperature class. Soils with an average annual soil temperature less than 47 degrees F. and average summer soil temperature less than 59 degrees F. at a 20 inch depth.

Duripan – a subsurface horizon that is cemented by silica. They commonly contain accessory cements, including calcium carbonate. They vary in appearance, but all have very firm moist consistence and are brittle even after prolonged wetting.

Eolian – pertaining to the wind, and deposits of silt, sand and other materials which were transported and laid down by the wind (sand dunes, loess blankets).

Evapotranspiration – loss of water from a land area through transpiration of plants and evaporation from the soil. Also the volume of water lost through evapotranspiration.

Flood Plain – a nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Frigid – soil temperature class. Soils with an average annual soil temperature less than 47 degrees F. and an average summer soil temperature greater than 59 degrees F. at a 20 inch depth.

Glacial Outwash – gravel, sand, and silt, commonly stratified, deposited by glacial melt water.

Gravel – rounded or angular fragments of rock up to 3 inches in diameter.

Head (hydraulic gradient) – the height of the free surface of fluid above any point in a hydraulic system; a measure of the pressure or force exerted by the fluid.

Horizon, Soil – a layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major soil horizons are:

A Horizon. The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with mineral material. It is also a plowed surface horizon which had once been a B, C, or E soil horizon.

B Horizon. The mineral horizon that formed below an A, E, or O horizon. It has (1) accumulated clay, iron, alluminum, humus, carbonates, gypsum, or silica, (2) evidence of removal of carbonates, (3) redder or browner colors from coatings of oxides than overlying or underlying horizons, (4) granular, blocky, or prismatic structure, or (5) any combinations of these.

C Horizon. Horizon or layer, excluding hard bedrock, that is little affected by soil forming processes described in A, B, or E horizons.

E Horizon. A mineral horizon which has lost a significant amount of clay, iron, or aluminum, leaving a concentration of sand and silt particles, mainly quartz.

O Horizon. Layer dominated by organic material, such as undecomposed or partially decomposed leaves, needles, and twigs on the surface of mineral soils. Other O layers are in peat or muck which were deposited under water and that have decomposed to varying stages.

R Layers. Hard bedrock.

Infiltration – the downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Interbed – a bed, or layer, typically thin, of one kind of rock material occurring between or alternating with beds of another kind.

Isotope – a radioactive form of a chemical element.

Lacustrine – material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lime – calcium carbonate.

Loam – soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess – fine grained material, dominantly of silt-sized particles, deposited by wind.

Mesic – soil temperature class. Soils with an average annual soil temperature between 47 degrees F. and 59 degrees F.

Moderately Well Drained – the soil is wet for short but significant periods of time usually because of a slow permeable layer or intermittently high water table. Some mottled colors may occur at depths of about 30-40 inches.

Montmorillonite – a kind of clay characterized by swelling with wetting and shrinking with drying. It has a high capacity for exchange of cations (see cation exchange capacity).

National Pollution Discharge Elimination System (NPDES) – permitting system under the Clean Water Act..

Organic Matter – plant and animal residue in the soil in various stages of decomposition.

Pan – a compact, dense layer in a soil that impedes that movement of water and the growth of roots. For example, duripan, fragipan, claypan, and plowpan.

Parent Material – the unconsolidated organic and mineral material in which soil forms.

Perched Water Table – the surface of a local zone of saturation held above the main body of groundwater by an impermeable layer of stratum,

usually clay, and separated from the main body of groundwater by an unsaturated zone.

Permeability (aquifer) – is the ease with which the aquifer transmits water, and is measured by the volume of water moved in a unit of time, under a unit hydraulic gradient, through a unit area.

Permeability (soil) – the quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

	Inches per Hour
Very Slow	Less than 0.06
Slow	0.06 to 0.2
Moderately Slow	0.2 to 0.6
Moderate	0.6 to 2
Moderately Rapid	2 to 6
Rapid	6 to 20
Very Rapid	20 or more

pH Value – a numerical designation of acidity and alkalinity in soil (see Reaction, soil)

Poorly Drained – water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly permeable layer within the profile, seepage, or a combination of these.

Pyroclastic Rocks – rocks composed of materials fragmented by volcanic explosion. They are characterized by a lack of sorting.

Quaternary – the second period of the geological era (Cenozoic), in which we live, covering the past 2-3 million years. Informally designated the Age of Man.

Radionuclide – any radioactive chemical element.

Reaction, Soil – A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as:

	pH
Extremely Acid	below 4.5
Very Strongly Acid	4.5 to 5.1
Strongly Acid	5.1 to 5.6
Medium Acid	5.6 to 6.1
Slightly Acid	6.1 to 6.6
Neutral	6.6 to 7.4
Mildly Alkaline	7.4 to 7.9
Moderately Alkaline	7.9 to 8.5
Strongly Alkaline	8.5 to 9.1
Very Strongly Alkaline	9.1 and higher

Residuum – unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rhyolite (rhyolitic) – a group of extrusive igneous rocks with the general composition of granite, typically exhibiting flow texture.

Rock Fragments – rock or mineral fragments having a diameter of 2 millimeters or more; including gravel, cobblestones, stones, and boulders.

Sand – individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains are quartz.

Series, Soil – a group of soils that have about the same profile, except for differences in texture of the surface layer or of the underlying material. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shrink-Swell – the shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica – a combination of silicon and oxygen. The mineral form is called quartz.

Silt – individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter.

Soil – a natural three-dimensional body at the earth's surface. It is capable of supporting land plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil Depth – the depth of a soil to a layer which essentially inhibits root growth – bedrock, duripan, fragipan. Depth groupings are:

	Inches
Very Deep	60 or more
Deep	40 to 60
Moderately Deep	20 to 40
Shallow	10 to 20
Very Shallow	Less than 10

Soil Slope – expressed in terms of percentage – the difference in elevation in feet for each 100 feet horizontal distance. Normally each slope class has variable limits but those chosen for this atlas are:

	Slope (percent)
Nearly Level	0 to 2
Gently Sloping	2 to 6
Moderately Sloping (or Rolling)	6 to 12
Moderately Sloping (or Hilly)	12 to 25
Steep	25 to 50
Very Steep	50 and more

Solum – the upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Somewhat Excessively Drained – water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly permeable. Some are shallow. Some are so steep that much of the

water they receive is lost as runoff. All are free of the mottling related to wetness.

Somewhat Poorly Drained – the soils are wet for significant periods but not all the time. Usually has mottled colors within about 20 inches of the surface.

Subsoil – technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum – the part of the soil below the solum.

Subsurface Layer – technically, the E horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Surface Soil – the soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches. Frequently designated as the "plow layer" or the "Ap horizon".

Terrace (geologic) – an old alluvial plain, ordinarily flat or undulating, generally bordering a river or a lake.

Texture, Soil – the relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are: sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse", "fine", or "very fine".

Tilth Soil – the condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

TKN (Total Kjeldahl Nitrogen) – a measure of the amount of organic nitrogen, in milligrams per liter.

Transmissivity – the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Trihalomethanes – a family of organic compounds named as derivatives of methane, wherein three of the four hydrogen atoms in the molecular structure are substituted by either fluorine, chlorine, bromine, or iodine. Standards are applied to the sum of analytically determined concentrations of chloroform, dichlorobromomethane, chlorodibromomethane, and bromoform.

Volcaniclastic – pertaining to a clastic rock (one composed of broken fragments) containing volcanic material in whatever proportion, and without regard to its origin or environment.

Well Drained – water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Xeric – soil moisture class. Soils with Mediterranean type climate with moist winters and springs and dry summers. These soils are moist more than one-half the time during the growing season.

SNAKE PLAIN AQUIFER

TECHNICAL REPORT

APPENDIX A

SOILS

COLD MOIST SOILS ON TERRACES AND FLOOD PLAINS

1. Kilgore Variant-Hagenbarth-Alex Association
   Very deep, well to somewhat poorly drained medium textured soil with slopes of 0 to 4 percent on terraces and flood plains. (Cryic-Xeric)

Kilgore Variant Soils
Surface Texture – Silt Loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil texture – Silt Loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2.0 inches per hour)
Depth – Very deep (>60 inches)
Slope – 0 – 4 %
Drainage – Somewhat poorly
Average annual precipitation – 16-25"
Frost free season (32° F) – 40-60 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 35
Classification – Pachic Cryoboroll, fine-loamy, mixed, frigid

Hagenbarth Soils
Surface Texture – Silt Loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil Texture – Clay Loam
Subsoil Cation Exchange Capacity (CEC) - High
Permeability – Moderately slow (.2 to 0.6 inches per hour)
Depth – Very deep (>60 inches)
Slope – 1-50%
Drainage – Well
Average annual precipitation – 16-25"
Frost free season (32° F) – 40-60 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 20
Classification – Argic Pachic Cryoboroll, fine-loamy, mixed

Alex Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – High

Surface Organic Matter – High
Subsurface Texture – Loam
Subsoil Cation Exchange Capacity (CEC) - Medium
Permeability – Moderate over rapid (.6 to 2.0"/hour over 6 to 20"/hour)
Depth – Very deep (>60 inches)
Slope – 1-4%
Drainage – Moderately Well
Average annual precipitation – 16-19"
Frost free season (32° F) – 50-70 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 15
Classification – Pachic Cryoborolls, fine-loamy over sand or sandy skeletal

COOL, WET TO DRY SOIL ON TERRACES AND FLOOD PLAINS

2. Bannock-Heiseton-Fulmer Association
   Very deep, well, moderately well, and poorly drained, medium and moderately coarse textured soils with slopes of 0 to 4 percent on terraces and flood plains. (Frigid-Aridic)

Bannock Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Substratum Texture – Loam over very gravelly sand
Substratum Cation Exchange Capacity (CEC) - Low
Permeability – Moderate (0.6 to 2.0 inches per hour)
Depth – Very deep (>60 inches)
Slope – 1-4%
Drainage – Well
Average annual precipitation – 8-13"
Frost free season (32° F) – 90-130 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 35
Classification – Aridic Calcixerolls, Coarse-loamy over sandy or sandy skeletal, mixed, frigid

Heiseton Soils
Surface Texture – Loam and sandy loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Medium
Substratum Texture – Loams and fine sandy loams

Substratum Cation Exchange Capacity (CEC) - Low
Permeability – Moderate rapid (2 to 6 inches per hour)
Depth – Very deep (>60 inches)
Slope – 0-4%
Drainage – Moderately Well
Average annual precipitation – 8-13"
Frost free season (32° F) – 95-120 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 30
Classification – Aquic Xerofluvents, coarse-loamy, mixed (calcareous), frigid

Fulmer Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Substratum Texture – Loam
Substratum Cation Exchange Capacity (CEC) - Medium
Permeability – Moderately slow (0.2 to 0.6 inches per hour)
Depth – Very deep (>60 inches)
Slope – 0-1%
Drainage – Poorly
Average annual precipitation – 10-13"
Frost free season (32° F) – 94-126 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 10
Classification – Typic Haplaquolls, fine-loamy, mixed (calcareous), frigid

3. Terreton-Levelton Association
   Very deep, well drained and very poorly drained, moderately fine textured and moderately coarse textured soils of 0 to 6 percent on old lakebeds and terraces. (Frigid-Aridic)

Terreton Soils
Surface Texture –Silty clay loam and sandy loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – Medium
Substratum Texture –Stratified clay and silty clay loams
Substratum Cation Exchange Capacity (CEC) – Very high
Permeability – Slow (0.06 to 0.2 inches per hour)
Depth – Very deep (>60")
Slope – 0-6%
Drainage – Well
Average annual precipitation – 8-10"

Frost free seasons (32° F) – 80-100 days
Potential groundwater recharge – fair – receives extra accumulation from other areas
% of unit (including similar soils) – 40
Classification – Typic Torriorthents, fine, motmorillonitic (calcareous), frigid

Levelton Soils
Surface Texture –Silty clay loam or clay loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – Medium
Subsoil Texture – Silty clay
Subsoil Cation Exchange Capacity (CEC) – Very High
Permeability – Very slow (<0.06 inches per hour)
Depth – Very deep (>60")
Slope – 0-2%
Drainage – Very poorly drained
Average annual precipitation – 8-10"
Frost free seasons (32° F) – 80-100 days
Potential groundwater recharge – fair, receives extra accumulation from other areas
% of unit (including similar soils) – 30
Classification – Typic Haplaquepts, fine, montmorillonitic (calcareous), frigid

4. Whiteknob-Terreton Association
   Very deep, well drained, medium and moderately coarse textured soils with slopes of 0 to 12 percent on alluvial fans, terraces, and lakebeds. (Frigid-Aridic)

Whiteknob Soils
Surface Texture –Loamy and gravelly loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Substratum Texture –Very gravelly sandy loam
Substratum Cation Exchange Capacity (CEC) – Very low
Permeability – Moderate (0.6 to 2 inches per hour)
Depth – Very deep (>60")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 7-11"
Frost free seasons (32° F) – 70-110 days

Potential groundwater recharge – Poor
% of unit (including similar soils) – 40
Classification – Xerollic Calciorthids, sandy-skeletal, mixed, frigid

Terreton Soils
Surface Texture –Sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Substratum Texture – Clay
Substratum Cation Exchange Capacity (CEC) – Very high
Permeability – Slow (0.06 to 0.2 inches per hour)
Depth – Very deep (>60")
Slope – 0-8%
Drainage – Well
Average annual precipitation – 7-9"
Frost free seasons (32° F) – 90-105 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Typic Torriorthents, fine, montmorillonitic (calcareous), frigid

5. Little Wood-Balaam-Adamson Association
   Very deep, well and somewhat excessively drained, medium and moderately coarse textured soil with slopes of 0 to 4 percent on terraces. (Frigid-Xeric).

Little Wood Soils
Surface Texture –Very gravelly loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Medium
Subsoil Texture – Sandy clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (0.6 to 2 inches per hour)
Depth – Very deep (>60")
Slope – 0-4%
Drainage – Well
Average annual precipitation – 12-16"
Frost free seasons (32° F) – 70-110
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Ultic Argixerolls, loamy-skeletal, mixed, frigid

Balaam Soils
Surface Texture – Gravelly sandy loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Medium
Subsoil Texture – Very gravelly coarse sandy loam
Subsoil Cation Exchange Capacity (CEC) – Very low
Permeability – Moderately rapid over very rapid (0.6 to 2.0" per hr/20" or more per hr)
Depth – Very deep (>60")
Slope – 0-4%
Drainage – Somewhat excessively
Average annual precipitation – 14-18"
Frost free seasons (32° F) – 60-90 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 25
Classification – Ultic Haploxorolls, sandy-skeletal, mixed, frigid

Adamson Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Medium
Subsoil Texture – Fine sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate over rapid (0.6 to 2.0 inches per hr/6 to 20 inches per hr)
Depth – Very deep (>60")
Slope – 0-4%
Drainage - Well
Average annual precipitation – 12-16"
Frost free seasons (32° F) – 60-90 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 20
Classification – Calcic Pachic Haploxerolls, sandy-skeletal, mixed, frigid

WARM, WET TO DRY SOILS ON TERRACES AND FLOOD PLAINS

6. Snake-Philbon Association
   Very deep, well drained, medium and coarse textured soils with slopes of 0 to 10 percent on terraces. (Mesic-Aridic)

Snake Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High

Substratum Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Slow (0.06 to 0.2 inches per hours)
Depth – Very deep (>60")
Slope – 0-2
Drainage – Somewhat poorly
Average annual precipitation – 8-12"
Frost free season (32° F) – 100-130 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 60
Classification – Aquic Calcixerolls, fine-silty, carbonatic, mesic

Philbon Soils
Surface Texture –Muck (organic)
Surface Cation Exchange Capacity (CEC) – Very high
Surface Organic Matter – Very high
Substratum Texture –Mucky silt loam
Substratum Cation Exchange Capacity (CEC) – Very high
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Very deep (>60")
Slope – 0-1
Drainage – Very poorly drained (high water table)
Average annual precipitation – 8-12"
Frost free season (32° F) – 100-130 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 15
Classification – Terric Medisaprists, loamy, mixed, euic, mesic

7. Declo-Feltham Association
   Very deep, well drained, medium and coarse textured soils with slopes of 0 to 10 percent on terraces. (Mesic-Aridic)

Declo Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to .2 inches per hour)
Depth – Very deep (>60")
Slope – 0-10%
Drainage - Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-140 days

Potential groundwater recharge – Poor
% of unit (including similar soils) – 60
Classification – Xerollic Calciorthids, coarse-loamy, mixed, mesic

Feltham Soils
Surface Texture – Loamy fine sand
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Substratum Texture – Loamy fine sand and sandy loam
Substratum Cation Exchange Capacity (CEC) – Very low
Permeability – Rapid over moderately rapid (6 to 20" per hour/2 to 6" per hour)
Depth – Very deep (>60")
Slope – 0-7%
Drainage – Somewhat excessively drained
Average annual precipitation – 7-12"
Frost free season (32° F) – 125-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 20
Classification – Xeric Torriorthents, sandy, mixed, mesic

8. Paulville-Declo Association
   Very deep, well drained, medium textured soils with slopes of 0 to 20 percent on terraces. (Mesic-Aridic)

Paulville Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Very deep (>60")
Slope – 0-6%
Drainage - Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 45
Classification – Xerollic Haplargids, fine-loamy, mixed, mesic

Declo Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Very deep (>60")
Slope – 0-20%
Drainage - Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Xerollic Calciorthids, coarse-loamy, mixed, mesic

9. Woodskow-Decker Association
   Very deep, somewhat poorly and moderately well drained, medium and moderately coarse textured soils with slopes of 0 to 2 percent on terraces. (Mesic-Aridic)

Woodskow Soils
Surface Texture – Sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate rapid (2 to 6" per hour)
Depth – Very deep (>60")
Slope – 0-2%
Drainage – Moderately well
Average annual precipitation – 8-11"
Frost free season (32°) – 125-140 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 40
Classification – Aquic Camborthids, coarse-loamy, mixed, mesic

Decker Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Substratum Texture – Loam
Substratum Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2 inches per hour)

Depth – Very deep (>60")
Slope – 0-2%
Drainage – Somewhat poorly
Average annual precipitation – 8-12"
Frost free season (32°) – 125-140 days
Potential groundwater recharge – Good
% of unit (including similar soils) – 30
Classification – Aquic Calciorthids, fine-loamy, mixed, mesic

COLD, MOIST SOILS IN BASALT PLAINS

11. Vadnais-Ramrod Association

Deep and moderately deep, well drained, medium textured soils with slopes of 1 to 12 percent on basalt plains. (Cryic-Xeric)

Vadnais Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 1-12%
Drainage – Well
Average annual precipitation – 18-26"
Frost free season (32°) – 40-80 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 45
Classification – Argic Pachic Cryoborolls, fine-loamy, mixed

Ramrod Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Deep (>40")
Slope – 1-12%
Drainage – Well
Average annual precipitation – 18-26"
Frost free season (32°) – 40-80 days

Potential groundwater recharge – Fair
% of unit (including similar soils) – 30
Classification – Argic Pachic Cryoborolls, fine-loamy, mixed

COOL, DRY SOILS ON BASALT PLAINS

12. McCarey-Tenno-Rock Outcrop Association
Moderately deep and shallow, well drained, medium textured soils with slopes of 0 to 30 percent on basalt plains. (Frigid-Xeric)

McCarey Soils

Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Medium
Subsoil Texture – Clay loam
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-15%
Drainage – Well
Average annual precipitation – 12-16"
Frost free season (32°) – 80-100 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 40
Classification – Calcic, Argixerolls, fine-loamy, mixed, frigid

Tenno Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Stony loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Shallow (10-20")
Slope – 0-30%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32°) – 95-125 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Lithic Xerollic Camborthids, loamy, mixed, frigid

Rock Outcrop
Potential groundwater recharge – Fair
% of unit (including similar soils) – 15

13. Malm-Bondfarm-Rock Outcrop Association
Moderately deep and shallow, well drained, moderately coarse textured soils and rock outcrop with slopes of 2 to 20 percent on basalt plains. (Frigid-Aridic)

Malm Soils
Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Fine sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 2-20%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32°) – 80-125 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 40
Classification – Xerollic Calciorthids, coarse-loamy, mixed frigid

Bondfarm Soils
Surface Texture –Sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Shallow (10-20")
Slope – 2-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32°) – 80-100 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Xerollic Calciorthids, loamy, mixed, frigid

Rock Outcrop
Potential groundwater recharge – Fair
% of unit (including similar soils) – 20

14. Grassy Butte-Matheson-Diston Association

Very deep to moderately deep, well and somewhat excessively drained, moderately coarse and coarse textured soils with slopes of 0 to 20 percent on eolian sand covered basalt plains. (Frigid-Aridic)

Grassy Butte Soils
Surface Texture – Loamy sand
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Substratum Texture – Loamy sand
Substratum Cation Exchange Capacity (CEC) – Low
Permeability – Rapid (6 to 20 inches per hour)
Depth – Very deep (>60")
Slope – 0-20%
Drainage – Somewhat excessively
Average annual precipitation – 8-11"
Frost free season (32°) – 80-115 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 35
Classification – Typic Calciorthids, sandy, mixed, frigid

Matheson Soils
Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Fine sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Deep (>40")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32°) – 94-125 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 25
Classification – Xerollic Calciorthid, coarse-loamy, mixed, frigid

Diston Soils
Surface Texture – Loamy sand
Surface Cation Exchange Capacity (CEC) – Very low
Surface Organic Matter – Low
Subsoil Texture – Loamy sand
Subsoil Cation Exchange Capacity (CEC) – Very low
Permeability – Rapid (6 to 20 inches per hour)

Depth – Moderately deep (20-40")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32°) – 80-100 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 15
Classification – Xerollic Durorthids, sandy, mixed, frigid

15. McBiggam-Goodington Association
    Very deep, well drained, medium textured soils with slopes of 2 to 20 percent on volcanic ash covered basalt plains. (Frigid-Aridic)

McBiggam Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Slow (.06 to .2 inches per hour)
Depth – Very deep (>60")
Slope – 2-8%
Drainage – Well
Average annual precipitation – 12-16"
Frost free season (32°) – 70-100 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 40
Classification – Typic Argixerolls, fine-silty, mixed, frigid

Goodington Soils
Surface Texture –Silt loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Very slow (<.6 inches per hour)
Depth – Deep (>40")
Slope – 2-20%
Drainage – Well
Average annual precipitation – 12-16"
Frost free season (32°) – 60-90 days

Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Typic Palexerolls, fine, montmorillonitic, frigid

16. Aecet-Bereniceton-Rock Outcrop Association

Moderately deep and deep, well drained, moderately coarse textured soils and rock outcrop with slopes of 0 to 25 percent on basalt plains. (Frigid-Aridic)

Aecet Soils
Surface Texture – Stony sandy loam
Surface Cation Exchange Capacity (CEC) – Very low
Surface Organic Matter – Low
Subsoil Texture – Clay loam
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32°) – 80-115 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Xerollic Calciorthids, fine-loamy, mixed, frigid

Bereniceton Soils
Surface Texture – Sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Substratum Texture – Clay loam
Substratum Cation Exchange Capacity (CEC) – High
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Deep (>40")
Slope – 0-25%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32°) – 80-115 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Xeric Torriorthents, fine-loamy, mixed (calcareous), frigid

Rock Outcrop
Potential groundwater recharge – Fair
% of unit (including similar soils) – 20

17. Panchari-Polatis Association
Very deep and moderately deep, well drained medium textured soils on slopes of 0 to 12 percent on basalt plains. (Frigid-Aridic)

Panchari Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Very deep (>60")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 95 -120 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 45
Classification – Xerollic Calciorthids, coarse-silty, mixed, frigid

Polatis Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Moderately deep (20-40 inches)
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 95-125 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Xerollic Calciorthids, coarse-silty, mixed, frigid

WARM, DRY SOILS ON BASALT PLAINS

18. Portneuf-Portino-Trevino Association

Very deep to shallow, well drained, medium textured soils with slopes of 0 to 25 percent on basalt plains. (Mesic-Aridic)

Portneuf Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Very deep (>60")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-155 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 45
Classification – Durixerollic Calciorthids, coarse-silty, mixed, mesic

Portino Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-155 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Xerollic Calciorthids, coarse-silty, mixed, mesic

Trevino Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)

Depth – Shallow (10-20")
Slope – 0-25%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 110-165 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 20
Classification – Lithic Xerollic Camborthids, loamy, mixed, mesic

19. Deerhorn-Rehfield-Rock Outcrop Association

Moderately deep and deep, well drained, moderately coarse textured soils and rock outcrop with slopes of 0 to 15 percent on basalt plains. (Mesic-Aridic)

Deerhorn Soils
Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – High
Subsoil Texture – Loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Very slow (<.06 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-15%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 90-120 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Argic Durixerolls, fine-loamy, mixed, mesic

Rehfield Soils
Surface Texture – Sandy loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – High
Subsoil Texture – Sandy clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Deep (>40")
Slope – 2-15%
Drainage – Well
Average annual precipitation – 11-13"
Frost free season (32° F) – 90-120 days
Potential groundwater recharge – Poor

% of unit (including similar soils) – 25
Classification – Ultic Argixerolls, fine-loamy, mixed, mesic

Rock Outcrop
Potential groundwater recharge – Fair
% of unit (including similar soils) – 20

20. Sidlake-Paulville-Rock Outcrop Association

Very deep and moderately deep, medium and moderately coarse textured soils and rock outcrop with slopes of 0 to 15 percent on basalt plains. (Mesic-Aridic)

Sidlake Soils
Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Sandy clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 2-15%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 120-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Xerollic Haplargids, fine-loamy, mixed, mesic

Paulville Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Very deep
Slope – 0-6%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Xerollic Haplargids, fine-loamy, mixed, mesic

Rock Outcrop
Potential groundwater recharge – Fair
% of unit (including similar soils) – 15

21. Gooding-Power-Rock Outcrop Association
Deep and very deep, well drained, medium textured soils and rock outcrop with slopes of 0 to 25 percent on basalt plains. (Mesic-Aridic)

Gooding Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Silty clay
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Very slow (<.06 inches per hour)
Depth – Deep (>40")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 100-150 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 40
Classification – Xerollic Paleargids, fine, montmorillonitic, mesic

Power Soils
Surface Texture – Silt loams
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Very deep (>60")
Slope – 0-15%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 110-160 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 15
Classification – Xerollic Haplargids, fine-silty, mixed, mesic

Rock Outcrop
Potential groundwater recharge – Fair
% of unit (including similar soils) – 15

23.Gooding-Hamrub Association
Deep, well drained, medium textured soils with slopes of 0 to 20 percent on basalt plains. (Mesic-Aridic)

Gooding Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silty clay
Subsoil Cation Exchange Capacity (CEC) – High
Permeability – Very slow (.06 to .2 inches per hour)
Depth – Deep (>40")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 100-150 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 40
Classification – Xerollic Paleargids, fine, montmorillonitic, mesic

Hamrub Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Deep (>40")
Slope – 2-12%
Drainage – Well
Average annual precipitation – 12-15"
Frost free season (32° F) – 90-120 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Calcic Argixerolls, fine-silty, mixed, mesic

24.Paulville-McCain-Rock Outcrop
Very deep and moderately deep, well drained, medium textured soils

and rock outcrop with slopes of 0 to 20 percent on basalt plains. (Mesic-Aridic)

Paulville Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately Slow (.2 to .6 inches per hour)
Depth – Very deep (>60")
Slope – 0-6%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Xerollic Haplargids, fine-loamy, mixed, mesic

McCain Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately Slow (.2 to .6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 110-160 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Xerollic Haplargids, fine-silty, mixed, mesic

Rock Outcrop
Potential groundwater recharge – Fair
% of unit (including similar soils) – 15

25. Portneuf-Minidoka Association
Very deep and moderately deep, well drained, medium textured soils with slopes of 0 to 12 percent on loess covered basalt plains. (Mesic-Aridic)

Portneuf Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Very deep (>60")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-155 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 45
Classification – Durixerollic Calciorthids, coarse-silty, mixed, mesic

Minidoka Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 110-160 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Xerollic Durorthids, coarse-silty, mixed, mesic

26. Karcal-Yutrue-Chilcott Association

Very deep and moderately deep, well drained, fine and medium textured soils with slopes of 0 to 12 percent on basalt plains. (Mesic-Aridic)

Karcal Soils
Surface Texture – Cobbly clay
Surface Cation Exchange Capacity (CEC) – Very high
Surface Organic Matter – Medium
Substratum Texture – Clay
Substratum Cation Exchange Capacity (CEC) – Very high

Permeability – Slow (.06 to .2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-5%
Drainage – Well
Average annual precipitation – 10-16"
Frost free season (32° F) – 70-80 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Entic Chromoxererts, montmorillonitic, mesic

Yutrue Soils
Surface Texture – Stony clay
Surface Cation Exchange Capacity (CEC) – Very high
Surface Organic Matter – Medium
Subsoil Texture – Clay
Subsoil Cation Exchange Capacity (CEC) – Very high
Permeability – Very slow (<.06 inches per hour)
Depth – Very deep
Slope – 0-12%
Drainage – Well
Average annual precipitation – 12-16"
Frost free season (32° F) – 60-100 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Vertic Xerochrepts, fine, montmorillonitic, mesic

Chilcott Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Medium
Subsoil Texture – Medium
Subsoil Cation Exchange Capacity (CEC) – Very high
Permeability – Slow (.06 to .2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 125-170 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 20
Classification – Abruptic Xerollic Duragids, fine, montmorillonitic, mesic

27. Portino-Trevino-Rock Outcrop Association

Moderately deep and shallow, well drained, medium textured soils and rock outcrop with slopes of 0 to 25 percent on basalt plains. (Mesic-Aridic)

Portino Soils

Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-155 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Xerollic Calciorthids, coarse-silty, mixed, mesic

Trevino Soils

Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Shallow (10-20")
Slope – 0-25%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 110-160 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Lithic Xerollic Camborthids, loamy, mixed, mesic

Rock Outcrop

Potential groundwater recharge – Fair
% of unit (including similar soils) – 20

28. Vining-Keko-Sidlake Association

Very deep to shallow, well drained, moderately coarse, textured soils with slopes of 2 to 20 percent on loess mantled basalt plains. (Mesic-Aridic)

Vining Soils

Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Fine sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 2-15%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 110-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Xerollic Camborthids, coarse -loamy, mixed, mesic

Keko Soils

Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Fine sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Very deep (>60")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 115-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Xerollic Camborthids, coarse-silty, mixed, mesic

Sidlake Soils

Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Sandy clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium

Permeability – Moderate (.6 to 2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 2-15%
Drainage – Well
Average annual precipitation – 8-10"
Frost free season (32° F) – 120-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 25
Classification – Xerollic Haplargids, fine-loamy, mixed, mesic

COOL, DRY SOILS ON LOESS OR EOLIAN SAND DEPOSITS

31. Rexburg-Ririe Association

Very deep, well drained, medium textured soils with slopes of 0 to 25 percent on silty eolian deposits. (Frigid-Xeric)

Rexburg Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Very deep (>60")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 12-16"
Frost free season (32° F) – 75-110 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 45
Classification – Calcic Haplexerolls, coarse-silty, mixed, frigid

Ririe Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – High
Surface Organic Matter – High
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Very deep (>60")
Slope – 0-20%
Drainage – Well
Average annual precipitation – 13-18"

Frost free season (32° F) – 70-100 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Calcic Haplexerolls, coarse-silty, mixed, frigid

32. Grassy Butte-Wolverine-Sand Dunes Association

Very deep, excessively drained, coarse textured soils and sand dunes with slopes of 0 to 30 percent on eolian covered plains. (Frigid-Aridic)

Grassy Butte Soils
Surface Texture – Loamy sand
Surface Cation Exchange Capacity (CEC) – Very low
Surface Organic Matter – Low
Substratum Texture – Loamy sand
Substratum Cation Exchange Capacity (CEC) – Very low
Permeability – Rapid (6 to 20 inches per hour)
Depth – Very deep (>60")
Slope – 0-20%
Drainage – Excessively drained
Average annual precipitation – 8-11"
Frost free season (32° F) – 80-115 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 35
Classification – Typic Calciorthids, sandy, mixed, frigid

Wolverine Soils
Surface Texture – Sand
Surface Cation Exchange Capacity (CEC) – Very low
Surface Organic Matter – Low
Substratum Texture – Sand
Substratum Cation Exchange Capacity (CEC) – Very low
Permeability – Very rapid (20" or more per hour)
Depth – Very deep (>60")
Slope – 0-30%
Drainage – Excessively
Average annual precipitation – 8-13"
Frost free season (32° F) – 90-125 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 30
Classification – Xeric Torripsamments, mixed, frigid

Sand Dunes
Potential groundwater recharge – Good
% of unit (including similar soils) – 20

33. Sand Dunes-Wolverine Association
Very deep, excessively drained, coarse textured soils and sand dunes with slopes of 0 to 50 percent on eolian covered plains. (Frigid-Aridic)

Sand Dunes
Potential groundwater recharge – Good
% of unit (including similar soils) – 60

Wolverine Soils
Surface Texture – Sand
Surface Cation Exchange Capacity (CEC) – Very low
Surface Organic Matter – Low
Substratum Texture – Sand
Substratum Cation Exchange Capacity (CEC) – Very low
Permeability – Very rapid (20" or more per hour)
Depth – Very deep (>60")
Slope – 0-30%
Drainage – Excessively
Average annual precipitation – 8-13"
Frost free season (32° F) – 90-125 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 20
Classification – Xeric Torripsamments, mixed, frigid

WARM, DRY SOILS ON LOESS OR EOLIAN SAND DEPOSITS

34. Vining-Escalante-Quincy Association
Moderately deep and very deep, well and excessively drained soils with slopes of 0 to 40 percent on terraces and eolian sand covered plains. (Mesic-Aridic)

Vining Soils
Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Fine sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low

Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 0-30%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 110-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Xerollic Camborthids, coarse-loamy, mixed, mesic

Escalante Soils
Surface Texture – Fine sandy loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Fine sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Very deep (>60")
Slope – 0-10%
Drainage – Well
Average annual precipitation – 8-14"
Frost free season (32° F) – 100-140 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Xerollic Calciorthids, coarse-loamy, mixed, mesic

Quincy Soils
Surface Texture – Fine sand
Surface Cation Exchange Capacity (CEC) – Very low
Surface Organic Matter – Low
Substratum Texture – Fine sand
Substratum Cation Exchange Capacity (CEC) – Very low
Permeability – Very rapid (20" or more per hour)
Depth – Very deep (>60")
Slope – 0-40%
Drainage – Excessively drained
Average annual precipitation – 8-12"
Frost free season (32° F) – 135-180 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 10
Classification – Xeric Torripsamments, mixed, mesic

COOL, MOIST SOILS ON FOOTHILLS AND MOUNTAINS

41. Xerochrepts-Xeralfs, Steep Association

Moderately deep, well drained, medium and moderately coarse textured soils with slopes of 15 to 60 percent on the sideslopes of the Island Park Caldera (Frigid-Xeric)

Xerochrepts

Surface Texture – Loams and sandy loams
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Medium
Subsoil Texture – Loams
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 15-40%
Drainage – Well
Average annual precipitation – 18-30"
Frost free season (32° F) – 60-90 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 45
Classification – Xerochrepts

Xeralfs

Surface Texture – Loams and silt loams
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Loam, clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Very deep (>60")
Slope – 15-40%
Drainage – Well
Average annual precipitation – 18-30"
Frost free season (32° F) – 60-90 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 35
Classification – Xeralfs

42. Targahee-Crystall Butte Association

Moderately deep and very deep, well drained, moderately coarse and medium textured soils with slopes of 15 to 40 percent on foothills and mountain slopes. (Cryic-Xeric)

Targahee Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Medium
Subsoil Texture – Generally sandy loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately rapid (2 to 6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 15-40%
Drainage – Well
Average annual precipitation – 30-35"
Frost free season (32° F) – 40-80 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 45
Classification – Typic Cryochrepts, loamy-skeletal, mixed

Crystal Butte Soils
Surface Texture – Loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – High
Subsoil Texture – Loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Very deep (>60")
Slope – 15-30%
Drainage – Well
Average annual precipitation – 20-24"
Frost free season (32° F) – 40-80 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 35
Classification – Argic Pachic Cryoborolls, fine-loamy, mixed

COOL, DRY SOILS ON VOLCANOES AND LAVA BEDS

51. Lava Beds-Cinderhurst Association
Very shallow, well drained, medium textured soils and lava beds with slopes of 1 to 30 percent on plains. (Frigid-Aridic)

Lava Beds
Potential groundwater recharge – Good
% of unit (including similar soils) – 70

Cinderhurst Soils
Surface Texture – Extremely cobbly silt loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Very cobbly silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Very shallow (<10")
Slope – 1-15%
Drainage – Well
Average annual precipitation – 12-16"
Frost free season (32° F) – 60-90 days
Potential groundwater recharge – Fair
% of unit (including similar soils) – 20
Classification – Lithic Mollie Haploxeralfs, loamy-skeletal, mixed, frigid

52. Camborthids-Haplargids, steep Association

Moderately deep, well drained, medium and moderately coarse textured soils with slopes of 15 to 60 percent on sideslopes of old volcanoes. (Frigid-Aridic-Xeric)

Camborthids
Surface Texture – Silt loams and loams
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Loams
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Very deep (>60")
Slope – 15-60%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 100-130 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 50
Classification – Camborthids

Haplargids Soils
Surface Texture – Loams, gravelly loams
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium

Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Moderately deep to deep (20 to >40")
Slope – 15-40%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 100-130 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Haplargids

WARM, DRY SOILS ON VOLCANOES

53. McCain-Portino-Porneuf Association

Deep and moderately deep, well drained, medium textured soils with slopes of 5 to 20 percent on old shield volcanoes. (Mesic-Aridic)

McCain Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Medium
Surface Organic Matter – Low
Subsoil Texture – Silty clay loam
Subsoil Cation Exchange Capacity (CEC) – Medium
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Moderately deep (20-40")
Slope – 5-20%
Drainage – Well
Average annual precipitation – 8-12"
Frost free season (32° F) – 110-160 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 35
Classification – Xerollic Haplargids, fine-silty, mixed, mesic

Portino Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderate (.6 to 2 inches per hour)
Depth – Moderately deep (20-40")
Slope – 5-20%
Drainage – Well
Average annual precipitation – 8-11"

Frost free season (32° F) – 100-155 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 30
Classification – Xerollic Calciorthids, coarse-silty, mixed, mesic

Portneuf Soils
Surface Texture – Silt loam
Surface Cation Exchange Capacity (CEC) – Low
Surface Organic Matter – Low
Subsoil Texture – Silt loam
Subsoil Cation Exchange Capacity (CEC) – Low
Permeability – Moderately slow (.2 to .6 inches per hour)
Depth – Deep (>40")
Slope – 0-12%
Drainage – Well
Average annual precipitation – 8-11"
Frost free season (32° F) – 100-155 days
Potential groundwater recharge – Poor
% of unit (including similar soils) – 20
Classification – Xerollic Durorthids, coarse-silty, mixed, mesic

Criteria used in rating the cation exchange capacity in soils.

CEC (Meg/100 grams of soil)		
<5	-	Very low
5-15	-	Low
15-25	-	Medium
25-35	-	High
>35	-	Very high