GEOLOGY OF DAM SITES

ON

LEWIS RIVER, WASHINGTON

The attached report on the above subject was opened to public inspection by Interior Department press notice No. 92601 dated March 23, 1951. The report was prepared by A. F. Bateman, Jr., Geologist, under the direction of C. E. Erdmann, Regional Geologist, Mineral Classification Branch, Conservation Division, U.S. Geological Survey, Great Falls, Montana. The field examinations were made by Mr. Erdmann during the 1936 field season, and the notes, sketches, and other data obtained at that time were used by Mr. Bateman in the preparation of the report.

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Introduction

Special dam site topographic maps 1/ on a scale of 1:4800 have

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1/Plan and profile of Lewis River, to mile 87, and tributaries, Washington. Sheets E and F.

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been prepared for seven sites on the trunk stream of the Lewis River. Contour intervals on all of these maps are 10 feet on land and 1 foot on water except for Island Camp dam site on which the interval is 10 feet on land and 5 feet on water, and the Quartz Creek dam site on which the interval is 5 feet for both land and water. Preliminary geologic field investigation and mapping have been completed at all of these sites and a geologic reconnaissance has been made of a possible site at mile 52 on the trunk stream for which no special dam site map has been made.

Each site is discussed briefly, proceeding upstream.

Eddy Rock dam site

Eddy Rock dam site is located on the East Fork Lewis River, one mile above its mouth. This is approximately 3½ miles east of the village of Woodland. U. S. Highway No. 99 skirts the west edge of the dam site.

At the dam site, the stream occupies a strike valley cut to a depth of 200 feet or more below water level. Valley fill consists of silt and sand. Bedrock is made up of a series of basalt flows with interbedded volcanic agglomerates, breccias, tuffs, and tuffaceous sediments. Dip of beds is northeast at angles varying from 40 to 50 degrees throughout most of the dam site area. No faults were observed. Joints are developed chiefly in the basalts; they consist of master joint systems produced by tectonic stress, and less persistent and less well defined systems resulting from cooling. Permeability of the agglomerates is probably rather low; permeability of the basalts is probably medium because of the highly developed joints. Very permeable basalt flow breccia was observed in two localities.

Foundation is underlain by a thick volcanic agglomerate, poorly exposed and hence largely unknown in character. Both abutments are in basalt with minor amounts of agglomerate. The left abutment is structurally the weakest because the beds dip into the river. The site is probably suitable for a wide base dam and warrants further investigation. Maximum safe height above tide for construction of a dam without accessory work is about 100 feet. This would require a dam slightly more than 800 feet in length and would impound a reservoir of 202,000 acre-feet. Topography limits the maximum height of dam to 120 feet. A dam at this height would have a crest length of about 900 feet. If a dike approximately 600 feet long were constructed across a small saddle south of the proposed axis, a dam might be built to 160 feet. This would require a structure nearly 1,400 feet long at the crest. Geology of the reservoir is little known, but probably is about the same as at the dam site. So far as is known, the entire left reservoir bank is supported by rock.

The dam site is at the approximate head of tide, whose total range in this area is about 30 feet. Consequently, the effect of tides on the foundation of a dam must be evaluated before construction is considered.

Yale dam site

Yale dam site is on the trunk stream of Lewis River 35.5 miles above its mouth. It is about 5 miles southeast of the village of Yale. Both abutments are accessible by rather poor dirt roads.

The dam site is in a narrow strike gorge cut into the rock floor of a broader U-shaped valley. Thin, irregular cover of active alluvium and talus makes up the only valley fill. On the right or north abutment, the U-shaped valley section is covered with an estimated 10 feet of glacial drift except for two benches under which the drift is probably 30 to 50 feet thick. Bedrock consists of: (1) An upper group of basic andesite flows that average somewhat less than 50 feet in thickness; and (2) a lower group of dense, black basalt flows, associated agglomerates composed of red and brown fragments in a tuff matrix, and tuffaceous sediments. Total thickness of the lower group is probably about 300 feet divided into at least 3 flows. In some parts of the dam site, these rocks show leaching and oxidation from hydrothermal alteration. The flows dip moderately to the southeast. The only good determination of dip and strike was N. 70°E., 20° SE. No faults were observed. The flows in the upper or andesitic group are fractured into irregular blocks that average 18 inches on a side or are in rude columns about 12 inches in diameter and oriented perpendicular to the flow surface. All of the rocks in the lower or basaltic group are highly fractured by both cooling and tectonic joints. Blocks probably average less than 6 inches on a side. Flow contacts appear tight for the most part, but a series of seeps occurs between the highest and second of the basalt flows. Movement of ground water in bedrock will be almost entirely through the joints and flow contacts. Orientation of the flow contacts parallel to the course of the stream makes loss by this method particularly likely.

The foundation and right abutment are underlain by the basaltic lavas, agglomerates, and probably some tuffaceous sediments. The left abutment is underlain by the uppermost basalt flow and the andesite flows. The right abutment is weakest structurally because the beds dip into the river.

This site is suitable for a dam, but feasibility of the project as a whole depends on leakage from the reservoir. Behind the left abutment is a saddle at approximately altitude 510 feet, underlain by alluvium. Depth of fill is not known, but bedrock reaches altitude 440 in the floor of this channel about 2,000 feet downstream. Total length is about one mile. Behind the right abutment is a buried channel whose surface is about altitude 460 feet. Electrical resistivity investigations indicate tentatively that rock floor of the channel is about altitude 340 feet. Hence, there is 120 feet or more of valley fill probably consisting of glacial debris. Length of this channel is only about 3,500 feet. About two miles behind the right abutment is a 4½ mile long buried valley approximating the present course of Speelyai Creek. The divide on the ground surface is about altitude 495 feet in sec. 17, T. 6 N., R. 4 E. Electrical resistivity investigations in this vicinity tentatively indicate that low point in the rock floor of this channel is about altitude 340 feet. Fill materials are probably glacial and may contain large amounts of outwash gravels and sands.

Height of dam is limited on topographic grounds by the Speelyai Creek divide to about altitude 490 feet, which is about 275 feet above stream level at the dam site and 265 feet above high-water level in Lake Merwin. A dam to altitude 490 feet would be approximately 1,350 feet long and would require a dike 25 feet high and 1,300 feet long across the saddle behind the right abutment.

This site cannot be considered feasible until sufficient study has been made of the debris filling the buried channels to insure that reservoir leakage would not be prohibitive or that water percolating through the fill materials would not reach velocities sufficiently great to start cutting.

Cougar dam site

Cougar dam site is on the trunk stream of Lewis River at mile 45.8. It is about 2½ miles east of the village of Cougar by a surfaced road that skirts the right abutment.

The dam site is in a shallow gorge, from which the left bank rises steeply. The right bank rises very steeply to a broad rock bench about 75 feet above river level, from which the steep valley wall rises to a second bench about 450 feet above river level. Valley fill is extensive and complicated. The older topography was buried by extensive outwash deposits from Mt. St. Helens. These deposits, crudely stratified and sorted, were derived from an older till that consisted largely of volcanic material. In some localities the outwash is of great thickness, as much as 200 feet or more, and in some places it is covered by 100 feet or more of unsorted till, the upper part of which was partially reworked by water. Geologically recent lava from Mt. St. Helens poured down a narrow channel near the east quarter corner of sec. 25, T. 7 N., R. 4 E., then spread laterally across and down the valley, covering the glacial deposits. The gorge now occupied by the river skirts the outer margin of this flow, at which point the lava is 25 to 50 feet thick. At one point a short distance upstream from the dam site, 25 feet of gravels are exposed beneath the lava. Permeability of both the glacial deposits and lava is no doubt high, and structural stability is very doubtful.

Bedrock consists of highly silicified agglomerates, tuffs, and interbedded sediments, probably Eocene in age, intruded by dikes and sills of andesite. General dip of these rocks appears to be about 20 degrees east. There are two major sets of joints that cut both the igneous rocks and sediments. Permeability of these rocks is negligible as compared to that of the valley fill including the flow.

The left abutment, underlain by the older sediments, tuffs, and agglomerates cut by the andesite dikes and sills, is no doubt adequate. The right abutment, however, is underlain by the highly permeable glacial deposits capped by the recent lava flow. This abutment probably is not strong enough to support a masonry dam even in the gorge section of the valley where it would be only 75 feet high. Topography would allow a dam 225 feet high. An earth dam to some intermediate height might be feasible, but only after elaborate and extensive field testing had proven that there not only would not be excessive water loss through the glacial sediments and lava in the right abutment, but also that the water percolating through this abutment under reservoir pressure would not burst through some weak spot with disastrous results.

Devil's Backbone dam site

Devil's Backbone dam site is on the trunk stream of the Lewis River at mile 49.8. It is 33 miles from U. S. Highway No. 99 at Woodland. The connecting road is surfaced as far as the village of Cougar. From Cougar, 3-3/4 miles of graveled road and then 2¼ miles of unimproved road extends to within one-fourth mile of the dam site area.

The dam site is in a narrow rock gorge that the river has cut across a bedrock spur projecting northward from the left wall of the preglacial Lewis valley. The left wall of the present valley rises steeply for more than 1,000 feet above the river. The right wall rises steeply to a bench about 200 feet above the river. From this point it slopes gently upward for about one mile until it intersects the north wall of the preglacial valley which rises steeply to a local summit level of over 3,000 feet. Hence, the preglacial valley is slightly more than one mile wide. One electrical resistivity depth determination tentatively suggests that the rock floor of this valley is about altitude 590 feet or some 50 feet below the present river level. As well as can be judged from surface exposures, the fill materials below altitude 1,040, about the highest possible pool level, consist of horizontally stratified gravels with minor amounts of interbedded sands and silts. The fill materials are very pervious, as is demonstrated by the presence of many springs issuing from the drift on the north side of the river.

Bedrock consists of andesite agglomerates with subordinate amounts of interbedded tuffaceous and carbonaceous sediments, probably Eocene in age, and lava flows. These rocks have been intruded by dikes of fine-grained, porphyritic andesite. The agglomerates and sediments dip southeastward at approximately 25 degrees. They show but little jointing; the dike rocks are highly fractured so that they break into blocks not more than one foot on a side. One small fault was found on the right abutment in the downstream portion of the site. Its strike is N. 80° E., and dip 55° NW. Agglomerates on either side of the fault were displaced 10 to 15 feet. Permeability of the agglomerates and sediments is probably very low, but that of the fractured dikes high.

The left abutment is largely concealed by talus and soil, but appears to be mainly agglomerate. It is no doubt safe for an arch dam. Agglomerates and sediments make up the foundation and lower part of the right abutment. Upper part of the right abutment is dike rock, which although highly jointed probably has ample strength for a masonry dam. Contact between the dike rocks and agglomerate is tight. Above the dike rock and filling the channel behind the right abutment is the highly pervious glacial drift.

This site itself would probably be satisfactory for a dam with pool level 130 to 140 feet above river level. However, water loss through the fill in the preglacial channel with the attendant danger of a failure at some joint in this debris make construction of a dam infeasible.

Mile 52 dam site

A brief geologic reconnaissance was made of the right abutment of a possible site at mile 52 on the trunk stem of the Lewis River. This abutment can be reached by foot over the Lewis River trail. It is about 2½ miles from the end of the road.

At this site the river flows in a flat-bottomed valley about 1,600 feet wide, above which both walls rise very steeply for at least 800 feet. Depth to rock floor of the valley is unknown, but may be as much as 100 feet. Valley fill consists of glacial drift, much of which is probably coarse outwash gravels.

Bedrock consists of a dark colored fine-grained basalt exposed at the river's edge, overlain by soft, tough agglomerate that is in turn overlain by a hard, dense, fresh andesite. Attitude of these rocks seems to be about horizontal. Several large springs discharge from the contact between the andesite and agglomerate.

Further investigation might prove this site adequate for an earth dam. This appears to be the only site by which the reservoir area afforded by the "Big Bottom" could be utilized since Devil's Backbone and Cougar sites appear to be infeasible.

Reservoir flowline is limited to altitude 1,030 feet, as a higher level would drown Eagle Cliff site. A dam to this height would be approximately 2,400 feet long.

Eagle Cliff dam site

Eagle Cliff dam site is on the trunk stream of Lewis River at mile 61.7 in sections 24 and 25, T. 7 N., R. 6 E. The site is accessible only by trail up the right bank of the river. It is about 12 miles from the end of the road.

The dam site is in a narrow valley. From the stream, the left bank rises steeply to benches 70-80 feet and 120 feet above water level. Above these benches, the valley wall continues to rise in a steep rock cliff that forms the north boundary of Eagle Cliff. The right bank rises steeply to benches 140-150 feet and 240 feet above the river. The high bench continues northward on a gentle slop and merges with Cedar Flats, a relatively flat bench covering several square miles at an altitude of 1,350 to 1,400 feet. The ridge underlying this bench is only about one mile wide. It forms the divide between Muddy River and Pine Creek. Active and inactive alluvium covers the stream bed and the low bench on the left bank. Depth to rock floor of the valley is unknown. Glacial till mantles the other benches and the slopes where rock is not exposed. It is mostly tuffaceous sand without much clay, so is very permeable.

Bedrock at the dam site consists of an intrusive syenite porphyry. The presence of Eagle Cliff is due to the superior resistence of this rock and the character of its jointing. Abutting against the syenite in the downstream portion of the left abutment are two lava flows of a thoroughly jointed somewhat vesicular andesite. Permeability of the syenite is low.

Both abutments are in the syenite, and so are equal in bearing power. The left abutment is covered from the river surface at altitude 1,025 feet to 1,120 feet, but rock is exposed from there to 1,495 feet. In the right abutment, rock is exposed from stream level to 1,190 feet. Foundation is in the same rock.

This site is suitable for a masonry dam, but further investigations are necessary to determine the height to which one could be built. The chief problems are: (1) the depth to rock foundation in the river channel; and (2) conditions under the glacial drift behind the right abutment. If the spur between Muddy River and Pine Creek is supported by rock, well and good, but if it is breached by an older stream valley filled with permeable materials, reservoir leakage might be excessive and limit the height of dam.

A dam to altitude 1,250, the maximum allowed by topography, would stand 225 feet above the stream, would be 1,180 feet long, and would impound 143,000 acre feet of water. A dam to the top of exposed rock at altitude 1,190 feet would stand 165 feet above the stream, would be 1,[illegible]30 feet long, and would impound 56,000 acre feet of water.

Cascade Gorge dam site

Cascade Gorge dam site is on the trunk stream of Lewis River at mile 70.8. It is 21 miles upstream from the end of the road. Access is easiest by foot trail down the right bank of the river 3.8 miles from the crossing of the river by a graded road from Guler, Washington, some 30 miles to the southeast.

The dam site is in a narrow gorge cut in the bottom of a broader high level valley. The right bank rises steeply from river level to the summit of Spencer Peak at 3,842 feet. Except for a narrow bench at 1380-1400 feet in the downstream half of the dam site area, the left valley wall rises steeply to a broad bench at about altitude 1,600 feet. Bedrock in the river channel is probably at shallow depth, but is covered by a thin veneer of active alluvium. The low bench on the left bank is underlain by inactive alluvium. The high bench on the left and the right wall above 1500-1600 feet altitude is covered with a dark gray, tuffaceous soil, probably of outwash origin although derived in large part by weathering of volcanic agglomerate. Numerous springs issue from the soil on top of the andesite flow.

Bedrock consists of lava flows of fresh, dense, hard, massive, dark gray andesite, showing little frothy or vesicular material, but considerably fractured at the base. Below the andesite in some places is flow breccia separated at the bottom by a very irregular contact from a carbonaceous mudstone. In two localities, 30 to 45 feet of tuff were present at some distance below the andesite. Below these rocks is a soft, dull agglomerate composed of small red and green fragments and large angular blocks of dark gray andesite in a fine green or gray matrix. Top of the agglomerate was not seen. Total thickness is unknown, but is more than 200 feet. The andesite flows appear to dip gently upstream. At the proposed axis is a syncline trending a little west of north. Joints in the agglomerate are few and its permeability is probably low. The andesite has well developed columnar jointing that is nearly always vertical. Its permeability is probably moderate to low because seepage would take place along the many short, irregular joint surfaces of the hexagonal columns.

At the proposed axis, both abutments and the foundation are in andesite. However, the thickness of andesite in the stream bed is small. Since the contact between the andesite and agglomerate is weak, this material would probably have to be removed down to sound agglomerate. Both abutments rise in nearly vertical walls of andesite to about altitude 1,550 feet or 190 feet above the stream. Strength is ample for an arch dam of required height. The agglomerate in the foundation is rather weak, and might be crushed by the high loadings of a gravity dam. A wide base earth or rock fill dam would also be recommended. A dam to altitude 1,550 would be approximately 350 feet long and would impound 48,000 acre-feet of water.

Quartz Creek dam site

Quartz Creek dam site is on the trunk stream of Lewis River at mile 76.4. It is about two miles upstream from the crossing of a graded road from Guler, Washington. Access is by foot over Lewis River Trail.

The dam site is in a narrow gorge cut into rock. From the stream, the left wall rises steeply to 2,200 feet altitude, the limit of topography on the river map. The right bank rises steeply to a bench at 1,760 feet altitude, behind which there are a number of knobs of glacial debris whose summits reach altitudes varying from 1,809 to 1,997 feet. About 400 feet from the river a depression with low point at altitude 1,820 feet separates this area from the main valley wall.

Deposits of active alluvium on the stream bed are small and thin, and bedrock is exposed in many places. The bench and knobs behind the left abutment, as well as much of the right valley wall, are underlain by glacial deposits. These consist of tuffaceous soil, tuffaceous boulder clay, fluvial gravels and sands, and lacustrine silts and clays. Permeability of these materials vary greatly; it is high for the soil and gravels and probably low for the till and silts. Ground water moves along the bedrock surfaces; only one spring was noted in the dam site area.

Bedrock consists of several flows of hard, dark gray, massive andesite that is locally vesicular and that has agglomeratic phases. Beneath the andesite is a coarse, slightly bedded volcanic agglomerate. Contact between the two is tight. The flows show a broad syncline with axis intersecting the river channel near mid-point of the dam site area. Dip on the downstream side is 12°, S. 80° E., and on the upstream side 25°, S. 34° W. The andesite is considerably jointed; in many localities this jointing is columnar and often much distorted. Agglomerate also jointed, but less extensively. Field evidence shows that these fractures will transmit water under low head, at least near ground surface.

Original plan was for a dam above the upper falls with pool level about altitude 1,820, and a powerhouse below the lower falls, giving a total head of about 215 feet. A dam at this location would be on a foundation made up of a thin layer of hard, dense andesite dipping downstream at a low angle, resting on agglomerate. Andesite is exposed in the left abutment for 50 feet above the stream, passes under a cover of loose, tuffaceous till, and reappears in a nearly vertical cliff with its base at 1,900± feet. Andesite is also exposed in the right abutment to altitude 1,725, above which it is covered. Rock probably does not stand higher than 1,775 feet beneath the glacial deposits behind the right abutment. Consequently, unless further investigation proves a higher dam feasible, maximum pool level would be about this altitude. Spillway could probably be routed through the depression behind the glacial knobs. A dam to 1,775 feet would stand 55 feet above present stream level and would be about 500 feet long, of which 300 feet would be a dike section with maximum height of about 50 feet. The reservoir would store only about 3,000 acre-feet of water.

About 500 to 600 feet downstream, where the synclinal axis crosses the river, is an alternate and probably stronger location for the dam axis. This area should show maximum compression. Hence, the joints should be more tightly closed and percolation through the abutments less. Andesite appears in the right abutment to altitude 1,775 feet, above which it is covered with thin soil below altitude 1,825, but andesite is probably close to the surface. Foundation is in agglomerate, which would have to be protected for it is susceptible to scour. The agglomerate might crush under heavy load, so an arch dam or wide-base earth fill dam would probably be better than a gravity dam. For pool level at altitude 1,775, a dam 95 feet high and about 400 feet long would be required. A higher dam cannot be considered until the rock profile behind the left abutment has been established by drilling or other means.

Island Camp dam site

Island Camp dam site is located on the trunk stream of the Lewis River at mile 82.2. Access is rather difficult. The site is most easily reached on foot by trail down the right bank of the river from the Guler-Randall road, a distance of about 6 miles. This crossing is about 65 miles north of U. S. Highway No. 830, which follows the north bank of the Columbia River.

The dam site is in a narrow, deep, vertical-walled notch cut into a broad, high-level valley. Both walls rise almost vertically to small benches about 100 feet above the stream. Above the benches the valley walls are steep. In the gorge, bedrock is veneered with small, thin deposits of active alluvium. The benches and upper slopes are blanketed with a tuffaceous till.

Bedrock consists of a rather soft, massive, volcanic agglomerate overlain by one or more flows of hard, dense, massive andesite. The exact relationship between these two rocks is not known clearly because of the small size of exposure. The rocks dip southwest to south at angles varying from 15 to 40 degrees. An anticline may be present, but further investigations are necessary to be certain. No faults were observed. At least 5 sets of joints are present, some of which are filled with calcite. Permeability of the rocks is low, but there would be some seepage along bedding and joint surfaces. Ground water moves on the bedrock surface. One spring was observed on the right bank.

Best section for a dam is downstream from VABM 2264, where both abutments and the foundation will be in andesite. The right abutment will be weakest because the rocks dip into the open canyon and because agglomerate is present a short distance behind the valley wall. This site is suitable for a masonry dam, and probably best suited for an arch dam. A height of 250 feet has been suggested on topographic grounds. Such a dam would be 800 feet long and would impound 28,000 acre-feet of water. Rock is present to this height in the left abutment, but in the right abutment is exposed for only 100 feet above the stream. Hence, the height of dam will depend on conditions beneath the till cover in the upper right abutment area. Further exploration is needed. A dam 100 feet high would be approximately 150 feet long, but would impound only 600 acre-feet of water.

Geology of the reservoir area is probably about the same as at the dam site, and no leakage is expected except in the dam site area. The small storage capacity of the reservoir would limit use of the dam to power production.