# General Engineering Geology of Part of the Lower Snake River Canyon, Washington

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## Introduction

The development of the lower Snake River in southeastern Washington by the U. S. Army Corps of Engineers in the interests of navigation, irrigation, and power was authorized by Congress in 1945. The law approved the plan of development whereby such dams as are necessary to provide slack-water navigation and irrigation would be constructed. Two of the four dams proposed for the lower Snake River are within the area mapped. These are Dam No. 2, Lower Monumental, at river mile 44.7; and Dam No. 3, Little Goose, at river mile 72.2. Both dams will be a combination of concrete and embankment type construction. Each will include single lift navigation locks, power generating installations and fishways. Construction of the dams will require the relocation of approximately 65 miles of railroad and many miles of state and county roads within the mapped area. In addition, the construction of several miles of access roads will be necessary.

The engineering geology of the lower Snake River canyon, as presented in the following text, is confined to generalities only and is without reference to specific engineering sites. For more detailed information pertaining to the geology of specific engineering sites on the Snake River, the reader is referred to the special reports and investigations prepared by the Sections of Geology and Exploration, Corps of Engineers, Walla Walla District, Walla Walla, Washington, and Portland District, Portland, Oregon.

The geologic map is the base of the report. The map explanation includes a description of the material found in the various deposits along with the distinctive topographic and lithologic characteristics. Most of the engineering geology text is in tabular form to facilitate the selection of specific kinds of information. The more detailed general geology report accompanies the map and engineering geology text in manuscript form.

## Geologic Feasibility of Engineering Developments

Geologically the lower Snake River canyon in many ways is ideally suited for the construction of dams, either as presently conceived for navigation purposes, or larger dams for power. Excellent foundation material and copious quantities of easily excavated construction materials occur at many places throughout the length of the canyon. Geologic structures are simple, and no seismic activity has been recorded in the area. Existing slopes are relatively stable, and no evidence was seen of large landslides..

## Topography

The Snake River has cut a deep canyon into the Columbia River Plateau in southeastern Washington. The canyon is nearly 1,500 feet deep at the eastern edge of the area mapped, decreasing to about 1,000 feet at the western edge. The canyon walls are generally steep and rugged and have good rock exposures. The bottom of the canyon, in most places, is considerably wider than the river channel and the inside of every curve is occupied by a large terrace, the surface of which is 30 to 250 feet or more above the river.

## General Foundation Conditions

Nearly flat-lying basalt flows, comprise the foundation rocks within the area mapped. Individual flows range in thickness from 15 to over 150 feet but may vary considerably in thickness laterally. The rock is generally hard and strong and will provide an excellent foundation in most places. In some places interbedded sedimentary or pyroclastic material occurs between the basalt flows. These are composed of gravel, sandy-silt, clay-like material or volcanic ash, in places soft and in other places compacted or baked. In most places the beds are thin, but locally may be as thick as 30 feet or more. Zones of vesiculation and brecciation, usually accompanied by some alteration, are common at contacts between flows and may be as much as 30 feet thick. Where these contact zones or interbedded materials occur at critical elevations in the foundation area, additional excavations to sound rock may be necessary. Grouting of contact zones at other elevations also may be required.

No major faults were observed, but small faults and sheared and brecciated zones occur scattered throughout the basalt formations. These sheared and brecciated zones range in width from a few inches to 30 feet or more and in most cases show no measurable vertical displacement. Tension joints and other minor fractures occur almost everywhere throughout the lava.

Although individual flows vary considerably in permeability, a series of flows generally is considered to be pervious and capable of absorbing considerable water at the surface and transmitting it readily in the zone of saturation. The depth to the water table depends on the extent to which the lava is drained by deep canyons and the existence of less pervious material, such as the massive dense sections of individual flows, dikes, or sills, and interstratified layers of tuff, clay, or soil. Factors affecting permeability of basalts, in a probable decreasing order of importance, are as follows: (1) scoriaceous and fragmental zones at the tops and bottoms of successive flows; (2) large open spaces at the contact of one flow with another; (3) open joints, formed by shrinkage during cooling; (4) caverns formed in flows by the draining away of subsurface streams of liquid lava from beneath hardened crusts; (5) vesicles and cavities resulting from the expansion and escape of gases during cooling; and (6) fissures produced by faulting and fracturing after the flows have cooled. Minor leakage through the basalt members along reservoir walls can be expected, but should not be serious enough to endanger safety or feasibility of the proposed engineering structures.

## Construction Materials

With the exception of clay, construction materials are abundant throughout the canyon. Some of the materials, however, may be in deficient quantities at a specific construction site. An unlimited quantity of basalt is available for crushed rock and riprap of nearly all sizes. The numerous joints and fractures in the basalt facilitate blasting and crushing. The large unconsolidated fluvio-glacial and alluvial deposits insure adequate quantities of sand and gravel of nearly all sizes Screening and washing will probably be necessary for most of the deposits. Deleterious material may be present in some places. Unlimited quantities of silt are available for impervious fill, however, moisture control and the addition of other materials may be required for proper compaction.

## Stability of Slopes in Dam Site and Reservoir Areas

Present slopes appear to be stable, and no evidence was observed of landslides in the area. Recent talus deposits, mantle benches and the lower slopes of the cliffs nearly everywhere throughout the canyon, but they are relatively small in magnitude by comparison with similar deposits flanking the Columbia River, and consequently will not present the problems that have been encountered there. Where unconsolidated materials, either talus accumulations or sand and gravel banks, comprise the reservoir walls, some failure and slumping will probably result from saturation and erosion by the reservoir waters, but is not expected to be serious.

## DESCRIPTION OF ROCK UNITS

| MAP UNITS | CHARACTER | DISTRIBUTION AND THICKNESS | TERRAIN AND NATURAL SLOPES | DRAINAGE AND PERMEABILITY | EXCAVATION | STABILITY | POSSIBLE USE | ORIGIN OF DEPOSIT |
|---|---|---|---|---|---|---|---|---|
| RECENT ALLUVIUM | Unconsolidated stream deposits of sub-angular quartz sand and silt, silty basaltic rubble, and well-rounded gravel of nearly equal amounts of basalt and pre-Tertiary igneous and metamorphic rocks. | Covers Snake River canyon and tributary floors to highest water level. Thickness: trace to a maximum of probably 50 feet. | Valleys characteristically elongate, flat-floored and sinuous. Majority of streams intermittent. Natural slopes flat to gentle; steep where banks undercut. | Drainage good and permeability high in gravels; less so in silts. | Easily worked with power equipment except below water table. | Generally saturated. Low angle slopes necessary in cuts. Poor foundation material for heavy loads. | Suitable, with screening, for base course and road metal; can be used for concrete aggregate. Some deleterious material may be present and washing may be necessary. | Stream transported products of mechanical and chemical erosion. |
| RECENT EOLIAN* DEPOSITS | Deposits of buff-colored, massive, unconsolidated silt, lithologically indistinguishable from the Palouse formation; dune sands of well-sorted, unconsolidated angular grains of quartz with some admixed silt and dirty floury ash deposits, composed of a mixture of fine, angular, cellular fragments of glass and silt. | A blanket of recent eolian silt covers most of the area. Dune sands occur locally on many of the Snake River terraces. Small volcanic ash deposits occur scattered throughout the canyon; usually on the lee or northeastern side of a hill or bluff, and especially at the lower extremities of small gulches. Thickness: trace to as much as 3 feet of silt, 60 feet of dune sand, and 10 feet of ash. | Silt deposits of uneven terrain, controlled by the underlying slopes; surfaces smooth and slopes flat to fairly steep. Dune sands characterized by uneven terrain including low elongate ridges, rounded mounds, depressions and blowouts; natural slopes gentle to steep on lee slopes. Ash deposits have small terrace form on valley sides or are fan-shaped; natural slopes flat to steep. | Silt and ash deposits unconsolidated to slightly compacted; drainage poor and permeability low. Dune sands have moderate to high permeability and good drainage. | All are easily worked with hand tools. | Low strength when dry; very weak when saturated. Low angle slopes necessary in cuts. Soil stabilization necessary to retard drifting by winds. | In general, deposits are too small to be of much value. Dune sand fair for use as blending sand but washing may be necessary; may also be used as pervious fill. Ash deposits probably too small for source of pozzolanic material. Silt probably not suitable as impervious fill because of poor compaction. | Silts derived from deflation of the Palouse formation and silty glacial deposits. Dune sands derived from wind erosion of alluvial and glacial deposits. Ash deposits in part wind-blown and in part water-laid, presumably from eruptions of Cascade volcanoes. |
| TERRACE* SILTS | Deposits of buff and tan silt, with some small basalt pebbles and angular grains of coarse basaltic sand scattered throughout the mass. Bulk of the material is massive, but commonly stratified near the base, showing alternating thin beds of silt and quartz sand. | Discontinuous remnants throughout the area capping canyon and tributary terraces. Thickness: trace to maximum of about 25 feet. | Uneven terrain characterized by rolling low mounds. Slopes very gentle to fairly steep. | Material loose to slightly compacted; interbedded fine sands at base of deposit. Drainage poor; permeability low. | Easily worked with hand tools. | Low strength when dry, very weak when saturated. Stability poor because of basal sands which promote slumping. | May be suitable for impervious fill or aggregate filler. | Mixture of glacial rock flour and reworked Palouse formation. Partly lacustrine, alluvial, and eolian. |
| PEBBLY* SILTS | Deposits of light tan to gray unconsolidated silt, numerous included angular basalt pebbles, berg-rafted erratics and small lenses of sand and rubble. Material generally poorly stratified and poorly sorted. | Occurs chiefly as terrace remnants or veneer on tributary valley floors and walls upstream from Lyons Ferry. Thickness: trace to generally less than 10 feet, but locally as much as 20 feet. | Uneven terrain, characterized by smooth rounded irregularly shaped mounds or terrace forms. Natural slopes gentle to moderate. | Material loose to slightly compacted. Drainage poor; permeability low. | Easily worked with hand tools. | Low strength when dry; very weak when saturated. Will stand at high slopes but subject to slumping and gullying. | The numerous included pebbles, occasional boulders, and small size of deposits preclude their being of much use; however, they may find limited use as impervious fill or aggregate filler. | Deposited on valley floors and walls by pro-glacial floodwaters; later reworked by slope wash. |
| SCABLAND DEPOSITS | Deposits nearly all basaltic in composition exhibiting an apparent general, though irregular, decrease vertically upward in average grain size. Caliche coating common on pebbles and cobbles near surface. Upper: Predominantly coarse basaltic sand and fine gravel, lesser amounts of interbedded silt, fine sand, coarse gravel, and basaltic rubble. Material nearly all subangular to subrounded, unconsolidated and well-bedded in thin lenticular forsets. Lower: Poorly sorted and poorly bedded sub-angular to rounded pebbles and cobbles of basalt in a matrix of sandy-silt. Minor amounts of interbedded sand and silt and many angular basaltic boulders up to 10 feet or more in diameter occur. | Upper: Comprises fill remnants in protected places on canyon walls up to elevation of 1,300 feet. Thickness: from a thin veneer to several hundred feet. Lower: Comprises large canyon terraces downstream from Riparia, up to 5 miles in length. Thickness: from a few feet to 250 feet. | Upper: Gently undulating surfaces, some low elongate ridges. Seldom flat with sloping sides up to 35 degrees. Lower: Uneven terrain characterized by gently undulating surface, a few broad shallow depressions and gentle to steeply sloping sides up to 35 degrees. | Material loose and porous to slightly compacted. Upper probably more permeable than lower deposits. Drainage good to excellent. | Difficult to work with hand tools because of abundant cobbles and boulders, some more than 10 feet in diameter. Easily worked with light machinery, but boulders may require special handling. Over-burden generally thin but lower deposits may have as much as 20 feet of terrace silt or 60 feet of dune sand. | Low to high strength depending on material. Cuts of $1\frac{1}{2}$ to 1 necessary in upper deposits. Lower deposits generally stable at 1:1, and oil-sprayed railroad cuts stable at slopes of 1/3:1. | Source of sand and gravel for concrete aggregate, pervious fill and highway material. Aggregate material will require washing and screening. Cobble and boulder gravel, after screening and washing, suitable for crushed rock and riprap. Some deleterious material may be present. | Glacial debris deposited by glacial meltwater streams. |
| SNAKE RIVER GRAVEL | Poorly consolidated, generally well stratified silts, sands, and silty stream gravels. Gravels generally poorly sorted, well rounded, and range in composition from 40 to 60% basalt; remainder largely intrusive and metamorphic rocks. Interbedded sand and silt is moderately well-sorted, angular basalt and/or quartz fragments. Boulders as large as 3 feet or more in diameter are common. | Terrace remnants a few hundred feet to about $6\frac{1}{2}$ miles in length occurring inside of river bends in Snake River canyon, upstream from vicinity of Riparia. Thickness: from a few feet to a maximum of about 150 feet. | Deposits characterized by gentle undulating surface and gentle to steep side slopes. | Material loose and porous to slightly compacted. Permeability and drainage mostly good except where thick silt lenses encountered. Wells generally very productive. | Easily excavated with light machinery, but locally boulders may be large and abundant enough to require special handling. Overburden generally thin, but locally there may be as much as 40 feet of dune sand or 25 feet of terrace silt. | Low to high strength depending on material. Cuts generally stable at 1:1, and in places as high as 2/3:1. | Source of sand and gravel for concrete aggregate, pervious fill and highway material. Material for aggregate will probably require washing and screening. Some deleterious material may be present. Cobble and boulder gravels, after screening, suitable for crushed rock or riprap. | Reworked older alluvial gravels and glacial meltwater debris. |
| PALOUSE FORMATION | Buff to light brown, massive, homogeneous, unconsolidated loessial silt. The material is extremely well-sorted, more than 90% of it passing a No. 200 (U.S.) sieve. Predominantly angular quartz grains; lesser amounts of feldspar, mica and hornblende; traces of other minerals. Weathering may extend to depth of several feet, and caliche zones occur at depths of 18 inches to 10 or more feet. | Mantles most of plateau upland surface. Thickness: from a few inches to over 200 feet. Where thin is difficult to separate from more recent eolian deposits. | Maturely dissected terrain characterized by smooth-surfaced, gently rolling to steep-sided hills. | Drainage poor and permeability low. | Easily excavated by hand tools. | Low strength when dry; very weak when saturated. Stable in road cuts at slopes as high as 1/3:1, but may gully or slough. Powdery when dry; plastic and sticky when wet. | Source of fines. May represent possible source of impervious fill. Unsurfaced roads unstable; powdery when dry; plastic and sticky when wet. | Wind-blown deposit derived from deflation of glacial outwash, or may be, in part, derived from Ringold formation. |
| INTRACANYON BASALT | Dark gray to black, generally dense, finely porphyritic, and fresh appearing lava flows. Characterized by well-developed small, but irregular, columns. | Discontinuous, small remnants of old lava-filled valleys scattered along canyon walls. Thickness: maximum about 100 feet. | Uneven, irregular and usually elongated masses. Slopes very gentle to nearly vertical cliffs. | Drainage good. Permeability variable. | Blasting necessary. Broken rock and talus may be removed by power shovel. Overburden generally thin. | High strength. Stability of slopes controlled by local joint patterns, but generally stable at slopes nearly vertical. | Excellent source of crushed rock for concrete aggregate, pervious fill, and highway material. Broken rock, talus, or crushed rock suitable for riprap. Limited use for masonry, where jointed so as to be quarried in large blocks. | Lava flows. |
| COLUMBIA RIVER BASALT | Dark gray to black where fresh, dark brown on weathered surfaces. Hard except where weathered or altered, and generally slightly vesicular. Most flows aphanitic; some porphyritic with feldspar phenocrysts. Flow contact zones vesicular or scoriaceous, commonly oxidized and unsound. Central and lower parts of flow are dense, with massive columns. Composed of feldspar, augite, olivine, and magnetite in a glassy matrix. Rock well-jointed. Weathering confined mostly to minor oxidation on exposed surfaces and along joints. | Underlies surficial deposits and forms canyon walls throughout mapped area. Thickness: individual flows range in thickness from 15 to over 150 feet; total thickness of lavas not known, but may exceed 5,000 feet. | Upland surface generally flat to gently undulating and covered by loess. Slopes in canyon walls flat on benches, steep on faces. Lower faces and parts of benches generally covered by talus. | Permeability poor to high. Drainage generally good. | Same as intracanyon basalt. Overburden, however, may be quite thick in places. | High strength. Good foundation material. Where flow contacts, breccias, or sedimentary interbeds are located at critical elevations in the foundation area, additional excavation to sound rock may be necessary. Grouting of contact zones also may be required. Talus deposits stable at slopes of $1\frac{1}{2}$:1. Stability of bedrock slopes controlled by local joint patterns, but generally stable at slopes near vertical. | Same as intracanyon basalt. Deleterious zeolites, opal, etc., present in some flows. | Lava flows. |

* Not mapped