HYDRAULIC MODEL STUDIES
FOR THE DESIGN OF THE
SEMINOE STONEY GATE SPILLWAY

Hydraulic Laboratory Report No. 3.4

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

MARCH 15 1935
Subject: Hydraulic model experiments for the design of the Seminole Stoney-gate Spillway.

SUMMARY

Model tests of the original design showed the Seminole Spillway to have ample capacity for the maximum discharge. Flow in the chute, however, was rather rough, unsymmetrical, and noisy.

Tests indicated that flow conditions could be improved by making a few minor changes on the model. The design recommended by the Hydraulic Research Department had incorporated in it the following revisions:

a. A revised gate section, rectangular in shape down to the piers;

b. Pier tailpieces toed in 0.94 feet from their designed positions toward the centerline of the spillway;

c. The upper portion of the chute reshaped so as to correspond to the revised gate section;

d. Wing-walls having radii of 16 feet on each side above the gate section;

e. The outlet channel rotated so as to be on line with the rest of the spillway.

For the sake of economy, the floor of the approach channel was raised 12.5 feet to elevation 6294.5.

The positions of the piers in the gate section and the approach to the gate section are very important factors in a spillway of this type. A comparison of the original and recommended designs are shown on Figure 5.
Seminoe Dam will be located on the North Platte River, 33 miles northeast of Rawlins, Wyoming, and about 25 miles above the existing Pathfinder Dam. The Seminoe Reservoir, which will have a storage capacity of about 910,000 acre-feet, will provide additional storage for the North Platte Irrigation Project and enable irrigation expansion in that section of the State. The 260-foot high concrete arch dam, situated in a narrow granite canyon, will also enable power generation, Figure 1.

A ring-gate or morning-glory spillway similar to the one used on the Owyhee Dam was originally proposed for the Seminoe Dam. Because of the geology of the site, the spillway would necessarily have been located in the left canyon wall. The original diversion tunnel was located in the right canyon wall, and in order to utilize this tunnel for the ultimate spillway, a Stoney-gate design for the right canyon wall was proposed.

A model of the ring-gate spillway was constructed in the laboratory and a few tests made. No report was written of this work because the tests were incomplete, and the data would have been a duplication of that obtained on the Owyhee Spillway and described in Hydraulic Laboratory Report No. 159.

The Stoney-gate spillway, a drawing of which is shown in Figure 2, will consist of a short trapezoidal approach channel leading from the reservoir to the gate section; a gate section, the floor of which resembles a flat crested weir with a curved upstream face; a transitional chute, the invert of which is a flat parabola; and a 30-foot diameter horizontal tunnel. The gate section is rectangular down to the end of the piers, and converges slightly in a downstream direction. Flow through the spillway will be controlled by three Stoney gates each measuring 14 feet between piers and located at the highest point on the crest. The spillway is designed for a maximum discharge of 50,000 second-feet which will require a head of about 50 feet on the crest. The chute which commences as a horseshoe tunnel at the downstream end of the piers will gradually be transformed into a circular section 30 feet in diameter.
at the lower end. The chute will drop the water 150 feet on a slope not greater than 50°, measured with the horizontal, into the original 30-foot diameter horizontal diversion tunnel. Upon completion of the dam, the upper portion of the diversion tunnel will be plugged, and the lower 260 feet, together with 160 feet of open cut at the downstream end, will be utilized to carry the spillway flow.

THE LABORATORY

The laboratory in which the model of the Seminole Spillway was constructed and tested is located in the basement of the Old Customhouse in Denver where it is easily accessible to the designing staff of the Bureau of Reclamation. A plan of the laboratory is shown in Figure 3.

Water for supplying the models is measured over a 90° V-notch weir located in the end of a weir tank 6 feet by 12 feet by 4 feet deep, which is partially below the laboratory floor. From here, a 6-inch centrifugal pump having a capacity of 3 second-feet raises the measured water up into a constant level tank located as high as the ceiling of the laboratory will permit. A stationary skimming weir makes it possible to maintain a constant head of water in this tank. The water flows from the constant level tank through two 8-inch calibrated gatevalves, then through large expanding cones into two head tanks located directly below the constant level tank. Water is then supplied to the models directly from these head tanks. With this arrangement, two models can be operated simultaneously. After passing through the models, the water is collected in sheet metal flumes and returned to the weir tank. Thus, the same water is continuously circulated through the system. Two hookgages are used to observe the head on the V-notch weir, and one hookgage is provided for measuring the elevation of the water surface in each of the head tanks.

THE MODEL

A model of the Seminole Spillway was constructed in the laboratory on a scale of 1:60. A drawing of the model as finally revised is shown in Figure 4. The approach to the gate section was located in one of the laboratory head tanks and was constructed of sheet metal. The gate section
and chute were carved in a laminated block of wood made up of 2- by 12-inch planks. The block was split on the vertical centerline to facilitate the carving operation, and the two halves were later bolted together. A bandsaw cut was made just above the predicted maximum water surface line, so that the top could be removed for observation purposes. The chute and cover can both be seen in Photograph A, Figure 6. The piers were made of redwood and were held in place in the gate section by small dowels. Both piers and chute were thoroughly oiled and varnished before water was allowed to come in contact with them. The 260 feet of horizontal tunnel below the chute was rolled out of sheet metal, and the 160 feet of open cut was shaped from the same material. As the water entering the river from the spillway will have a supercritical velocity, a model of the riverbed was constructed below the spillway outlet in order to observe and remedy any undesirable effects that might be produced therein. This portion of the model consisted of a watertight box with side slopes similar to those encountered in the canyon below the dam. An adjustable weir located at the downstream end of the box served to regulate the tailwater elevation below the spillway outlet.

Eight piezometers were located at various intervals down the invert of the chute in order to observe the pressures at these points. Twenty-two piezometers were installed in the right-hand pier, as shown in the sketch on Figure 16, in order to obtain the drop in pressure through the gate section. These were installed on both faces of the pier, so the readings are representative of the entire gate section. Point-gage measurements of the water surfaces were also taken above the piers, through the gate section, and at various points down the chute. The head on the crest was observed from a hookgage which was connected to the laboratory head tank. The tailwater elevation at the spillway outlet was registered directly by a piezometer connected to the tailwater box.

THE ORIGINAL SPILLWAY DESIGN

The original design of the Seminoe Spillway, Figure 5, worked fairly well. It was quite certain, however, that a few improvements could be made. Flow through the gates was not exceptionally good, and this in turn caused the water surface in the chute to be irregular and unsymmetrical. In the original design, the beginning of the chute at the
downstream end of the piers, was of horseshoe shape with a curved bottom, thus the center gate had a larger area than either of the other two and a greater discharge flowing through it. This condition caused the deeper jet issuing from the center gate to predominate in the chute. This, together with an abrupt transition section directly below the piers, caused a large part of the water from the outer two gates to converge toward the center and ride on top of the water issuing from the center gate. As a result, a large fin formed down the center of the chute. Flow through the outer gates was not symmetrical, which from all indications was due to the unsymmetrical approach to the gate section. Flow in the chute was noisy, and this condition would be objectionable in the prototype as vibration might result. After reaching the vertical curve at the lower end of the chute, the centrifugal force created in that vicinity smoothed out the surface of the water making possible a very satisfactory flow in the horizontal tunnel. The photographs in Figure 6 show the model as originally designed. Photograph A is a view of the entire model with the chute cover removed, and B shows a discharge of 50,000 second-feet flowing down the chute. Photograph C, is a view looking downstream at the original gate section.

PRELIMINARY REVISIONS ON THE ORIGINAL SPILLWAY

Extensive tests were made on the original model with numerous minor changes, in an effort to improve flow conditions through the gates and in the chute before any definite measurements were recorded. This being the case, a brief summary of the procedure and the results obtained follows:

Installation of Hinged Piers

As a first effort to improve the flow through the gates and eliminate the objectionable fin down the center of the chute, a set of piers was constructed identical with the original ones except that the tailpieces (downstream of the gates) were hinged to the fore part as shown in the sketch on Figure 7. The stationary portions of the piers were mounted on the crest in the very same positions as were the originals. The hinged tailpieces however, could be set in any position desired while the model
was in operation. It was found that spreading the tailpieces outward from their original settings produced a larger and more irregular fin. By toeing the tailpieces in toward the centerline of the spillway, the fin was somewhat reduced in size. If the tailpieces were toed in an extreme amount, the fin directly below the gate section was further reduced in size but objectionable side fins were created in the lower portion of the chute. An interesting but aggravating problem to the test crew, was the fact that flow conditions changed as the water progressed down the chute. In other words, when flow conditions were satisfactory at the upper end, they were usually unsatisfactory at the lower end and vice versa. From results obtained on chutes of various designs tested in the laboratory on previous occasions, it was generally found that flow down a chute occurs with various surface forms, and if the chute is long enough and other conditions favorable, these forms may tend to repeat at intervals.

**Floor Raised in Upper Portion of Chute**

As there was a very sudden change in the slope of the chute floor just below the center gate which was not true of the slope below the outer two gates, an idea was conceived that filling in the invert in the upper part of the center of the chute with some material would decrease the depth of flow through the center gate and perhaps aid in correcting the difficulties encountered with surface fins. Plasticene (a commercial modeling clay) was pressed into place below the center gate forming the fill shown on Figure 7. Trial runs were then made with the long hinged piers installed on the crest. The tailpieces were adjusted to give the best flow conditions, and it was found that the addition of the fill made a very noticeable improvement. Flow through the outer two gates, however, was still unsymmetrical.

**Revision of Wing-walls**

An investigation showed that approach conditions to the right gate were superior to those to the left. A curved wall consisting of a flexible piece of sheet metal which could be bent to any desired radius was installed just above the left gate forming a continuation of the left wall of the gate section. Runs were then made to determine the curvature which would produce the best flow through the gates. It was
found that the larger the radius used, the better were the resulting approach conditions. As a conservative limit, a wing-wall having a radius of 16 feet was adopted. A similar wall having the same radius was installed on the right side of the gate section. The recommended design on Figure 5 shows a plan of these walls, and Photograph C, on Figures 6, 8, and 9 show views of the same. With the fill in the upper portion of the chute invert and the reconstructed wing-walls, flow through the gates and in the chute was much improved.

**GATE SECTION B**

Gate Section B was similar to the original design with the exception that short piers were installed and the gates were moved upstream as shown in "Gate Section B," Figure 7. The plasticene fill was left in the invert in the upper part of the chute. Contrary to expectations, flow conditions were quite unsatisfactory and testing was discontinued on this setup.

The plasticene fill was removed, the gate section was dug out so as to make the floor much flatter in cross-section without disturbing the centerline elevations, and the long hinged piers were again installed. Flow was somewhat better but still not very satisfactory.

**GATE SECTION C**

In a further effort to improve the flow through the gates, the Design Department submitted another gate section designated as "Gate Section C," Figure 7, which was rectangular in cross-section throughout, and in which the sudden change in slope below the center gate was eliminated. The piers and side walls were all parallel to the centerline of the spillway. The model was revised to conform with the new design. Photograph C, Figure 8, is a view of the gate section looking downstream. With the short piers installed, nothing but mediocre results were obtained.

**Long Hinged Piers Installed**

The short piers were replaced by the original long hinged piers. In this case, the stationary portions of the piers were set parallel to the centerline of the spillway. Trial runs were made while the tailpieces were adjusted to a position which gave the best flow conditions. The run
in which the best flow was obtained for Gate Section C is shown plotted as Test 11-1 on Figure 10. The tailpiece on the right pier was toed in 3.12 feet toward the centerline of the spillway and the tailpiece on the left pier was toed in 1.88 feet. It was found throughout these tests that in the majority of cases, the best results were obtained when the right tailpiece was toed in a greater amount than the left. This was necessary in order to compensate for the lack of symmetry in the approach structure. Approach conditions are very important in a spillway of this type, especially when large heads are involved. The profile of Test 11-1, Figure 10, represents the water surface elevation on the centerline of the spillway, and the sections shown were taken at the points indicated. An inspection of the sections show a considerable amount of irregularity in the water surfaces. Photographs A and B, Figure 8, show a discharge of 50,000 second-feet flowing down the chute with the long piers installed in Gate Section C. The pier tailpieces were set as shown in Test 11-1.

Approach Channel Floor Raised

The approach channel to the gate section was presumably deeper than necessary, and a series of runs were made as an investigation. The floor of the channel was raised by means of a succession of accurately fitted boards and the head at maximum discharge measured for each condition. The elevation of the raised channel floor is plotted against the observed head on the crest in each case in Graph B, Figure 11. The curve shows that for maximum discharge, the floor of the channel can be raised 12.5 feet (up to elevation 6294.5) without affecting the head on the crest. In all subsequent tests, the channel floor was at this elevation.

THE RECOMMENDED GATE SECTION

Resume of Pier Settings

The gate section was again revised to correspond to the drawing titled "The Recommended Design" shown on Figure 5. Photograph C, Figure 9, shows a view of this gate section looking downstream. The floor of the approach channel is at elevation 6294.5, the 16-foot radius wing-walls are installed, and the long hinged piers are set symmetrically in the gate section. A plot of this layout for a run of 50,000 second-feet is shown as Test 13-1 on Figure 10. Notice the center fins in the
sections taken at Stations 0+56.2, 0+89.0, and 1+26.5 and the side fins at Station 2+40.5. Photographs A and B, Figure 12, are two views of the water flowing down the chute at maximum discharge. Photograph C, is a view of the water approaching the gate section.

A number of runs were made on the recommended gate section with the pier tailpieces set in various positions in order to find a setting that would produce the best flow through the gates and down the chute. Profiles and sections of the water surfaces for a few of these settings are included in this report in order to impress upon the reader the importance of the pier positions in the proper operation of a spillway of this type. Tests 15-1 and 16-1, plotted on Figure 13, show the water surfaces in the gate section and chute for the maximum discharge when the right tailpiece was toed in 0.47 feet and 0.94 feet respectively. The tailpiece on the left pier remained untouched during these two tests.

Test 14-1, Figure 14, shows a plot of the water surface when both tailpieces were toed in 0.47 feet toward the centerline of the spillway. Test 17-1, Figure 14, shows the water surface for maximum discharge when the right tailpiece was toed in 0.94 feet and the left tailpiece was toed in 0.47 feet. In the latter case, flow conditions were quite satisfactory.

The Recommended Pier Setting

The best results using this gate section were obtained when both pier tailpieces were toed in 0.94 feet, Figure 15. An advantage of this setting over the last one mentioned is that the piers are symmetrical in the gate section. Water surfaces are plotted on Figure 15 for discharges of 50,000, 35,000, 20,000, and 10,000 second-feet. These results actually are a decided improvement over those obtained in all previous tests. The water surfaces are quite irregular for the partial discharges, but for these no serious consequences can result. To have excellent flow conditions for all discharges would require a spillway of different design. Photographs A and B, Figure 9, show two views of the recommended spillway discharging at 50,000 second-feet. Photograph C, shows the gate section, and D is a view of the complete spillway. A sketch of the left pier as recommended is shown in Figure 7. The other pier is an exact opposite. It is expedient to construct them in this manner in order to preserve the symmetry of the upper portion of the gate section.
Piezometer Pressures in Chute

Pressures obtained from the eight piezometers which were located along the invert of the chute are plotted on Figures 10 and 15, inclusive. An examination of these show that all pressures measured were above atmospheric.

Piezometer Pressures on Right Pier

Pressures registered by the 22 piezometers which were installed in both faces of the right pier are plotted for 3 discharges on Figure 16. The locations of these piezometers in the pier are shown in one of the sketches on Figure 16. Notice that for a discharge of 50,250 second-feet, the water surface in the center gate is higher than that in the right gate. Likewise, the piezometer readings in the center gate are greater than those in the right gate. It is necessary that the water surface be higher in the center gate than in the outer two if fin formation is to be reduced to a minimum. A second reason why the piezometers on the left side of the pier read higher than those on the right is that the general direction of flow is not parallel to the piers. This would cause the piezometers on the left face to register some velocity head, while those on the right face probably read less than the actual static head. The piezometers below the gates for discharges of 29,000 and 10,320 second-feet, Figure 16, verify this statement as some of them show readings which are above the water surface. The plot for 29,000 second-feet illustrates this point in another way. Although the right gate is open a greater amount than the center gate and the water surface is higher below the right gate than the center, the piezometers below the center gate indicate pressures larger than those below the right gate. The indicated pressures are difficult to analyze, however, they should be representative of those that actually do exist at the points where measured.

GATE OPERATING SCHEDULE

A gate operating schedule which proved very satisfactory on the model is shown on Figure 17. It was obtained by setting the three gates so as to give the best flow conditions for various discharges. The three gate openings were then plotted for each discharge. In order to
obtain satisfactory flow conditions in the chute, it is necessary that the center gate be open a greater amount than the side gates for all discharges less than 40,000 second-feet, as can be observed from Figure 17. It would seem that both side gates should be operated exactly alike, due to the inequality of approach conditions; this is not true. The approach to the right gate is superior to that on the left, consequently it is necessary that the right gate be open a greater amount than the left for discharges of less than 40,000 second-feet. This schedule was obtained using maximum head on the gate (reservoir elevation = 6357.0) as it was assumed that the Stoney gates would not be opened until the water surface in the reservoir approached this elevation. Very poor flow results when all gates are opened an equal amount for discharges of less than 40,000 second-feet. A side gate should not be operated separately or in conjunction with the center gate except in cases of necessity. Either the center gate alone or a combination of all gates should be used.

THE HEAD DISCHARGE RELATION AND THE COEFFICIENT OF DISCHARGE

The relation of head on the crest to discharge was obtained from the model of the recommended design with all gates fully open. A curve showing this relation is plotted on Graph A, Figure 11. For the maximum designed discharge of 50,000 second-feet, a head of 51 feet on the crest is required. An explanation is necessary at this point as to why the head on the crest for the maximum discharge in Graphs A and B, Figure 11, do not agree. The reason for the difference is the curve on Graph B was obtained from Gate Section C and the curves on Graph A were taken from the tests made on the recommended gate section. The maximum capacity of the spillway is 62,000 second-feet, but this would require a head of 59 feet on the crest. The coefficients of discharge for various heads on the crest were computed using the formula \( Q = CLH^{3/2} \), where \( L \) is the width of the gate section exclusive of piers, and measured directly above the gate slots. A curve showing the relation of the coefficient of discharge to the head on the crest is plotted on Graph A, Figure 11. Coefficients were not obtained for partial gate openings.
THE ORIGINAL OUTLET CHANNEL

Water leaving the trapezoidal outlet channel was at shooting flow, and this created considerable disturbance in the river and a high splash on the opposite canyon wall. The canyon walls are composed of granite and any damage done to them or the riverbed is unimportant. It is important, however, that the disturbance does not extend upstream sufficiently to interfere with the proper operation of the powerhouse. It is also essential that the jet shall not splash high enough on the far canyon wall to endanger a proposed road which will run along the river to the powerhouse. As originally designed, the outlet channel made an angle of 10°, in an upstream direction, with the centerline of the spillway in order to minimize on the amount of excavation in this open cut.

The model showed that the curved channel was ineffective as far as steering the stream of water was concerned. The water climbed up the right wall, only intermittently contacting the left, and shot out into the river as a jet concentrated in a vertical plane. This incident again demonstrates the fact that it is impossible to successfully deflect water in a horizontal direction when it is flowing at a velocity above critical in an open channel. The disturbance created in the river did not extend as far upstream as the powerhouse, so aside from appearance, no harm can result. Photographs A and B, Figure 18, show the jet discharging into the river from the original outlet channel. Flow in the 30-foot horizontal tunnel was very satisfactory for all discharges. For the maximum discharge of 50,000 second-feet, the tunnel flowed slightly more than two-thirds full.

THE RECOMMENDED OUTLET CHANNEL

The original trapezoidal channel was replaced by one which could be rotated in a horizontal plane. Runs were then made with the channel set at various angles, and the height of splash on the opposite canyon wall was measured. Figure 19 consists of a topographic plot of the west canyon wall with splash heights interposed on it for discharges of 50,000 and 30,000 second-feet. These are plotted for three positions of the channel, namely; 10° upstream, 0°, and 5° downstream with respect to the
centerline of the spillway. This plot should give some idea as to a safe elevation of the road on the west canyon wall. Notice that for a discharge of 50,000 second-feet, the splash is considerably higher with the channel turned 10° upstream than with it set at 0°. With it set at 10° upstream, the splash is 80 feet high, while for 0°, it is about 45 feet high. For the same discharge, the splash is practically identical for the channel set at 0° and 5° downstream. As the splash is much reduced and the general operation of the outlet more pleasing to the eye when the centerline of the channel coincides with the centerline of the spillway, this layout is recommended. Photographs A and B, Figure 18, show the jet discharging into the river for maximum discharge with the channel rotated 10° upstream, and Photographs C and D show the same jet discharging into the river with the channel and spillway on line as recommended. A complete summary of all test made on the Seminoe Spillway can be found in the appendix of this report.

ACKNOWLEDGMENTS

All laboratory work is under the general direction of E. W. Lane. The construction and testing of the Seminoe Stoney-gate Spillway was under the supervision of J. B. Drisko. He was assisted by Junior Engineers H. M. Martin and L. R. Brooks, who were in charge of construction, and J. M. Buswell, who directed the test crew. The office computations and the figures in this report were made by H. W. Brewer, R. K. Vierck, A. H. Neal, and E. C. Parks. The photographs were prepared by J. E. Warnock at Fort Collins.
## Appendix

### SEMINOE SPILLWAY
Casper Alcova Project
Log of Tests

<table>
<thead>
<tr>
<th>Test no.:</th>
<th>Approach:</th>
<th>Gate section</th>
<th>Piers</th>
<th>Pier setting:</th>
<th>Discharge:</th>
<th>Head on:</th>
<th>Remarks</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L : R : ft. : ft.</td>
<td>crest : ft. : Gate opening in ft.</td>
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<tr>
<td>1-1:</td>
<td>Original:</td>
<td>Original</td>
<td>C.L.</td>
<td>C.L. : 50,000 : 50.0</td>
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<td>-</td>
<td>Run with and without plasticine in the pier section.</td>
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<tr>
<td></td>
<td>No:</td>
<td>with tip</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2-1:</td>
<td>&quot; : &quot;</td>
<td>None</td>
<td>No : No</td>
<td>&quot; : &quot;</td>
<td>-</td>
<td>-</td>
<td>Tried various positions and curvatures of the left wing-wall. Runs greater than designed discharge.</td>
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<td>Original</td>
<td>C.L.</td>
<td>C.L. : 50,000 : 50.0</td>
<td>- : All open</td>
<td>-</td>
<td>Runs greater than designed discharge. A 16-foot semicircular left wing-wall was used.</td>
</tr>
<tr>
<td></td>
<td>with flex-</td>
<td>piers: piers</td>
<td></td>
<td>with flexible tail</td>
<td>57,000 : 54.0</td>
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<td>3-2:</td>
<td>&quot; : &quot;</td>
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<td>&quot; : &quot;</td>
<td>62,500</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
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<td>&quot; : &quot;</td>
<td>&quot; : &quot;</td>
<td>62,500</td>
<td>-</td>
<td>-</td>
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<tr>
<td>4-1:</td>
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<td>Original</td>
<td>&quot; : &quot;</td>
<td>Various : Various : Various : Various : Various</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>revised</td>
<td>Long hinged</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A 12-foot semicircular left wing-wall was used. A 20-foot semicircular left wing-wall was the best radius.</td>
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<tr>
<td>4-3a:</td>
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<td>C.L. : In 0.31 ft. :</td>
<td>&quot; : &quot;</td>
<td>-</td>
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### Appendix

**SEMINOE SPILLWAY**

Casper Alcova Project

**Log of Tests**

<table>
<thead>
<tr>
<th>Test no.</th>
<th>Approach</th>
<th>Gate section</th>
<th>Pier setting L</th>
<th>Pier setting R</th>
<th>Discharge cfs</th>
<th>Head on</th>
<th>Gate opening in ft.</th>
<th>Remarks</th>
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<td>Original</td>
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<td>Various</td>
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<td></td>
<td>Revised</td>
<td>without tail pieces</td>
<td></td>
<td></td>
<td>Various</td>
<td>Various</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td>Various</td>
<td>A 16-ft. semicircular left wing-wall was used.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Extended right side instead of using radius. Sixteen-ft. radius on left wing-wall.</td>
<td></td>
</tr>
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<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
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</tr>
<tr>
<td>5-1</td>
<td>&quot;</td>
<td>Gates Short</td>
<td>C.L. 50,000</td>
<td>50.82 ft.</td>
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<td>&quot;</td>
<td>&quot;</td>
<td>All open</td>
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<tr>
<td></td>
<td></td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Splash heights in river for discharges of 50,000, 40,000, 30,000, 20,000, 10,000, and 5,000 cfs.</td>
<td></td>
</tr>
<tr>
<td>5-2</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Various</td>
<td>Various</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Various</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Splash heights plotted on contour map for discharges of 50,000, 30,000, and 10,000 cfs. Outlet 10° upstream.</td>
<td></td>
</tr>
<tr>
<td>6-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>7-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Long hinged</td>
<td>&quot;</td>
<td>50,000</td>
<td>49.74 ft</td>
<td>&quot;</td>
<td>All open</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flow satisfactory. Floor of chute entrance flattened.</td>
<td></td>
</tr>
<tr>
<td>8-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>50.1 ft.</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Raised entrance cut and observed difference in headwater.</td>
</tr>
</tbody>
</table>
### Appendix

**SEMINOE SPILLWAY**

Casper Alcova Project

Log of Tests

<table>
<thead>
<tr>
<th>Test no.</th>
<th>Approach section</th>
<th>Piers</th>
<th>Pier setting L ft.</th>
<th>Pier setting R ft.</th>
<th>Discharge cfs</th>
<th>Head on crest ft.</th>
<th>Gate opening in ft.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-1a: Revised</td>
<td>Gate section</td>
<td>Long hinged</td>
<td>C.L.</td>
<td>C.L.</td>
<td>Various</td>
<td>Various</td>
<td>Various</td>
<td>Same as 6-1 except that outlet is on centerline of tunnel.</td>
</tr>
<tr>
<td>9-1b</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Same as 6-1 except that outlet is 5° downstream.</td>
</tr>
<tr>
<td>0-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>50,000</td>
<td>50.1</td>
<td>All open</td>
<td>Layout No. 2. Flow poor.</td>
</tr>
<tr>
<td>1-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Long hinged</td>
<td>In 1.88</td>
<td>In 3.12</td>
<td>50,250</td>
</tr>
<tr>
<td>1-2a</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>20,000</td>
<td>50.0</td>
<td>13.36</td>
<td>13.36</td>
</tr>
<tr>
<td>1-2b</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>20,000</td>
<td>50.0</td>
<td>Various</td>
<td>Various</td>
</tr>
<tr>
<td>2-1</td>
<td>&quot;</td>
<td>Recommended</td>
<td>&quot;</td>
<td>&quot;</td>
<td>In 0.94</td>
<td>In 0.94</td>
<td>50,250</td>
<td>50.70</td>
</tr>
<tr>
<td>2-2</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>34,520</td>
<td>50.34</td>
<td>21.25</td>
<td>27.81</td>
</tr>
<tr>
<td>2-3</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>20,380</td>
<td>50.82</td>
<td>17.88</td>
<td>16.88</td>
</tr>
<tr>
<td>2-4</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>10,370</td>
<td>51.06</td>
<td>6.10</td>
<td>8.44</td>
</tr>
</tbody>
</table>
## Appendix

### SEMINOE SPILLWAY
Casper Alcova Project
Log of Tests

<table>
<thead>
<tr>
<th>Test no.</th>
<th>Approach</th>
<th>Section</th>
<th>Piers</th>
<th>Pier setting</th>
<th>Discharge</th>
<th>Head on</th>
<th>Gate opening in ft.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-5</td>
<td>Revised</td>
<td>Long hinged</td>
<td>In 0.94:In 0.94</td>
<td>Various:Various:Various</td>
<td>-</td>
<td>-</td>
<td>Various:Coefficient of discharge runs.</td>
<td></td>
</tr>
<tr>
<td>13-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>C.L.:C.L.:50,110:51.0</td>
<td>All open:High fin at center of chute.</td>
<td>-</td>
<td>-</td>
<td>Fin still in center of chute.</td>
</tr>
<tr>
<td>14-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>In 0.47:In 0.47:50,250:50.94</td>
<td>-</td>
<td>&quot;</td>
<td>-</td>
<td>Flow fairly good. Fin left side.</td>
</tr>
<tr>
<td>15-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>C.L.:&quot;:50,390:50.94</td>
<td>-</td>
<td>&quot;</td>
<td>-</td>
<td>Flow rougher than 12-1.</td>
</tr>
<tr>
<td>16-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>In 0.94:50,390:50.94</td>
<td>-</td>
<td>&quot;</td>
<td>-</td>
<td>About the same as 12-1.</td>
</tr>
<tr>
<td>17-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>In 0.47:In 0.94:50,390:51.18</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Pier piezometer readings.</td>
</tr>
<tr>
<td>18-1</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>In 0.94:In 0.94:50,250:51.18</td>
<td>-</td>
<td>&quot;</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>18-2</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;:29,000:51.24:21.25:20.78:22.19</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
</tr>
<tr>
<td>18-3</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;:10,320:51.36:6.10:9.38:5.15</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
</tr>
<tr>
<td>18-4</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;:Various:Various:Various:Coefficient of discharge runs.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
</tr>
</tbody>
</table>
Laboratory head Tank

PLAN

SECTION D-D

NOTE

Diameters are perpendicular to invert in Chute

SECTION C-C

SECTION ALONG CENTER LINE (SECTION A-A)

PLAN OF GATE SECTION

SECTION B-B

Sand Box

MODEL OF SEMINOE SPILLWAY

MODEL SCALE 1:60

SCALE IN INCHES (MODEL)

NOTE

Diameters are perpendicular to invert in Chute

DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CASPER ALCOY PROJECT-WYOMING
HYDRAULIC MODEL STUDIES

MODEL SCALE 1:60

CHECKED DATE: APPROVED

1/24/34
A. Complete model.  
(Chute cover on left)  

B. Looking up chute,  
discharge 50,000 cfs.  

C. Original gate section (looking downstream)  
with revised wing-walls.  

ORIGINAL DESIGN
A. Looking up chute, discharge 50,000 cfs.

B. Another view of same run, discharge 50,000 cfs.

C. View of revised Gate Section "C."

GATE SECTION "C"
A. Piers toed in 0.94 feet, discharge 50,000 cfs.

B. Another view of same run, discharge 50,000 cfs.

C. Final gate section with approach floor raised.

D. Complete model as recommended.

RECOMMENDED SPILLWAY DESIGN
A. Piers set as designed, discharge 50,000 cfs.

B. Another view of same run, discharge 50,000 cfs.

C. Flow approaching gate section, discharge 50,000 cfs, head on crest 51 feet.

FINAL GATE DESIGN
FIGURE 4A

TEST 14-1
Q=50,250 CFS

TEST 17-1
Q=50,350 CFS

SCALE HEELS ARE INDICATED
MODEL SCALE IN INCHES

SEMINOE SPILLWAY WATER SURFACE PROFILES AND INDICATED PRESSURE HEADS FOR TESTS 14-1 AND 17-1
RECOMMENDED DESIGN

| TEST 12-1 | Q = 50,280 CFS |
| TEST 12-2 | Q = 34,512 CFS |
| TEST 12-3 | Q = 20,180 CFS |
| TEST 12-4 | Q = 10,370 CFS |

SCALE IN FEET PROTOTYPE
SCALE IN FEET MODEL
SCALE IN INCHES PROTOTYPE
SCALE IN INCHES MODEL

TEST 12-1: 0.50,280 CFS
TEST 12-2: 0.34,512 CFS
TEST 12-3: 0.20,180 CFS
TEST 12-4: 0.10,370 CFS
NOTE: These curves were obtained with maximum head on the crest.
A. Outlet channel discharging into river, discharge 50,000 cfs.

B. Splash on canyon wall, discharge 50,000 cfs.

ORIGINAL DESIGN
JET DIRECTED 10° UPSTREAM

C. Outlet channel discharging into river, discharge 50,000 cfs.

D. Splash on canyon wall, discharge 50,000 cfs.

RECOMMENDED DESIGN
JET ON LINE WITH SPILLWAY

OUTLET CHANNEL