Jake: Note my hasty changes. Walt.

Prefer use of word sediment instead of silt

HYDRAULIC MODEL STUDIES FOR THE DESIGN OF THE IMPERIAL DAM. → Spillway

(To be presented before the regional meeting of the Section of Hydrology of the American Geophysical Union on June 23, 1937, in Denver, Colorado.)

CUT If this is to be published it should be reworked. CUT

The exclusion of ~~silt~~ sediments from canals having their headings on rivers with fluvial beds has been long recognized as a major problem. With the advent of a partial systematic control of the Lower Colorado River waters, under the Boulder Canyon Act, this problem has become of primary importance.

definition? bed sediments

The Imperial Dam, a part of the Boulder Canyon Project, is located on the Colorado River, 20 miles by river above Yuma, Arizona, and when completed will raise the water surface above such that the water can be diverted at all stages of flow into the All-American Canal on the California side of the river and into the Gila Valley Canal on the Arizona side. Past experience with diversions from the river near this site indicated that considerable difficulty might be expected in excluding the silt carried by the river from the canal systems.

check name

The value of hydraulic model studies as an aid in the design was early recognized and different features of the structures were studied on sectional models. The results in those cases were applied with little or no correlation to adjacent structures or to the entire headworks.

In considering the Imperial Dam and its appurtenant headworks as a unit, four major problems were recognized in regard to the silt ~~being~~ transported in the river:

(1) Maintaining the river approach channel or channels free of silt obstructions,

(2) Maintaining the channels of approach to the individual units of the desilting works free of silt obstructions,

(3) Settlement of the silt in a desilting plant and discharging it from the tanks, and

(4) Disposal of the silt in the river.

The importance of the second of these problems was greatly reduced by the use of division walls from the gate structures to the individual tanks of the desilting plant and the third problem was studied by the hydraulic laboratory on separate models. For the solution of the first and fourth problems, it was recommended that a program of model testing be conducted on as large a scale as practicable.

In studies made with movable bed models, two ends may be accomplished - a quantitative analysis of the problem is obtained which may or may not include data relative to the basic principles of transportation of solid matter by running water or a qualitative or comparative analysis is obtained. In the latter case, such of the variables as it is possible are ~~to~~ eliminated from the problem ~~are deleted~~ by maintaining certain conditions constant throughout the series of tests.

In this particular case, it was decided to attack the problem with the view of obtaining a qualitative or comparative analysis. Numerous factors governed this decision. The primary reason was the urgent need for the results at the earliest possible date, modified of course by the factor of economy in conducting the tests. The necessity for a detailed quantitative analysis of the problem was questioned. Practically all hydraulic designs are solved in this manner and since a study of the basic principles of hydraulics by research was not imperative in the solution of this specific problem, the qualitative analysis was considered sufficient.

A study was made to determine the model scale and type of silt that could be used so that reasonably correct deductions might be made from the results obtained. It was considered probable, in view of the experience of others with small scale models, that in case a too great reduction in scale was used, it would be necessary to employ a material having a specific gravity less than that of silt and sand found in nature. The use of coal dust was considered, but the cost was found to be prohibitive.

The possibility of a distorted model scale would have made it possible to use a smaller scale. That type of model has been used to some extent for the study of river problems but the verification on prototype structures of results obtained in this manner are believed to be insufficient at the present time to justify complete confidence in the method. It was decided to make a model as large as the physical conditions at the site would permit, and to use a silt as fine as could be obtained at reasonable cost in the immediate vicinity of the model. The scale ratio used was 1:40. The model was constructed at the Bureau hydraulic laboratory near Montrose, Colorado, where ground space, water, and material were available. The model included the Colorado River 1½ miles upstream and 1¼ miles downstream.

The material actually used was dredged from the South Canal of the Uncompahgre ~~Irrigation District~~ Valley Water Users' Association adjacent to the laboratory where it had been deposited by the irrigation water diverted from the Gunnison River. The size of a typical sample of Colorado River silt such as that which will be handled through the headworks at Imperial ranges from 0.05 to 0.6 mm. in diameter. To have reduced that by the scale ratio of 1:40 would have required a material in the model ranging in size from 0.001 to 0.011 mm. Such material in the model would have been impractical, because it would have been so small in size that it would have remained in suspension and been carried through the model or if it would have settled, the rate would have been so slow as to require a test period too long to be practical. Secondly, the cost of a material of those proportions would have been uneconomical to provide. Consideration was given to shipping a supply of the actual Colorado River silt to the model, but it would have been out of scale to practically the same degree as the material actually used which ranged in size from 0.08 to 2.0 mm. It was concluded that the indications of the formation of silt bars on the model were much more severe than will be experienced on the prototype due to the use of silt as much out of proportion as the materials actually used.

Since the size of material was held constant insofar as possible throughout the entire set of tests, it served well as a basis of comparison and allowed a particular arrangement of headworks to be tested in approximately six hours.

The major problems in connection with the design of the All-American Canal intake structure were (1) a distribution of trashrack flow as nearly uniform as possible along the length of the rack; (2) a minimum of silt carried through the racks and a minimum deposition of silt within the forebay of the gates; (3) a maximum of silt carried into the sluice gates and through the sluiceways to the river; (4) good hydraulic conditions of discharge through the sluice gates and headgates; (5) protection of the upstream apron of the dam from removal of the silt which will naturally deposit there and which it is desired to retain as an additional element of stability of the dam.

The solution of these different problems have been accomplished by the use of five major supplemental structures.

(1) A trashrack curved in plan,

(2) A wing-wall or abutment at the downstream end of the trashrack separating the sluicegate forebay from the headgate forebay so that flow from the former to the latter will not upset the balanced flow conditions below the gates,

(3) A dike extending from the west end of the headgate structure at a right angle to the structure for a distance of about 560 feet, the outer end forming the upstream terminal for the trashrack,

(4) A training wall or groin at the east end of the sluiceway gate structure normal to the dam and extending across the upstream apron of the dam,

(5) A submerged training wall extending upstream to the left of the sluiceway gates to eliminate any tendency toward high velocities along the face of the spillway which might have a tendency toward disrupting good hydraulic conditions through the sluiceways and prevent the erosion of the silt deposition on the upstream apron.

During the course of the tests, several forms of the submerged training wall referred to in item 5 were tried, all with the thought of controlling and distributing the flow in the river as it approaches the trashracks. While the need of this particular structure was definitely indicated on the model, it was felt that no final solution of this particular problem could be reached by model studies and that the construction of this feature should be postponed until its most desirable character, location and dimensions can be determined by experience with the river itself. In fact, it was concluded that the final operating program on these various features affecting flow control and all like conditions affecting the operation of the discharge structures of the dam, must depend on actual experience with the river.

Simultaneous with the test program on the All-American Canal headworks, the model of one of the desilting basins and its appurtenances in the Gila Valley headworks was installed in the Arizona end of the Imperial Dam model.

At the time the model was constructed, certain features of the structure had not been detailed by the design department, but had been intentionally delayed until some model work could be completed. Preliminary operation of the model brought out the fact that the sluicing of the desilting basin should be effected by controlling the inlet gates to maintain shooting velocity along the bottom of the basin with a small volume of water rather than by flushing with a large volume admitted at low velocity. Subsequent tests resulted in a change of the design of the crest under the inlet gates at the upstream end of the desilting basin to improve the flow conditions when the gates are open only a small amount and the water level in the basin is low. Material improvement of the flow conditions through the sluicegates ~~were~~ was effected by altering the pier shape both upstream and downstream. The curved downstream ends of the piers for the headgates to the canal were studied until a design was evolved which changed the direction of the flow through an angle of ninety degrees with little disturbance. It was determined that the water into the canal could be admitted over the control gates with considerably less disturbance than that present when the water was admitted under the gates.

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HYDRAULIC LABORATORY
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Montrose, Colorado

July 27, 1938

From: Board of Consulting Engineers on the All-American Canal

To: R. F. Walter, Chief Engineer

Subject: Report on Special Features of the Discharge Structures for the Dam.

1. In accordance with instructions, the members of the Board met at the Montrose Hydraulic Laboratory on the forenoon of July 26 and in company with yourself, Engineers Savage, McBirney, Vetter and Warnock of the Denver Office, Mr. Williams, Construction Engineer, All-American Canal Project and Engineer Thomas and members of the laboratory staff, we witnessed, during the days of July 26 and 27, a series of tests on different arrangements of the approach and control structures for the desilting basins and sluiceway on the west side of the river, and for one of the Gila Valley structures on the east side.

2. The principal arrangements for the sluiceway and desilting works, set up and run for our inspection, comprised two out of some 37 different arrangements which have been tried out during recent months.

3. The major problems in connection with these structures lie in the effort to secure, for any direction of approach of the river, the best combination of the following operative conditions.

(1) A distribution of trashrack flow as nearly uniform as possible along the length of the rack.

(2) A minimum of silt carried through the rack and a minimum deposition of silt within the forebay of the headgates.

(3) A maximum of silt carried to and through the sluicegates and on through the sluiceway to the river.

(4) Good hydraulic conditions of discharge through the sluice gates and the headgates.

(5) Protection of the upstream apron of the dam from undue removal of the silt which will naturally deposit there and which is desired as an additional element in the stability of the dam.

4. This extended series of model tests has included, beside the dam and gate structures, the following major supplemental structures:

(1) A trashrack of varying length and form, straight or curved.

(2) A "V" shaped dyke at the downstream end of the trashrack, separating the sluice gates forebay from the headgates forebay and preventing flow from the former to the latter close to the sluice gates.

(3) A dyke extending from the west end of the headgate structure, at a right angle to this structure, for a distance of about 560 feet, its outer end forming the upstream terminal for the trashrack.

(4) A training wall or groin at the east end of the sluiceway gate structure, normal to the dam and extending across the upstream apron of the dam.

(5) An extension of the training wall referred to in item (4), in the form of a submerged weir, extending in curved plan upstream to a junction with the outer end of the dyke refferred to in item (3).

All of these various features are shown in the photographs and drawings accompanying the memorandum prepared by Messrs. Thomas, Warnock and Vetter, under date of July 25, 1936, and made available for our study during this visit.

5. From our observation of the model tests during this visit, from our examination of the photographs showing the results of previous tests, and from our general study of this problem, we are led to the conclusion that the final provision for control of the approach and delivery of the water to these discharge structures should include items (1), (2), (3) and (4) above, namely, the two dyke structures extending to the ends of the trashrack, the trashrack itself and the training wall or groin extending across the upstream apron of the dam; and further, that the location and dimensions of these structures, as indicated in arrangement No. 57, offer a combination for the final solution of these problems that, probably, is as satisfactory as any we may hope to attain. We therefore recommend, for release to the contractor, approval of the general character, dimensions and locations of these structures, as above defined.

6. With regard to the structure referred to in item (5), (some form of submerged weir to control and properly distribute the river flow approach to the trashrack), the various tests seem to indicate the need of some form of control of this character. We are of the opinion that some form of submerged weir, with provision for adjusting the height of crest, will probably prove a satisfactory means to this end.

7. The tests, however, have not been carried far enough to permit of any present definite conclusion as to the best location or form of such weir. We consider further model investigation desirable with reference to these features and such further studies might well include also an examination of the effect of a system of separate dykes set echelon fashion.

8. We may further note that, in our opinion, no final solution of all phases of this particular problem is likely to be reached by model study and that the final construction of this feature should be postponed until its most desirable character, location and dimensions, can be determined by experience with the river itself.

9. It seems proper, at this point, to call attention to the lack of similitude regarding the condition affecting silt deposition, as between the model and the prototype. In the latter, the silt will be definitely finer than that which is available for the model and velocities will be some six times greater. In order to realize a silt for model test, in any way properly comparable with that of the prototype, its size would need be far smaller than any thing which can be made available for model use. It results, therefore, that no conclusions regarding either time or volume of silt deposition can be drawn from the model tests. Such tests, however, are of value in indicating directions and changes in velocity and hence locations where deposition of silt may be anticipated. They are also of value as indicating quantity and location of silt deposition in a relative sense as between the different arrangements which have been tried out. Therefore, in reaching our conclusions regarding these matters, we have been guided rather by the latter considerations, than by the actual quantities of silt deposited or by the time period involved.

10. In general, we believe that the final operative program of these various features affecting flow control, and all like conditions affecting the operation of the discharge structures of the dam, must depend on actual experience with the river; but, with the permanent structures we have indicated, we are confident that ways and means may and will be found for the satisfactory control of these various operative features of the installation.

11. Regarding the Gila Valley discharge structures on the east side of the river, we were able to observe a first trial run on one of these structures with especial reference to the removal of silt from the discharge channel after silting up under a condition of non-use. The results obtained we consider favorable in high degree and with suitable combinations of discharge as between the two sets of gates, we believe that the proposed design offers every reasonable promise of effective operation for the purposes in view.

12. Regarding the extended series of laboratory investigations which have been carried on in connection with these problems, we deem it proper at this point to say that we have been strongly and favorably impressed with the character and extent of this work, involving as it has so many variables, intricately related, and susceptible of study only through some system of model representation. A continuation of this work with the same zeal and intelligence, will, we are sure, prove a strong factor in continuously nearer approaches to the effective solution of the many problems which the operation of these structures present.

Respectfully submitted,
Charles P. Berkey
W. F. Durand
Joseph Jacobs

— Copy —

Seattle, Wash., August 1, 1936

Mr. R.F. Walter,
Chief Engineer, U.S. Bureau of Reclamation
Denver, Colorado

Dear Mr. Walter:-

1. Because I had never been there before, as had other members of the Board of Engineers, it was suggested that I spend an extra day at Montrose, after they had left, and thus be afforded an opportunity to witness some additional tests on the Imperial Dam Model, to give a little further thought to some of the problems involved and, if it seemed desirable, to prepare a brief memorandum concerning same. What is here presented are, in general, matters which the Board, for lack of time, had no opportunity to consider in conference and which, therefore, are not dealt with, specifically, in the Board Report. They are, of course, presented as my personal views and not those of the Board.

2. Channel Control:- Judging from the photographs of previous tests, and from the tests witnessed during this visit, the best approach and delivery of water, to both the California and Arizona headworks, seems to result when the main river current is well away from the right bank, i.e., when it holds to the center of the channel or even a little beyond the center, toward the left bank. Uncontrolled, and under its variable condition of discharge, silt burden, etc., the river will doubtless continue, as in the past, to swing from one bank to the other and to form bars and cross channels in unpredictable places. It is thought, however, that control works can be provided that will force the main river channel away from the right bank, and permanently hold it there, if that is finally decided upon as a desideratum, which now seems probable.

3. It is suggested, therefore, that there be some model tests of the effect of spur dikes or groins built out from the right bank at points well above the dam and just above the rather extensive embayment on that side of the river. It is believed that the effect of these groins would be to throw the main current of the river easterly toward the center of the channel and also to silt up the embayment referred to above, both of which effects seem to be desirable. The tests should contemplate a determination of the best locations, the best angles with the bank, the best length and spacing, and the best top elevation, of the groins. My present thought is that two or three groins, about 500' long and 500' apart, will suffice but this is a detail to be determined by the tests. The excellent facilities and personnel at Montrose make it possible to conduct these tests expeditiously and economically. Another possible, though by no means certain, effect of providing controls to hold the river to the center channel, with its natural spread as it approaches the dam, is to make unnecessary the submerged weir above the trashrack which is now being considered as a possible need.

4. Spillway Flashboards:- While the river control referred to above may effect the best approach to the headworks, there will always be, in the vicinity of the headworks, a deposition of silt which it is intended shall be carried off through the sluiceway in order that adequate delivery to the canal headworks may be continuously maintained. There is a

possibility, however, that there may at times be so rapid and excessive a silt deposition that delivery to the headworks will be seriously interferred with unless, in addition to the sluiceway, there be some provision to relieve the situation. Should the condition of a deficient water delivery occur at a critical crop period, serious crop losses might ensue with the concommitant serious complaints, and possibly claimsof damage, from the water users.

5. To ensure keeping open the channel ways leading to the headworks, a dredge or a barge-mounted dragline might be permanently maintained above the dam, to be used when and as required. This rather expensive provision may become an ultimate necessity but it should be avoided, or at least deferred, as long as possible. It is believed that a prompt and material correction of a critical silt condition around the headworks might be secured by the use of flashboards on top of the spillway crest with provision for say a total of 24" in 6" lifts. As the flashboards would be used only during relatively low water condition, and as the dam is designed for a 10' overflow, no change of plans would be involved. All that would be required would be to provide, along the spillway crest, pairs of metal-lined sockets to accommodate removable steel bars between which the flashboards would be placed when required. Relatively small expense is involved in such a provision and it is respectfully submitted for consideration.

6. Spillway Overflow:- As further bearing upon the matter discussed in the two preceding paragraphs, and as relating to the question of relative discharge over the spillway and through the several gate structures under varying conditions of total river discharge, attention is called to two model tests made last Tuesday afternoon. The purpose of these tests was to determine the water surface elevation just above the dam, for varying river discharge, the spillway crest being blocked to prevent spillage. It will be recalled that the easterly end of the spillway model had settled about 2" and that the spillway crest, along its entire length, had been capped with planking to prevent spillage during the tests. Althoughe the spillway had settled about 2" at its easterly end the laboratory staff stated that the westerly end was intact and stood at its correct crest elevation of 181.0'. Therefore, the Tuesday afternoon tests, as to elevation of water surface against the dam, were referred only to the westerly end of spillway crest.

7. The results of these tests are shown in the following tabulation:

No.	Item	Unit	1st test	2nd test
1	Total River Discharge	s.f.	42900	20000
2	Through Calif. Headworks	"	15000	15000
3	" " Sluiceway	"	10000	3000
4	" Ariz. Headworks	"	17000	2000
5	Water surface elevation above spillway crest Model	inch.	1. ±	3/8 ±
6	crest at west end of spillway Prototype	ft.	3.33	2.08
7	Spillway discharge had spillway not been blocked.*	s.f.	24600	12100
8	Residue available for irrigation and sluicing.**	"	17400	7900

* Approximate weir discharges as estimated by J.J.
** These figures are Item (1) minus Item (7).

8. These tests, as to a possible loss of water over an unblocked spillway crest, disclose a condition of water wasteage that is hardly permissible under actual operation. It will be noted that both tests, particularly Test No.2, show a residue of water available for irrigation and necessary sluicing, after deducting spillway discharge from total river discharge, that is quite below requirements when full development under the All-American and Gila Canals is attained. It is difficult to believe that the conditions indicated by the model, in these particular tests, will actually obtain with the prototype. It is suggested, therefore, that there ought to be a check of all critical elevations and dimensions of the model as, for example, the spillway crest, the sills and tops of all gate openings, the floors of forebays and tailbays of all gate structures, etc. It might also be desirable to check the hydraulic computations upon which the detailed design of these various elements, and their relative dimensions and elevations, were based.

9. Groins on upstream apron of Dam.- Though the stability of the dam is not dependent thereon, a loading of silt on the upstream apron of the dam is deemed desirable as an additional safety factor, as was suggested in the Board Report. With flowage parallel to the dam toward the California Headworks, as would often be the case with the character of river control referred to in paragraphs 2 and 3, it might be necessary to provide groins on the upstream apron of the dam to ensure the desired silt loading mentioned above. It is suggested, therefore, that there be some model tests to determine the best length, spacing and crest elevation for such groins. Provably not more than one or two groins, in addition to the one at the extreme westerly end of spillway referred to in the Board Report, would be required. This is a detail that would be developed by the tests.

10. These groins, naturally, would tend to shift the current from along the face of the dam to a location along the outer ends of the groins, thus raising a question as to possible dangerous scour along the upstream toe of the apron—a condition that might compel longer groins than would

otherwise be required. It is my judgment that with the structure elevations as now provided in the plans, and for the quantity of flowage involved, there is no likelihood of undue scour, i.e., a scour that would dangerously approach the base of the upstream sheet-pile cutoff which extends down to about elevation 130'. It is, however, a phase of the problem that calls for some consideration. Unfortunately, the lower velocities and the coarser silt that obtain for the model, as compared with the prototype, make it difficult to draw conclusions, as to scour, from the model tests. However, the groin tests suggested in the preceding paragraph may, in addition to their primary purpose, afford a little information on this question of scour.

11. Some of the matters referred to above were briefly discussed with Messrs. Warnock, Thomas, and Dowd during the progress of the tests. They are respectfully submitted for your consideration.

Very truly yours

Joseph Jacobs

copies to Mr. Savage, Dr. Durand and Dr. Berkey

UNITED STATES

DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

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MEMORANDUM TO CHIEF DESIGNING ENGINEER

SUBJECT: PROGRESS REPORT OF MODEL

STUDIES AT MONTROSE, COLORADO OF THE

IMPERIAL DAM AND DESILTING WORKS

ALL-AMERICAN CANAL

- - - -

By

C. W. Thomas, J. E. Warnock, C. P. Vetter

- - - -

Montrose, Colorado

July 25, 1936

Montrose, Colorado, July 25, 1936

MEMORANDUM TO CHIEF DESIGNING ENGINEER
(C. W. Thomas, J. E. Warnock, C. P. Vetter)

Subject: Progress report on Model Studies at Montrose, Colorado of the Imperial Dam and Desilting Works - All-American Canal.

1. At its meeting at Yuma, Arizona in January 1935, the All-American Canal Consulting Board suggested that a model be constructed of the Imperial Dam and an adjacent part of the reservoir for the purpose of studying the flow of water and silt to the headgates of the All-American Canal.

2. Before construction work on the model was started a careful study was made in order to determine the model scale and the type of silt to use so that correct deductions might be made from the results obtained. The topography of the reservoir indicated that in order to get representative flow conditions it would be highly desirable to include in the model approximately $1\frac{1}{2}$ mile of reservoir upstream from the dam. Approximately 1/4 mile downstream from the dam was believed necessary to study the dissipation of energy and other tailwater phenomena. It was considered probable, in view of the experience of others with small scale models, that in case a too great reduction in scale was used it would be necessary to employ silt having a specific gravity less than that of silt and sand found in nature. The use of coal dust was considered but the cost was found to be prohibitive. It was further considered whether a distorted model scale (greater reduction of the horizontal than of the vertical dimensions) would make it possible to use a smaller model. Distorted scales have been used to some extent for the study of river problems but the verification on prototype structures of results obtained in this manner are believed to be insufficient, at the present time, to justify complete confidence in the method. It was therefore decided to make the model as large as the physical conditions at the selected site would permit, and to use a silt as fine as could be obtained at reasonable cost in the immediate vicinity of the model. It was found that a model to the scale of 1:40 could be built without excessive grading at the site and that a type of silt could be obtained very similar to the prototype silt of the Colorado River.

3. The site selected for the model was two miles below the mouth of the Gunnison Tunnel on the South Canal of the Uncompahgre project. At this point the canal drops approximately 50 feet in a distance of 500 feet thus making possible the use of the water for the model and returning it to the canal from which it was taken. A diagramatic sketch of the model and its relation to the canal is shown in figure 1. Water is taken from the canal through a 48-inch circular gate and carried to the measuring weir through a 24-inch welded steel pipe. From the weir the conduit to the model consists of a wooden flume. The sand representing silt is fed into the flow in this flume at a uniform rate by means of a mechanical feeder. At the upper end of the model a diverter gate is installed to permit wasting the water to the dry wash around the model or inducing it into the model. After the water passes through the model it is collected in a wooden flume and returned to the canal.

The 1935 Testing Program

4. During the 1935 season the reservoir was silted up between the upstream limit of the model and the dam. During this process the discharge was kept approximately constant at 21,000 second-feet (prototype or 2.075 second-feet in the model) and silt was added at the rate of 1% by weight of the flow of water. All water was discharged through the sluicegates and headgates and numerous observations were made of the manner in which the silt delta progressed downstream toward the dam. The main flow of the river would constantly change from one bank to the other keeping the slope of the delta practically unchanged. The data obtained during the silting process have not as yet been worked up but are expected to yield much valuable information on the subject. Observations were also made of the flow of water through the first by-pass gate and the first influent gate structure of the desilting works. The desirability of minor changes in the approaches to these structures was indicated by the observations and corrections were made accordingly in the design.

5. On July 15 the All-American Canal Consulting Board inspected the Hydraulic Laboratory. At the time of the meeting the model had been in actual operation for about two weeks and the delta had progressed only a short distance downstream. The Consulting Board observed and approved the action of the overflow weir and the sluiceway in regard to the dissipation of energy downstream. Based on the behavior of the model, the Board recommended certain changes in the alinement of the inlet channels downstream from the All-American Canal headworks and of

3. The site selected for the model was two miles below the mouth of the Gunnison Tunnel on the South Canal of the Uncompahgre project. At this point the canal drops approximately 50 feet in a distance of 500 feet thus making possible the use of the water for the model and returning it to the canal from which it was taken. A diagramatic sketch of the model and its relation to the canal is shown in figure 1. Water is taken from the canal through a 48-inch circular gate and carried to the measuring weir through a 24-inch welded steel pipe. From the weir the conduit to the model consists of a wooden flume. The sand representing silt is fed into the flow in this flume at a uniform rate by means of a mechanical feeder. At the upper end of the model a diverter gate is installed to permit wasting the water to the dry wash around the model or inducing it into the model. After the water passes through the model it is collected in a wooden flume and returned to the canal.

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the transition below the sluicegates. It was also recommended by the Board that the number of sluicegates be increased from eight to twelve. These changes were effected in the design prior to the issuance of specifications for the Dam and Desilting works. In its report the Board also approved the tentative test program for determining, by means of the model, the relatively best arrangement of trashrack and training dikes upstream from the headgates and sluiceway, for preventing coarse silt from entering the headgates and possibly causing obstructions in the inlet channel downstream. During the remainder of the season the silting up program was continued and by the time freezing temperatures made continuance of the testing program impractical the delta had reached the dam and headworks and a state of equilibrium had been reached at which the same amount of silt was carried through the headgates and sluiceway as was admitted to the reservoir upstream.

The 1936 Testing Program

6. It had been observed at the initial model runs during the 1935 season that the most favorable conditions at the headworks would be obtained if the flow approached from the left bank of the river crossing the reservoir from east to west in front of the dam and passing the sluiceway before it entered the headgates. A considerable portion of the heavy silt would then be discharged through the sluiceway and little difficulty was experienced in keeping the space inside the trashrack clear of silt. In its report dated July 25, 1935 the All-American Canal Consulting Board recommended that further study be given to this particular feature of the problem. It was believed, however, that an attempt should be made first to find a solution to the approach problem which would permit the river to meander unrestrictedly from side to side without causing serious silt deposits in front of the headgates at even the most adverse conditions of approach. The 1936 testing program to date has been conducted along these lines.

7. The laboratory was opened April 6, 1936 a few days after weather conditions permitted water to be turned into the canal system. After removing the debris accumulated by the winter storms and reconditioning the sluiceway portion of the model, an intensive testing program was inaugurated. Pressure measurements on the crest of this structure were made by means of piezometric openings for a series of discharges and gate openings. Watersurface measurements were made of the jet downstream from the gates. A complete calibration of the gates was effected and pictures were taken of flow conditions in the stilling pool. The data from these tests has been edited and presented in technical memorandum No. 516.

8. While these tests were being run changes in design developed during the winter were incorporated into the model. The Gila Valley Canal Headworks and Desilting Works were constructed but to date no testing has been done on this feature of the work.

9. To get the testing program under way three essentially different layout numbers 1 to 3 inclusive, were run with different river flows and different distributions of flow between the headworks and sluiceway. Based on the information obtained from these initial runs the decision was made to standardize on a river flow of 24,000 second-feet (prototype) and to distribute this flow with 10,000 second-feet through the headgates and 14,000 second-feet through the sluiceway and to make such further changes in the model as observations would indicate as being desirable.

10. Preliminary runs were made to determine the necessary length of time to obtain stable conditions in regard to silt deposition near the headworks. The results of these tests fixed the time at approximately six hours to obtain a near constant condition although fair indications of final results could be obtained in a shorter time. Accordingly the runs were made by regulating the discharge to the desired amount as indicated by the 18-inch contracted weir while the water was being diverted to the wasteway at the upper end of the model, and then turning it into the model and regulating the amount of water through the sluiceway and headworks. As soon as the flow became constant through these structures the timing was commenced. At the end of a six hour period, during which time the flow conditions were maintained constant, the flow was shut off. The model was drained in a manner such that the silt deposit was not disturbed and the results recorded by photographing with a 5x7 camera. During the running period observations were recorded at 15-minute intervals on the 18-inch measuring weir, the reservoir elevation, the tailwater elevation in the channels below the roller gates, the Venturi flume below the sluiceway, the Venturi flume in the canal and the 90-degree V-notch weir used to measure the discharge through the right gate of the headworks. These observations were made to assure constant flow conditions. Before each run was started all deposits of silt above elevation 168 inside the skimming weirs and trash-racks were removed. The inlet channels below the roller gates were thoroughly cleaned and the silt was removed from the channel below the sluiceway. Silt was fed into the water during the time the water was run through the model. The flow to the headworks and sluiceway was retained in the position to give the desired approach by means of sand bags.

11. It soon became evident that some sort of skimming weir was essential for obtaining the desired distribution of flow to the trashrack, and efforts were therefore concentrated on determining the most efficient shape and elevation of the weir in relation to the trashrack. Altogether 38 layouts were tested, several with the flow approaching from different directions. 25 of these layouts are listed with comments in the attached table. Prints of layouts 26 to 35 inclusive are shown on attached prints. For all layouts up to and including number 35, and also number 37, three units of the sluiceway (12 gates) were utilized for the disposal of surplus flow. For layouts 36 and 38 only two units (8 gates) were utilized and somewhat better flow conditions and silt control were obtained in this manner. In all cases better results were obtained when the flow approached from the left than when it approached from the right. Photographs of the following typical layouts are attached hereto, Numbers 1, 2, 6, 12, 19, 22 and 30

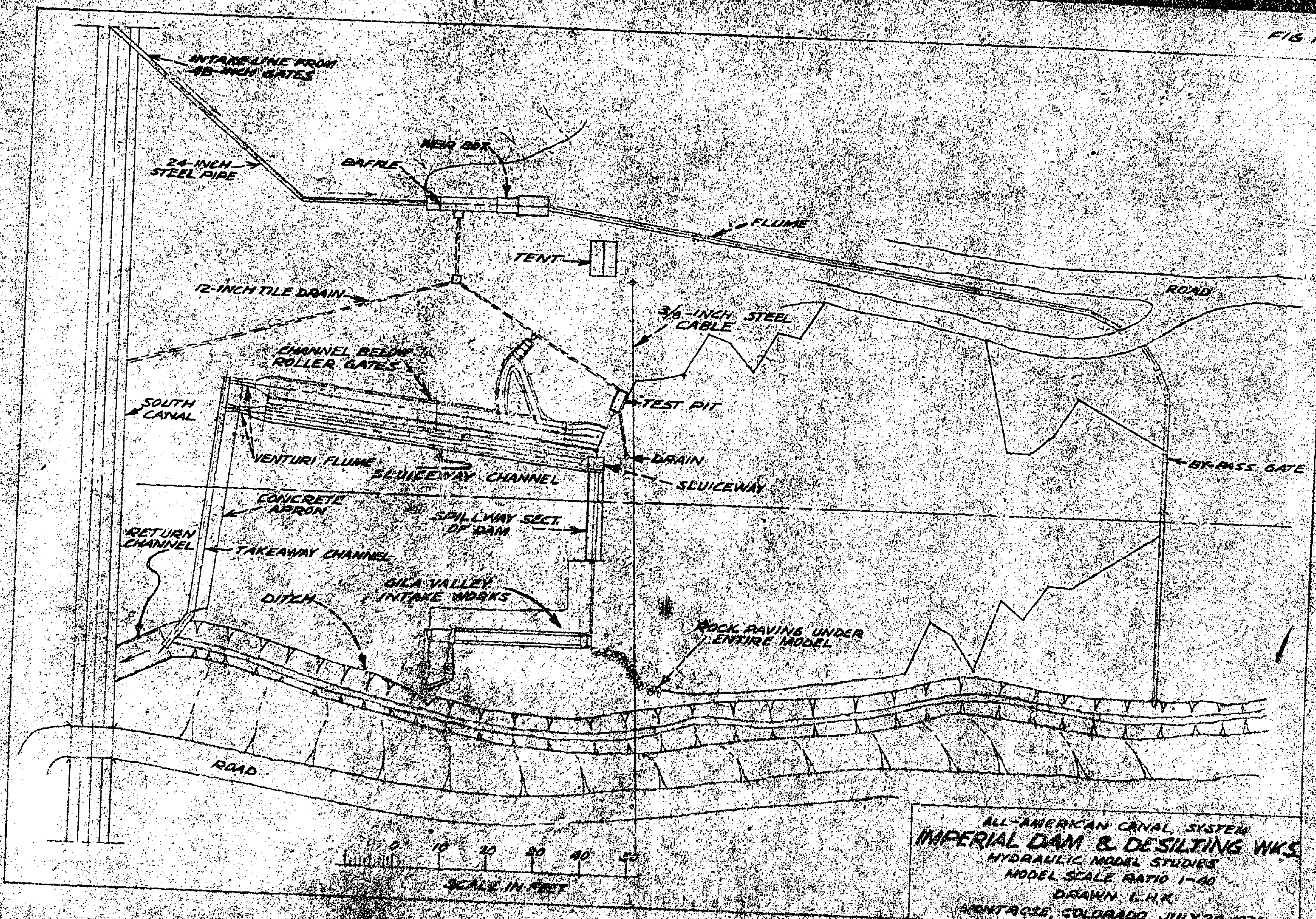
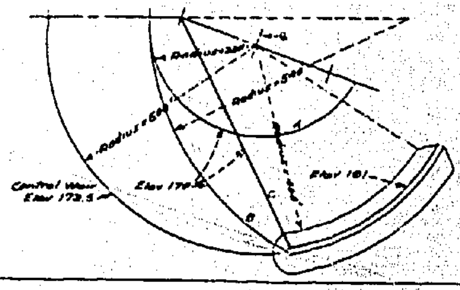
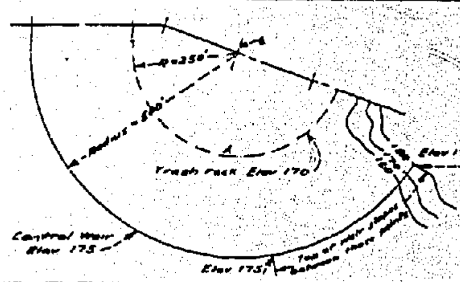
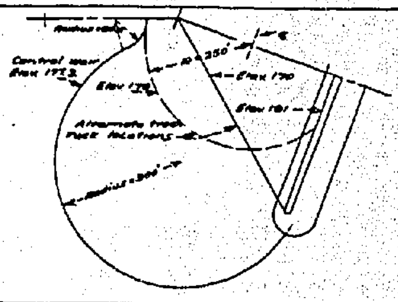
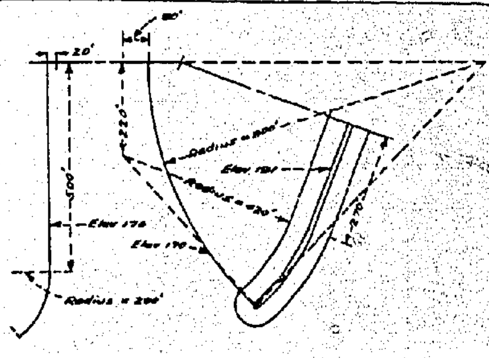
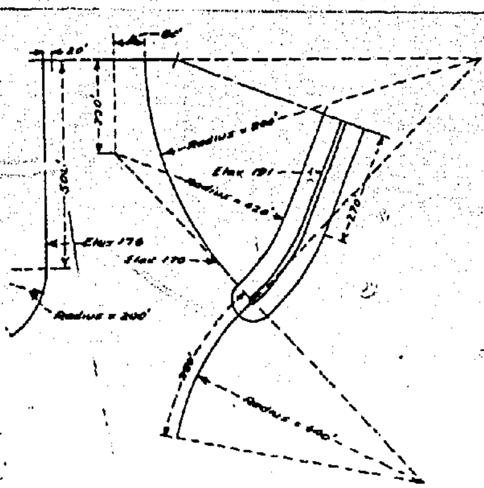

INTAKE LINE FROM
48-INCH GATES
24-INCH
STEEL PIPE
BAFFLE
WEIR BOX
FLUME
TENT
12-INCH TILE DRAIN
ROAD
3/8-INCH STEEL
CABLE
CHANNEL BELOW
ROLLER GATES
SOUTH
CANAL
TEST PIT
VENTURI FLUME
DRAIN
SLUICEWAY CHANNEL
BY-PASS GATE
SLUICEWAY
CONCRETE
APRON
SPILLWAY SECT.
OF DAM
RETURN
CHANNEL
TAKEAWAY CHANNEL
GILA VALLEY
INTAKE WORKS
DITCH
ROCK PAVING UNDER
ENTIRE MODEL
ROAD
0 10 20 30 40 50
SCALE IN FEET
ALL-AMERICAN CANAL SYSTEM
IMPERIAL DAM & DESILTING WKS.
HYDRAULIC MODEL STUDIES
MODEL SCALE RATIO 1-40
DRAWN L.H.K.
MONTROSE, COLORADO JULY 24 1936

FIG. 1.

1.

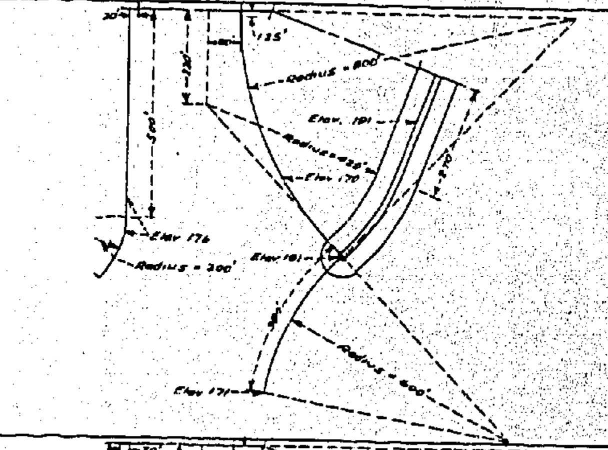
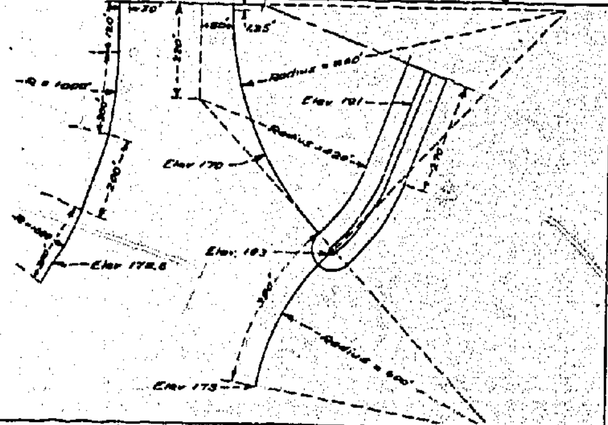
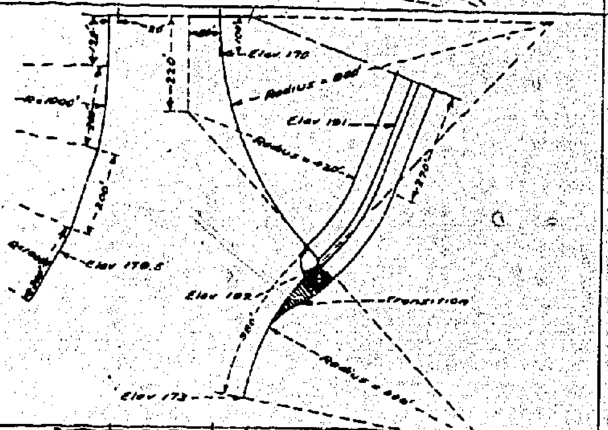
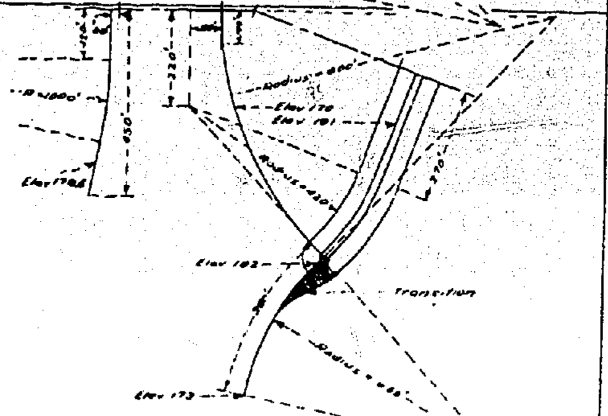
ALL-AMERICAN CANAL HEADWORKS

SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40
River Discharge - 24,000 second-feet - Headworks 10,000 - Sluiceway 14,000

Layout Number	Drawing	Position of River	W.S. Elev. Along Face of Dam	Length of Run	Results and Conclusions
1		Right		6 hrs.	Trashrack in position A. Large slow whirl inside trashrack. Area inside of trashrack and channels below roller gates badly silted. Excessive scour along submerged weir at end of dike. Results generally unsatisfactory.
2		Right		6 hrs.	Trashrack in position A. Flow conditions approaching roller gates and sluiceway good. Area inside trashrack and two center channels below roller gates badly silted. Little silt in right channel. Results unsatisfactory.
3		Right		6 hrs.	24,000 Second-feet discharge not run for this layout. Unsatisfactory conditions resulted with lower discharge.
4		Right		6 hrs.	Concentration of flow around end of dike. Flow evenly distributed to roller gates. Considerable drop in head from face of dam to roller gates. Deep channel scoured out along dike near nose. Area inside of trashracks and two center channels below roller gates badly silted. Right channel contained some silt. Favorable results from sluicing period. Results generally unsatisfactory.
5		Right		1 hr. 10 min.	Concentration of flow around end of dike. Good standing wave formed over first weir. Flow through trashracks well distributed. Very little effect over left weir. Area inside of trashrack badly silted. Some silt deposited in canal. Shallow channel inside of left weir. Short weir too low, raise to approximate elevation 180 and slope down at outside end. Raise long weir to obtain more effect.

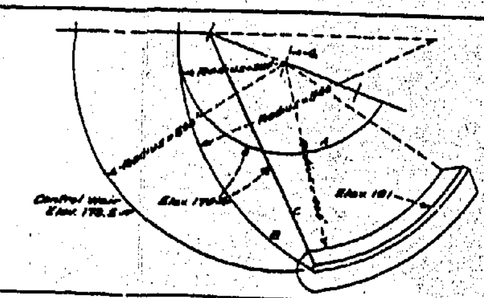
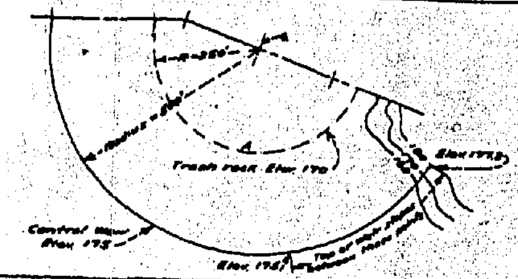
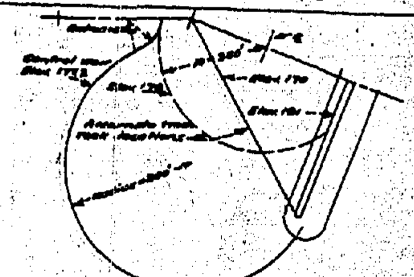
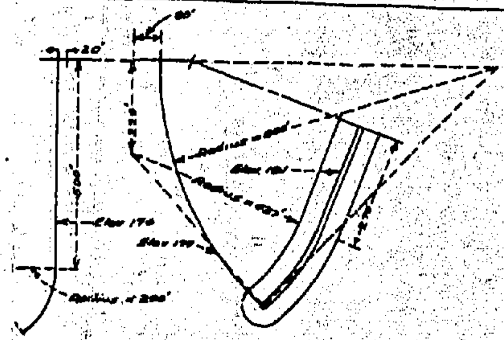
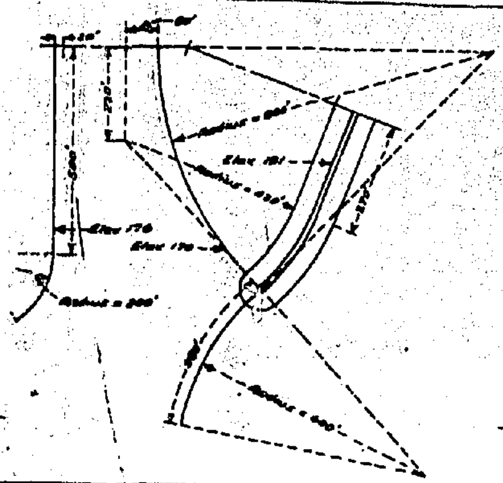
ALL-AMERICAN CANAL HEADWORKS

SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40
River Discharge - 24,000 second-feet - Headworks 10,000 - Sluiceway 14,000

Layout Number	Drawing	Position of River	W.S. Elev. Along Face of Dam	Length of Run	Results and Conclusions
6		Right		1¼ hr.	Concentration of flow near end of dike. Good standing wave over right skimming weir. Flow crossed to outside of left weir near end farthest from dam, turned along dam and flowed over weir and into sluices. Flow evenly distributed across front of intake inside of trashrack. Weir on left side effective at curve and at end next to dam. Channel along left skimming weir. Entire bar very rough. Slight channel around end of dike. Area inside of trashrack silted. Some silt in channels below roller gates. Raise right weir.
7		Right		3 hr.	Drop in head and rough flow conditions around nose of dike causing slightly higher velocities next to dike. End of weir next to dike not effective because drop in watersurface around end of dike allowed very little water to spill over weir. Good standing wave over weir beyond effect from dike. Slight whirl inside of dike and trashrack. Area inside of trashrack silted and some silt in channels below roller gates. The condition at the end of the dike would be corrected by a more efficient and less abrupt transition from the dike to the weir.
8		Left Center Right	184.0	6 hrs. 1 hr. 1 hr.	River on right side. Concentration of flow along dike and right weir. Smooth flow around end of dike. Good standing wave over right weir. Flow to roller gates evenly distributed. Some silt inside of trashrack and some in channels below roller gates. Channel from end of right weir across to end of left weir. Channel along entire length of this weir spreading to one half the width of the sluiceway at the end next to that structure. Sluicing period gave very satisfactory results. River from center - Good flow conditions. Considerable silt was sluiced continuously and much of bar that formed when river was on right side was removed. River from left side - Good standing wave along entire length of left weir. Considerable silt sluiced continuously. Left weir too high and possibly too long.
9		Left	184.0	9 hrs.	Slight concentration of flow over weir, extending about 40 feet ahead of crest of dam. Good distribution of flow over remainder of weir. Channel formed around end of weir and flowed in arc to nose of rock dike, causing slow whirl in area in front of sluiceway. Concentration of flow through trashrack near rock dike and some water flowed out of trashrack near sluiceway end. Slight circular motion inside of trashrack. Bar forms from end of left weir toward trashrack. Undesirable channel from end of weir.

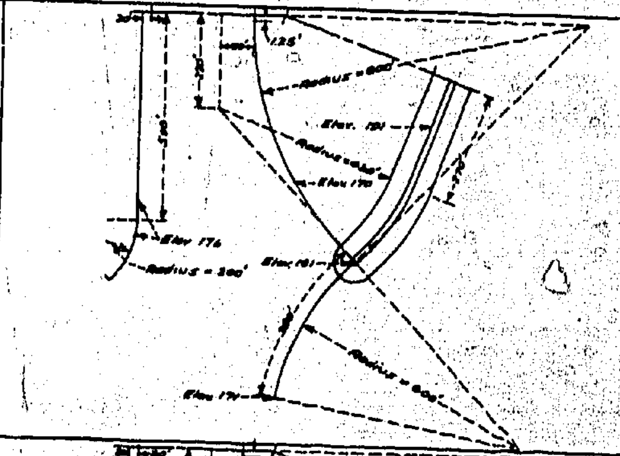
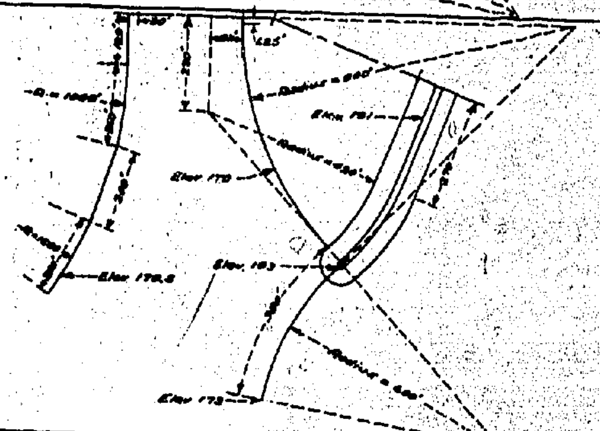
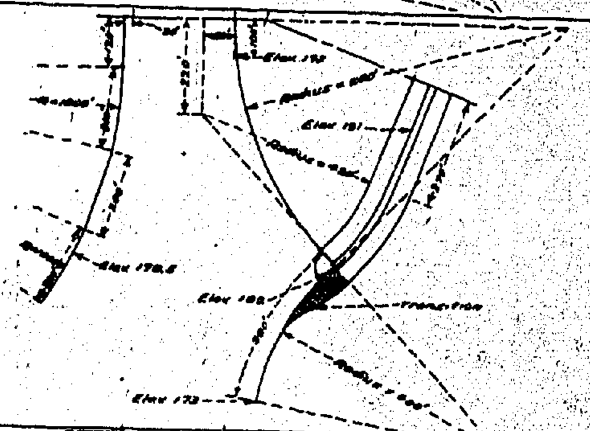
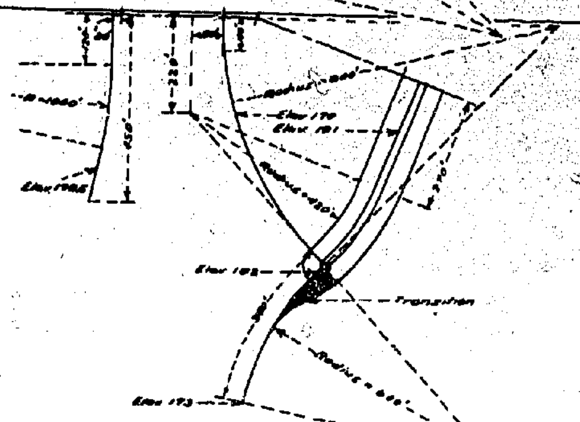
ALL-AMERICAN CANAL HEADWORKS

SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40
River Discharge - 24,000 second-feet - Headworks 10,000 - Sluiceway 14,000

Layout Number	Drawing	Position of River	W.S. Elev. Along Face of Dam	Length of Run	Results and Conclusions
1		Right		6 hrs.	Trashrack in position B. Large slow whirl inside trashrack. Area inside of trashrack and channels below roller gates badly silted. Excessive scour along submerged weir at end of dike. Results generally unsatisfactory.
2		Right		6 hrs.	Trashrack in position A. Flow conditions approaching roller gates and sluiceway good. Area inside trashrack and two center channels below roller gates badly silted. Little silt in right channel. Results unsatisfactory.
3		Right		6 hrs.	24,000 second-feet discharge not run for this layout. Unsatisfactory conditions resulted with lower discharge.
4		Right		6 hrs.	Concentration of flow around end of dike. Flow evenly distributed to roller gates. Considerable drop in head from face of dam to roller gates. Deep channel scoured out along dike near nose. Area inside of trashracks and two center channels below roller gates badly silted. Right channel contained some silt. Favorable results from sluicing period. Results generally unsatisfactory.
5		Right		1 hr. 10 min.	Concentration of flow around end of dike. Good standing wave formed over right weir. Flow through trashracks well distributed. Very little effect over left weir. Area inside of trashrack badly silted. Some silt deposited in canal. Shallow channel inside of left weir. Short weir too low, raise to approximate elevation 180 and slope down at outside end. Raise long weir to obtain more effect.

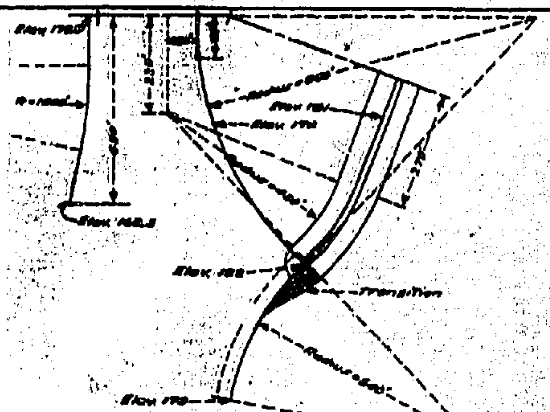
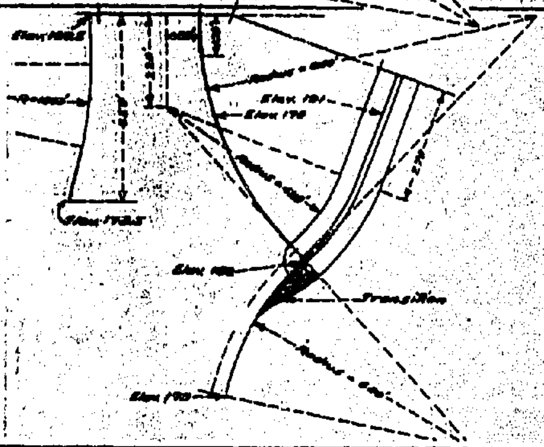
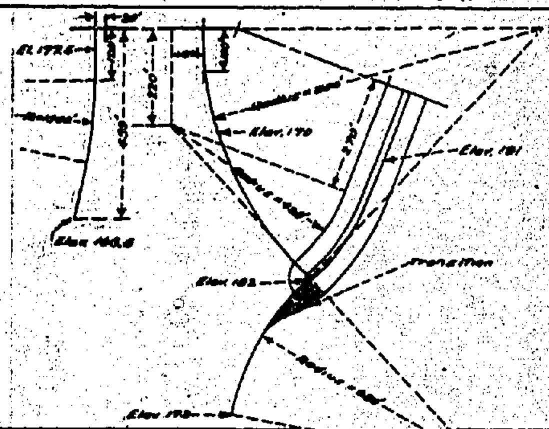
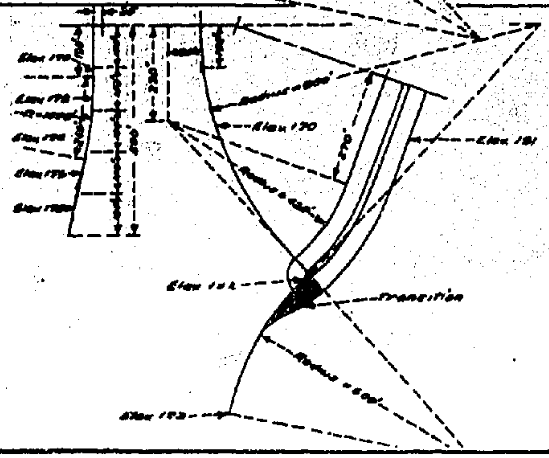
ALL-AMERICAN CANAL HEADWORKS

SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40
River Discharge - 24,000 second-feet - Headworks 10,000 - Sluiceway 14,000

Layout Number	Drawing	Position of River	Max. Elev. Along Face of Dam	Length of Run	Results and Conclusions
6		Right		1¼ hr.	Concentration of flow near end of dike. Good standing wave over right skimming weir. Flow crossed to outside of left weir near end farthest from dam, turned along dam and flowed over weir and into sluices. Flow evenly distributed across front of intakes inside of trashrack. Weir on left side effective at curve and at end next to dam. Channel along left skimming weir. Entire bar very rough. Slight channel around end of dike. Area inside of trashrack silted. Some silt in channels below roller gates. Raise right weir.
7		Right		3 hr.	Drop in head and rough flow conditions around nose of dike causing slightly higher velocities next to dike. End of weir next to dike not effective because drop in watersurface around end of dike allowed very little water to spill over weir. Good standing wave over weir beyond effect from dike. Slight whirl inside of dike and trashrack. Area inside of trashrack silted and some silt in channels below roller gates. The condition at the end of the dike could be corrected by a more efficient and less abrupt transition from the dike to the weir.
8		Left Center Right	184.0	6 hrs. 1 hr. 1 hr.	River on right side. Concentration of flow along dike and right weir. Smooth flow around end of dike. Good standing wave over right weir. Flow to roller gates evenly distributed. Some silt inside of trashrack and some in channels below roller gates. Channel from end of right weir across to end of left weir. Channel along entire length of this weir spreading to one half the width of the sluiceway at the end next to that structure. Sluicing period gave very satisfactory results. River from center - Good flow conditions. Considerable silt was sluiced continuously and much of bar that formed when river was on right side was removed. River from left side - Good standing wave along entire length of left weir. Considerable silt sluiced continuously. Left weir too high and possibly too long.
9		Left	182.0	[illegible] hrs.	Slight concentration of flow over weir, extending about 40 feet ahead of crest of dam. Good distribution of flow over remainder of weir. Channel formed around end of weir and flowed in arc to nose of rock dike, causing slow whirl in area in front of sluiceway. Concentration of flow through trashrack near rock dike and some water flowed out of trashrack near sluiceway end. Slight circular motion inside of trashrack. Bar forms from end of left weir toward trashrack. Undesirable channel from end of weir.

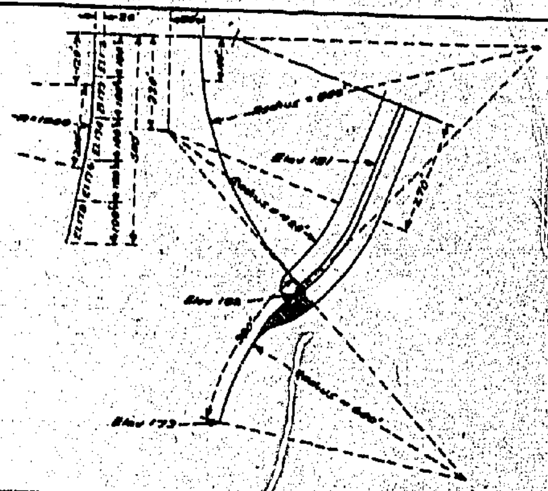
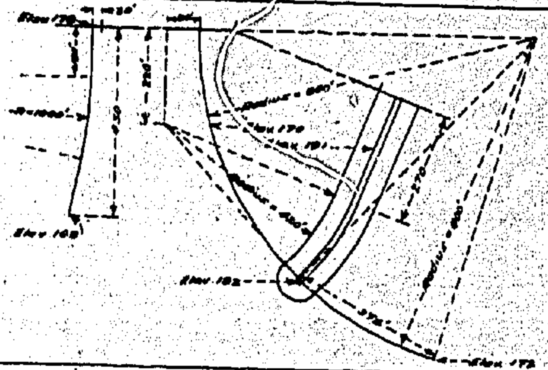
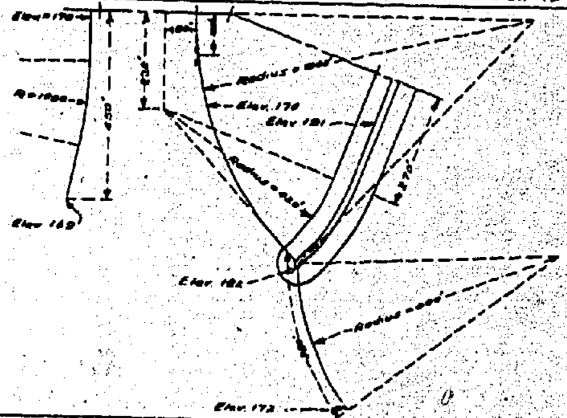
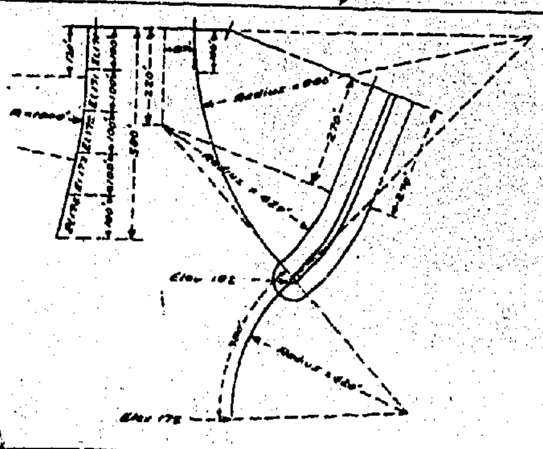
ALL-AMERICAN CANAL HEADWORKS

SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40
River Discharge = 24,000 second-feet - Headworks 10,000 - Sluiceway 14,000

Layout Number	Drawing	Position of River	W.S. Elev. Along Face of Dam	Length of Run	Results and Conclusions
10		Left	181.8	2 hrs.	Good standing wave over approximately 200 feet of left weir. Flow through trashracks well distributed. No channel around end of weir. Entrance to roller gates very good. Bar forms approximately 300 feet ahead of sluiceway. Good open area immediately in front of sluiceway. Weir should be lowered slightly at end next to dam to lower reservoir water surface.
11		Left	176.0	3 hrs.	Standing wave over weir fairly good. Concentration of flow along face of dam and across front of sluiceway causing drop in head around closed section of trashrack and uneven distribution of flow through trashracks. Approach to roller gates is from left causing drop around front of piers. Considerable silt sluiced continuously. Some silt inside trashrack after short run. Bar approximately 50 feet from sluiceway. Layout not satisfactory.
12		Left	181.8	7 hrs.	Good standing wave over left hand weir except at extreme out end. Flow through trashrack evenly distributed and entrance to roller gates good. No noticeable concentration of flow. No silt inside of trashrack after test. Bar formed approximately 200 feet ahead of sluiceway with channel along left weir, channel along trashrack and channel from end of left weir across to intersection of dike and right weir. Good open area in front of sluiceway and in front of trashrack from approximately the mid point to the dike and right weir. Sluicing operation very good. Left weir could possibly be lowered one foot at end next to dam and out end raised one foot and lengthened approximately 50 feet.
13		Left	185.0	5 hrs.	Flow concentrated along face of dam with standing wave over approximately 200 feet of left weir and very slight agitation over remainder. Entrance conditions through trashrack were fair except for a few feet around blocked out end. Sluices carry a large load of silt. Entrance to roller gates fair. Slight inflow from front prevents whirl inside of trashrack. No channel around end of left weir. Very little silt inside of trashrack. Channel along left weir. Layout gave fair results.

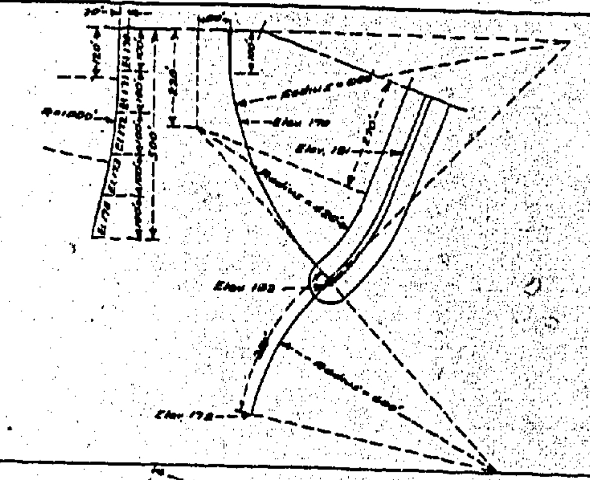
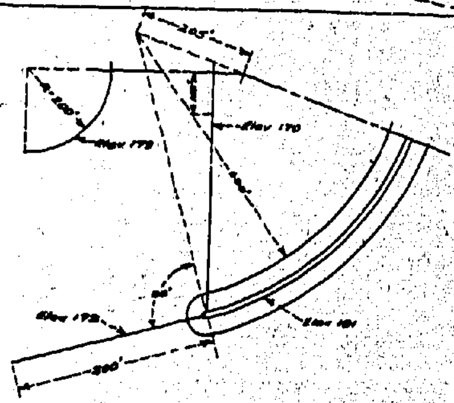
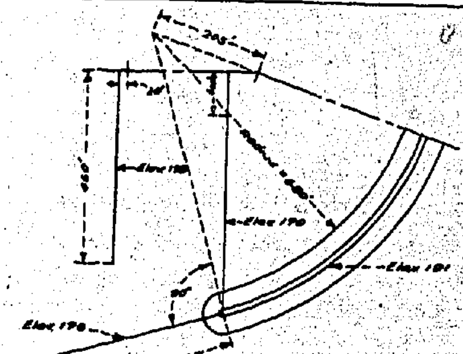
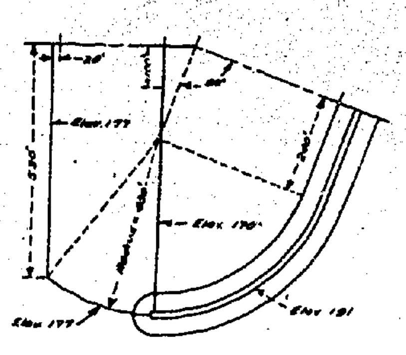
[illegible]

[illegible] OF LAYOUTS FOR [illegible] MODEL [illegible] RATIO 1:40
River Discharge = 24,000 second-feet = Headworks 10,000 = Sluiceway 14,000

Layout Number	Drawing	Position of River	Gage Elev. along Face of Dam	Length of Run	Results and Conclusions
14		Left	180.0	1¼ hrs.	Flow concentrated along face of dam with standing wave over approximately 500 feet of left weir and slight agitation over remainder. Entrance conditions through trashrack fair except drop in head around blocked out end and concentration of flow beyond this point for a few feet. Flow through roller gates good. Very little silt inside trashrack. Small silt bar approximately 50 feet from left about 20 feet wide and 150 feet long. Slots appeared to have some effect. Run too short to form conclusive opinion.
15		Right		6 hrs.	Large slow whirl on side of dike near bank. Smaller swift whirl near end of short weir causing excessive erosion. Flow to roller gates is from left at an angle forming large slow whirl in area between trashrack and dike. Some flow in wide arc approaching sluiceway from left. Excessive scour at end of dike. Area between trashrack and gates and channels below gates badly silted. Channel along right skimming weir and open area directly in front of sluiceway. Layout is unsatisfactory.
16		Right		5 hrs.	Standing wave over left weir not pronounced but enough agitation to keep silt moving. Concentration of flow along face of dam and across in front of sluiceway with slight drop in head around end of blanked off trashrack. Entrance conditions through trashrack and to roller gates good. Some silt deposited inside of trashrack. Small silt bar in front of sluiceway. Results with this layout were fair.
17		Left	180.0	7 hrs.	Flow piles up back of dike and forms a slow whirl. Also slow whirl inside of trashrack caused by uneven distribution of flow through trashrack. Bar forms near trashrack, continues through trashrack and approaches roller gates. Bar is drawn toward sluiceway also. Weir on left fairly clean. Layout was unsatisfactory.

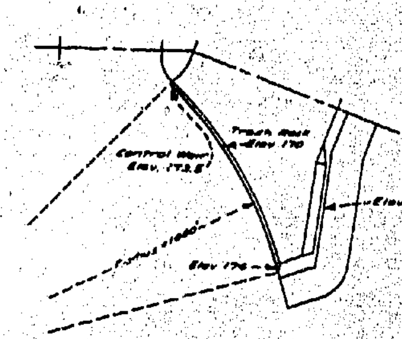
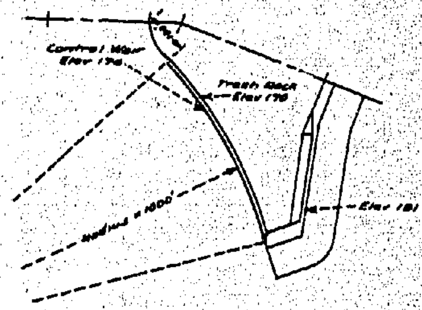
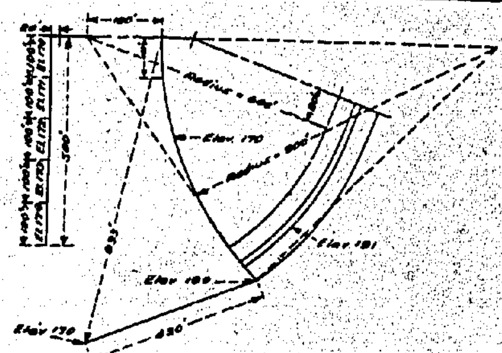
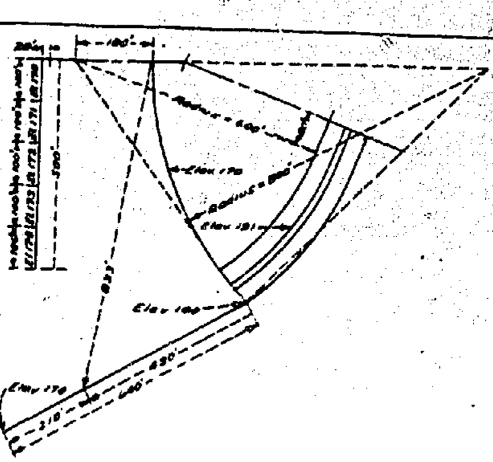
[illegible]

SUMMARY OF [illegible] - MODEL [illegible] RATIO 1:40
River Discharge = 24,000 second-feet - Headworks 10,000 - Sluiceway 14,000

Layout Number	Drawing	Position of River	[illegible] Elevation Face of Dam	Length of Run	Results and Conclusions
18		Left	180.0	5 hrs.	Flow conditions much the same as in layout 17 except the wave was not as pronounced because of the flow through the slots. Flow through trashrack and approach to roller gates good. Small bar in front of sluiceway. Slots appeared very effective in breaking up bar. Results of layout good.
19		Right	185.0	6 hrs.	Channel forms along upstream side of rock dike but is spread very effectively by weir at end of dike. Flow continues toward dam spreading some toward intake. Water flows toward dam over approximately one half of left weir then along dam toward intake and over other half of weir. Most of flow is through 1/4 of trashrack next to intake. Entrance to roller gates not good. Entrance to extreme left sluice gate not good. [illegible] occur along upstream side of rock dike and approximately one half of right weir. Slight channel along left weir. Large bar across front of entire intake works extending inside of trashrack about half way to roller gates. Open area in front of sluiceway small. Sluicing removed top of bar and formed channel around left weir, but none along trashrack. Results of layout unsatisfactory. Weirs too far from sluiceway.
20		Right		5 hrs.	Concentration of flow along outside of dike and upstream side of weir at end of dike. Good drop over weir and flow evenly spread. Concentration of flow at end of dike. Flow travels in large semicircle and approaches sluiceway from left. Good drop over all of left weir. Fairly good distribution of flow through trashrack. Some concentration in half next to dam. Entrance to roller gates at angle from left. Extensive erosion along outside of dike and about half of weir. Bar below weir extending about 80 feet inside of trashrack. Slight channel across bar toward sluiceway and along left weir. Results of layout unsatisfactory.
21		Right	185.0	6 hrs.	Swift channel along upstream side of rock dike spreading in large scouring arc at end of dike. Bar forms at end of dike and carries around end of dike inside of trashrack. Reservoir high on upstream side of dike. High velocity through about 120 feet of trashrack just outside of blocked off area and practically no flow thru remainder of rack. Entrance to roller gates very bad. Deep channel along upstream side of rock dike tapering out beyond end of dike. Bar to approximately elevation 184 extending through trashrack and filling channel upstream from sluiceway to within 220 feet of axis of sluice. Small channel to right of left weir. Small open area in front of sluiceway channel through trashrack around end of blocked off section. Bar formed inside of trashrack behind blocked off section. Two center channels below roller gates badly silted. Results and sluicing bad. General results unsatisfactory.

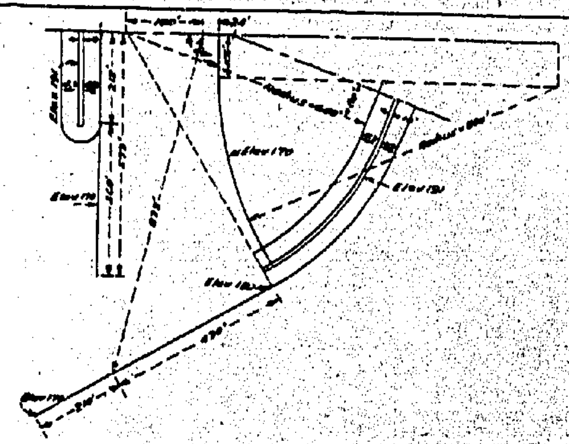
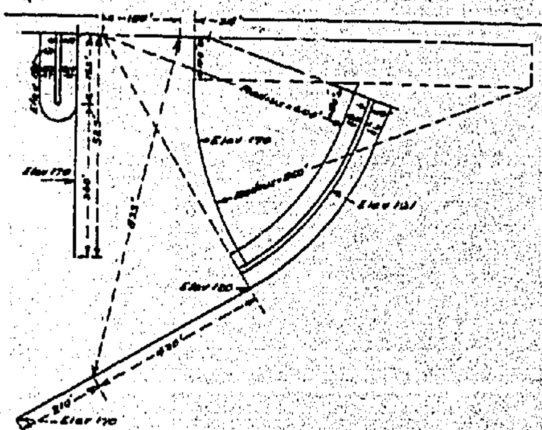
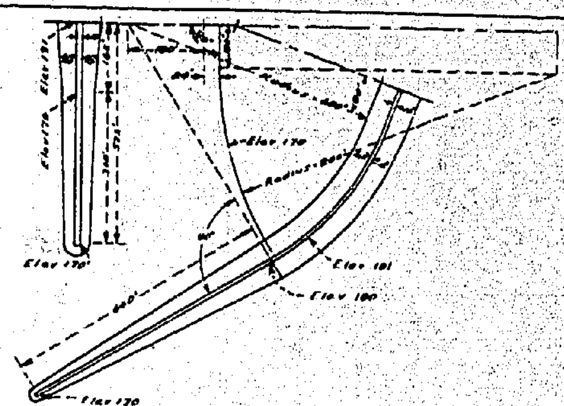
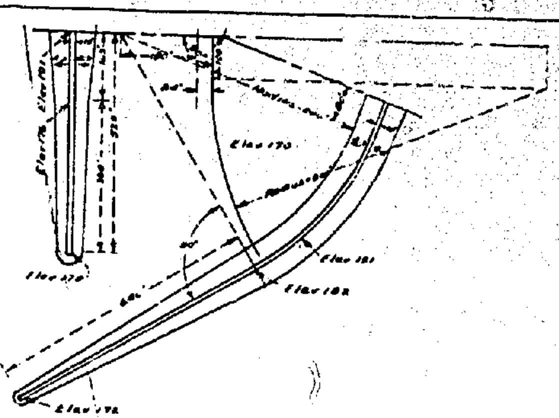
[illegible]

[illegible] 1:40
River Discharge = 24,000 second-feet — Headworks 10,000 — Sluiceway 14,000

Layout Number	Drawing	Position of River	[illegible] Elev. [illegible] Face of [illegible]	Length of Run	Results and Conclusions
22		Right	185.0	5 hrs.	Bad flow conditions around end of dike with excessive drop in head and bad whirl. Flow through trash-rack and to roller gates is at angle and not well distributed. Silt bar inside of trashrack and in front of sluiceway at approximate elevation 170. Channels below roller gates badly silted. Tendency for small channel to form around bar and approach sluiceway from left. Weir completely buried in bar. Results unsatisfactory.
23		Right	184.0	6 hrs.	Concentration of flow around end of dike. Flow through trashrack and entrance to roller gates not good. Inside of trashrack and channels below roller gates badly silted channel cut around to left caused high head over dam. Scour bad around nose of dike. Scour bad around nose of dike. Results very unsatisfactory.
24		Right	181.0	7 hrs.	Flow conditions good. Slow whirl inside of trashrack but not of severe proportion channel along trashrack and outside over left weir most of flow passing sluiceway. No silt inside of trashrack or in channels below roller gates. Good channel outside of trashrack. Channel around and over left weir. Considerable silt in front of sluiceway. Sluicing operation very satisfactory. General results fairly satisfactory.
25		Right	180.0	6 hrs.	Dike forced water out over right weir then around over left weir across trashrack. Water enters roller gates from directly in front considerable silt outside of trash-rack in front of sluiceway and very little inside of trashrack. Left weir was not as effective as when flow was from right. Sluicing operation gave favorable results. Sights effective in sluicing. General results fairly satisfactory.

ALL-AMERICAN CANAL HEADWORKS

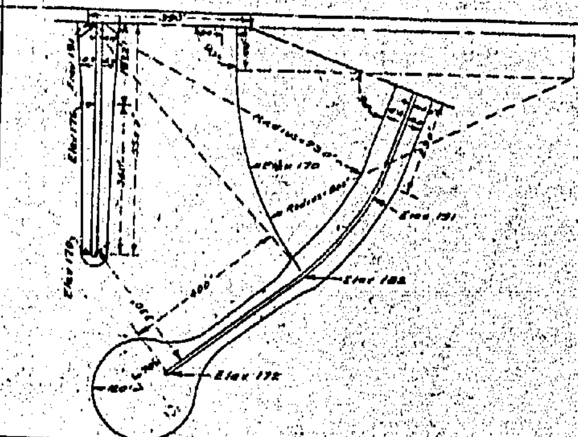
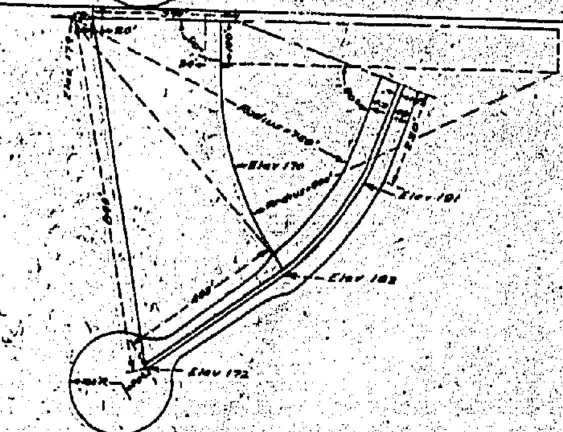
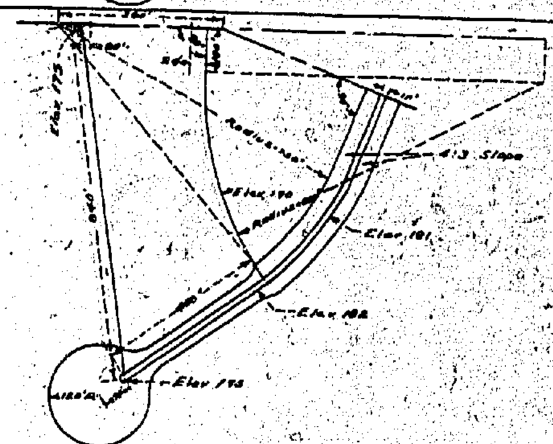
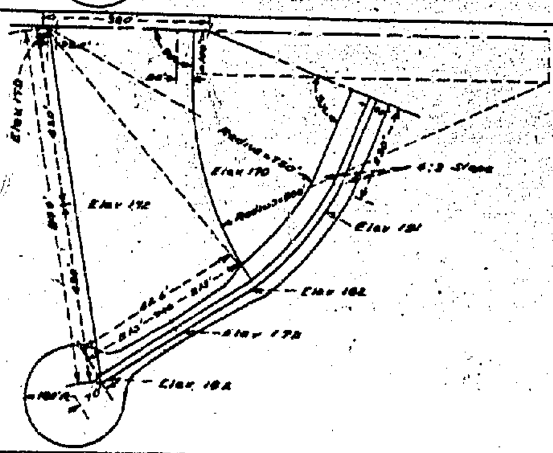
SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40
River Discharge - 24,000 Second-feet - Headworks 10,000 - Sluiceway 14,000

Layout Number	Drawing	Position of River	W.S. Elev. Along Face of Dam	Length of Run	Results and Conclusions
26		Right	181	3 hrs.	Flow conditions through trash-rack and approaching roller gates good. Good standing wave over right weir. Flow well spread and much of it forced around in front of sluices. Bar formed well away from sluiceway and intakes. Sluicing operation satisfactory. This layout appears satisfactory, with the river in this position but a longer run should be made.
27		Right	181.0	6 hrs.	Flow conditions through trash-rack and approach to roller gates fair. Current around end of right weir and into sluiceway over left weir. Standing wave over approximately 200 feet of left weir beyond end of stub dike. Considerable silt bar in front of sluiceway and a small bar inside of trash-rack near dike. Clear area inside of both weirs. Results not entirely satisfactory.
28		Right	181.5	6 hrs.	Flow conditions through trash-rack and entrance to roller gates fair. Flow over right weir divides, one current approaches sluiceway and the other flows in arc over left weir and returns to sluiceway around nose of stub dike on left. A silt bar formed in front of the sluiceway to approximate elevation 182 and a large bar formed inside of the trashrack. Some silt was carried into the inlet channels below the roller gates. A fair channel was maintained along a short portion of the left weir near the stub dike. The sluice period was very effective. Results not satisfactory.
29		Right	181.0	6 hrs.	Flow conditions through trash-rack and entrance to roller gates very good. All of trashrack effective and no drop in head around blocked-off section. Only part of right weir effective. The silt bar deposited in front of the sluiceway was very loose, but extended through the trashrack and was above 180. No silt in channels below roller gates. Open area inside of trashrack near dike. Results should be satisfactory with minor changes.

ALL-AMERICAN CANAL HEADWORKS

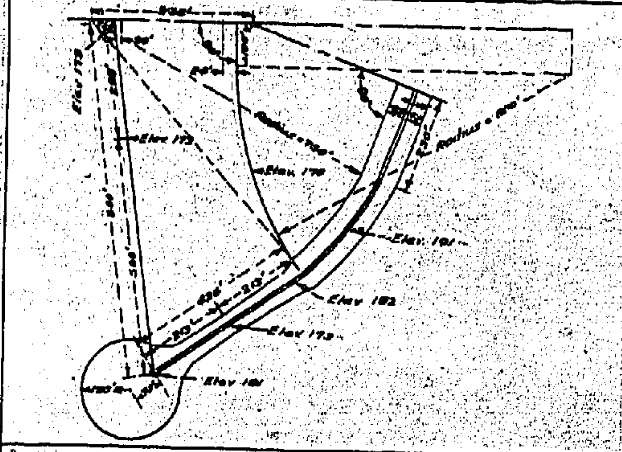
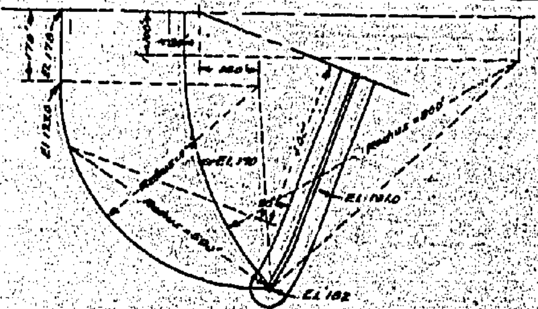
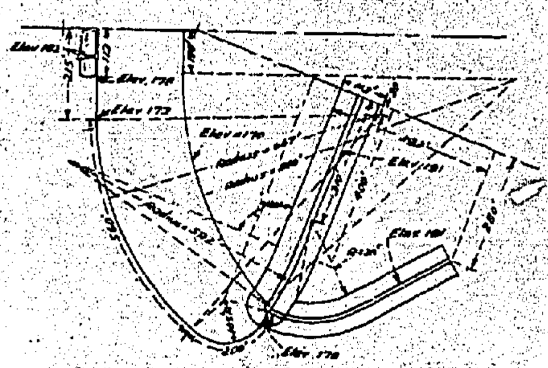
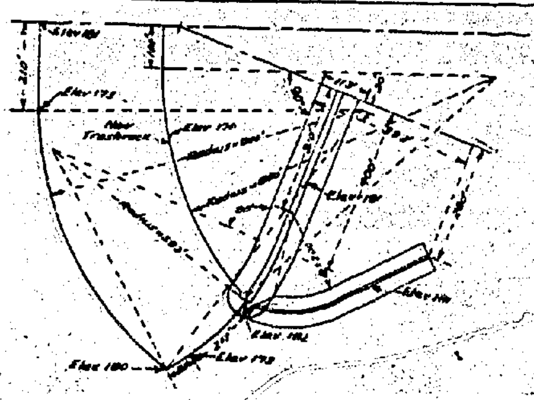
SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40

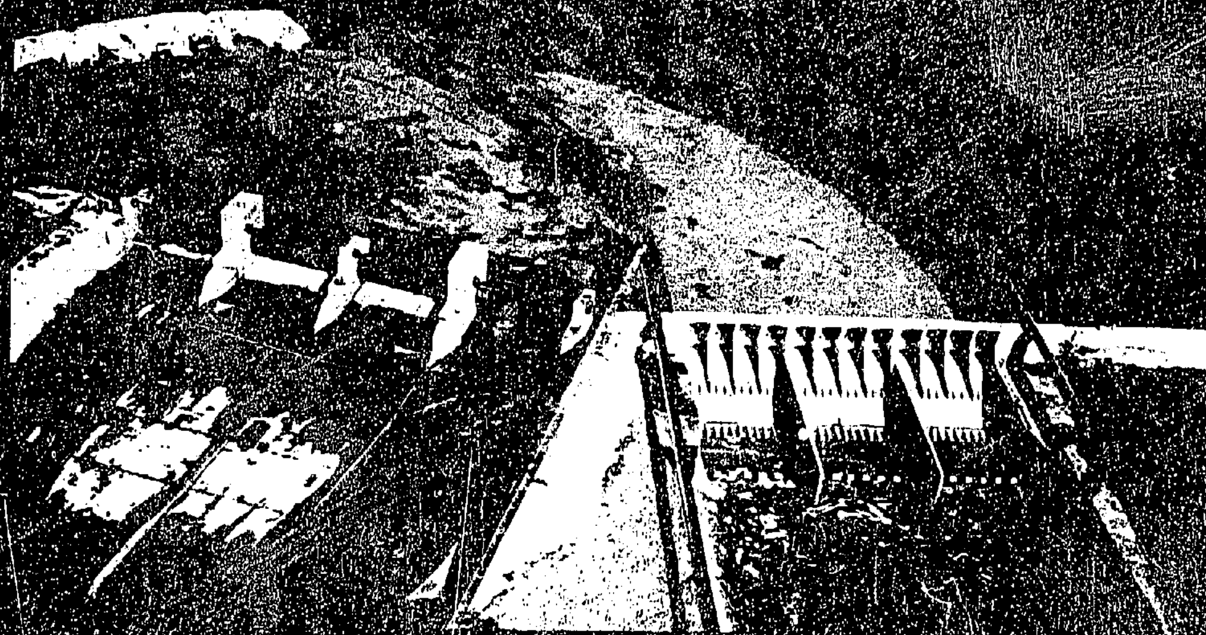
River Discharge - 24,000 Second-Feet - Headworks 10,000 - Sluiceway 14,000

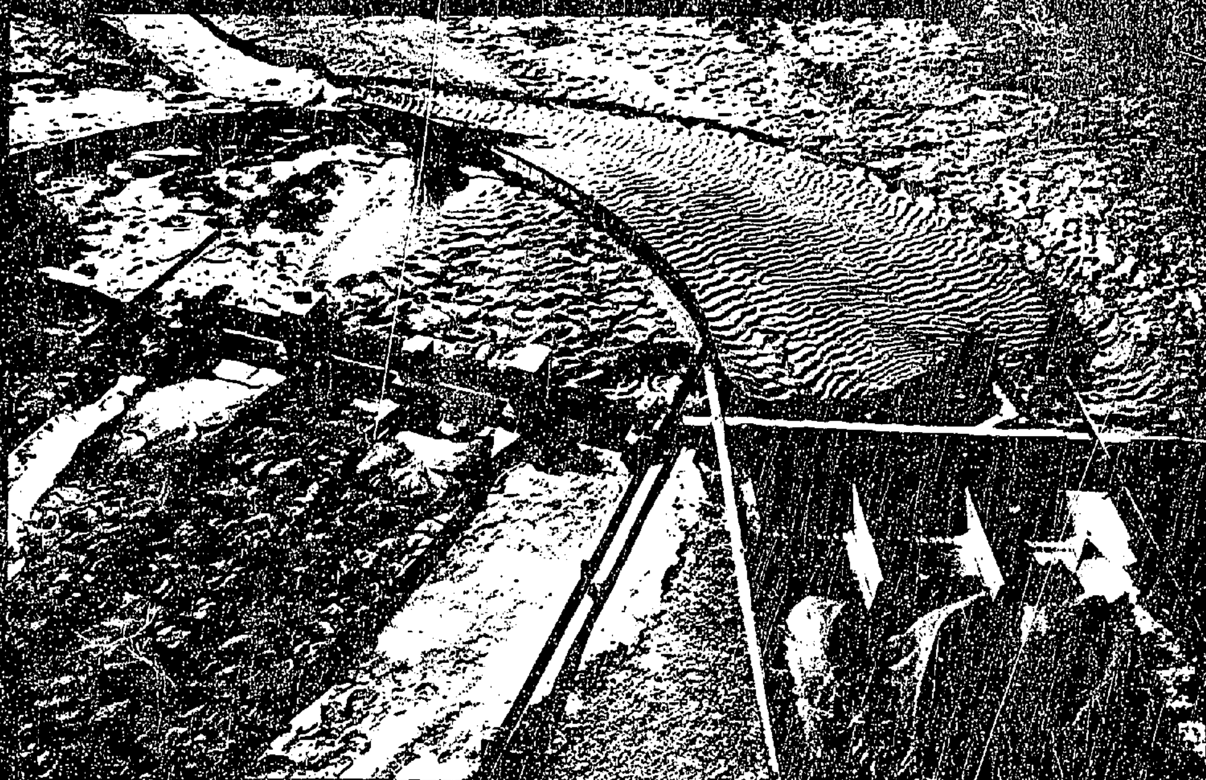
Layout Number	Drawing	Position of River	W.S. Elev. Along Face of Dam	Length of Run	Results and Conclusions
30		Right Left Center	180.5 182.5 182.5	6 hrs. 6 hrs. 4 hrs.	1. Even distribution of flow over right weir. Good drop in head over this weir and around nose of dike, causing bar to form at considerable distance from it. Left weir effective. No silt inside of trashrack or in channels below roller gates. Channel along left weir and along trashrack around bar to sluiceway. 2. Even flow from trashrack to roller gates. Slight whirl near left stub dike. Channel along left weir. Major portion of silt bar some distance from sluiceway. No silt inside of trashrack or in channels below roller gates. 3. River spread from right dike to approximate mid-point of dam. Current around end of stub dike spreading fan-like across front of sluiceway. Slightly higher velocity near sluice than through remainder of trashrack. Good approach to roller gates. Whirl in front of sluices back of stub dike. Solid bar from river extending through trashrack to roller gates. Channel around end of stub dike extending diagonally to right side of sluiceway behind stub dike. Sluicing period satisfactory for 1 and 2 but unsatisfactory for 3. Results satisfactory for 1 and 2 but unsatisfactory for 3.
31		Center	181.5	4 hrs.	Uniform flow through trashrack except for slight current near and next to sluiceway. Current approaching non-overflow section between sluiceway and intakes slightly to the left of a line normal to the axis of the intakes and another current swung around to the left and passed over the left weir approximately half of left weir forming channel along weir. Out ends of both weirs buried after run. Area between left weir and trashrack contained heavy bar. About one third of area between trashrack and roller gates covered by bar. Some silt in channels below roller gates. No sluicing period. Results unsatisfactory.
32		Center	181.5	6 hrs.	Flow well spread across entire front of sluiceway and intakes. Some flow along face of dam and into sluice. Good distribution of flow through trashrack. Standing wave over approximately 175-feet of left weir. Area inside of trashrack badly silted. Open area from pier 4 to rock dike extending 250 feet upstream to dike. Right channel free of silt. Some silt in two center channels. Some silt in two center channels. High bar in front of roller gate No. 1 and back of blanked-off trashrack. Channel along left weir extending approximately 250 feet upstream from sluiceway. Sluicing period satisfactory. Results unsatisfactory.
33		Center	183	2½ hrs.	Concentration of flow through right end of trashrack causing poor entrance to roller gates. Current across left weir at low point. Out ends of both weirs above water. Good standing wave over left weir from dam to a point about 300 feet from dam. Open area in front of blanked-off sluiceway to diagonal line from end of blanked-off trashrack to low point in left weir. Some silt inside of trashrack and in left center channel below roller gates. Channel from low point in weir to end of rock dike. Bar elevation approximately 176. Sluicing period not satisfactory. Results unsatisfactory.

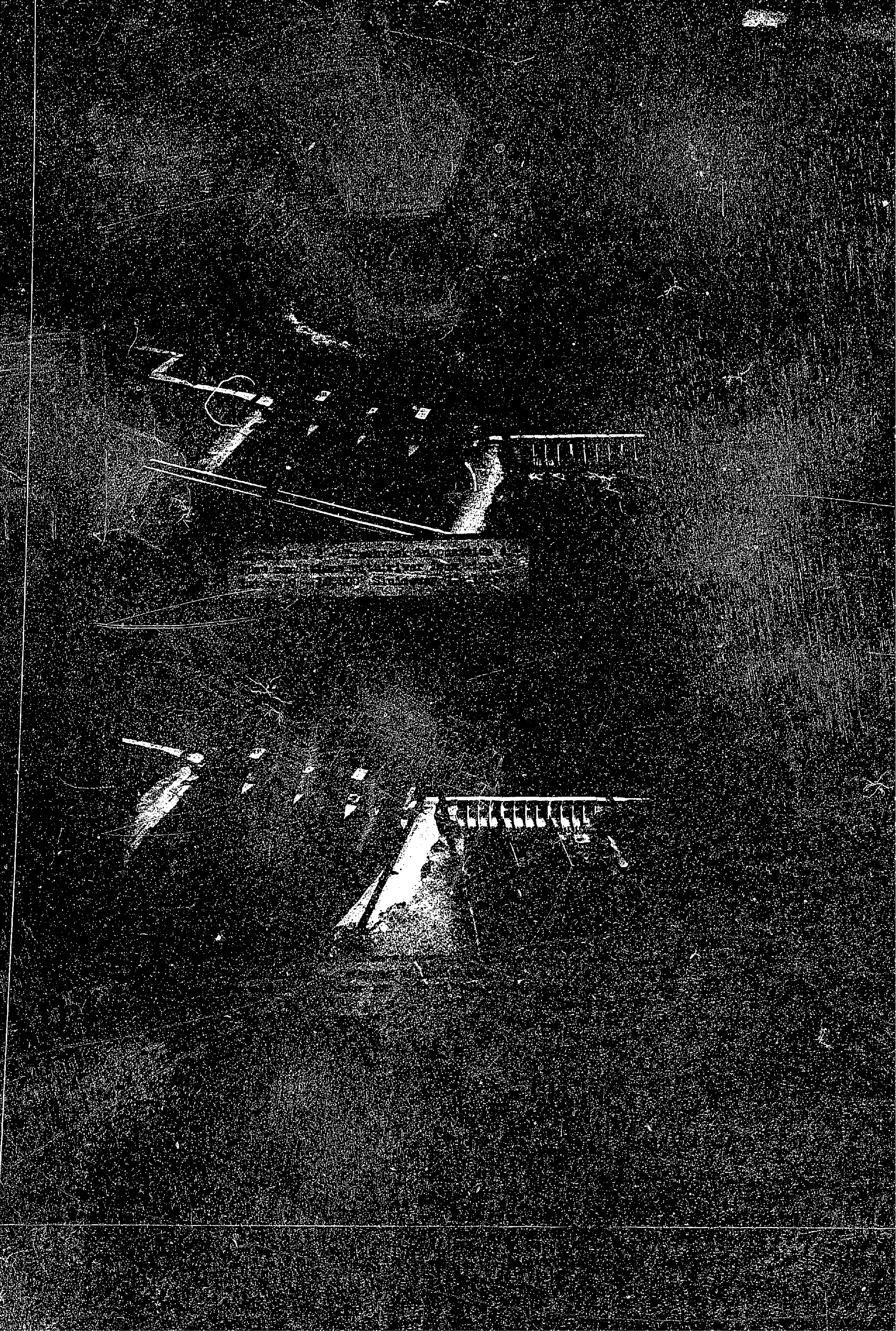
ALL-AMERICAN CANAL HEADWORKS

SUMMARY OF LAYOUTS FOR INTAKE WORKS - MODEL SCALE RATIO 1:40
River Discharge - 24,000 Second-Feet - Headworks 10,000 - Sluiceway 14,000

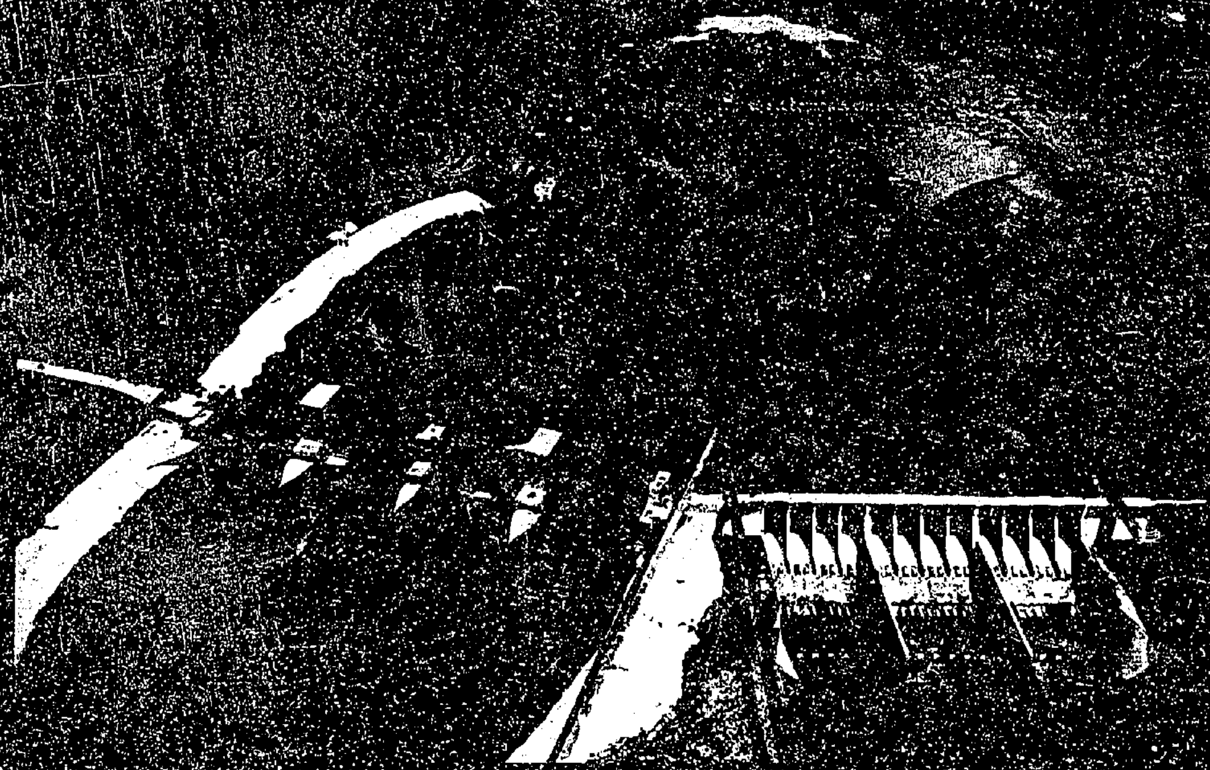
Layout Number	Drawing	Position of River	U.S. Elev. Along Face of Dam	Length of Run	Results and Conclusions
34		Center Left Right	179.5 181.5 182.0	4 hrs. 5 hrs. 5½ hrs.	1. Flow through trashrack and entrance to roller gates good. Flow divides at junction of straight weirs, approximately 1/3 of flow to right and remainder to left. Silt bar close to sluiceway. Some silt inside of trashrack. Channel along left weir from sluiceway to low point in weir. Small clear space below right weir downstream from low point. 2. Flow through trashrack and entrance to roller gates good. Upstream end of left weir above water but remainder was very effective. Silt bar not as large as with flow from center. Some silt inside of trashrack and inside channels below roller gates. 3. Flow through trashrack and approach to intake good. Left weir effective for 200 feet upstream from sluiceway. Right weir effective for 200 feet upstream from nose of dike. Large silt bar in front of sluiceway and considerable silt inside of trashrack but very little in channels below roller gates. Sluicing period satisfactory for all three runs. Results generally satisfactory.
35		Right	183	6 hrs.	Flow conditions thru trashrack and to roller gates fair. End of right weir next to dike effective for a distance of 120 feet from nose of dike. Flow is mostly outside of weir and approaches sluiceway over 200 feet of left weir next to dam. Large silt bar formed in front of sluiceway and considerable bar inside of trashrack. Sluicing period only partially effective. Results unsatisfactory.
36		Left Right	181 181	6 hrs. 6 hrs.	1. Flow through trashrack and entrance to roller gates good. Left portion of weir very effective. After the run there was no silt inside of the trashrack or in the channels below the roller gates and only a very small amount inside of the weir. No sluicing period. Results very good for this position of river. 2. Flow through trashrack and entrance to roller gates fair. Current around nose of dike and along right portion of weir. Standing wave over right section of weir and over extreme left end. After run there was some silt inside of the trashrack and some in the inlet channels below the roller gates. A large bar formed in the channel between the trashrack and weir. If trashrack had not been so fine probably more silt would have entered it and approached the roller gates. Results unsatisfactory for this position of river.
37		Right	181	4 hrs.	Flow through trashrack and entrance to roller gates fair. Weir action satisfactory. Large silt bar deposited outside of trashrack but did not extend thru trashrack. The finer trashrack installed for this test became partially clogged and probably obstructed the advance of the silt bar. Sluicing period only partially effective. Results not entirely satisfactory.

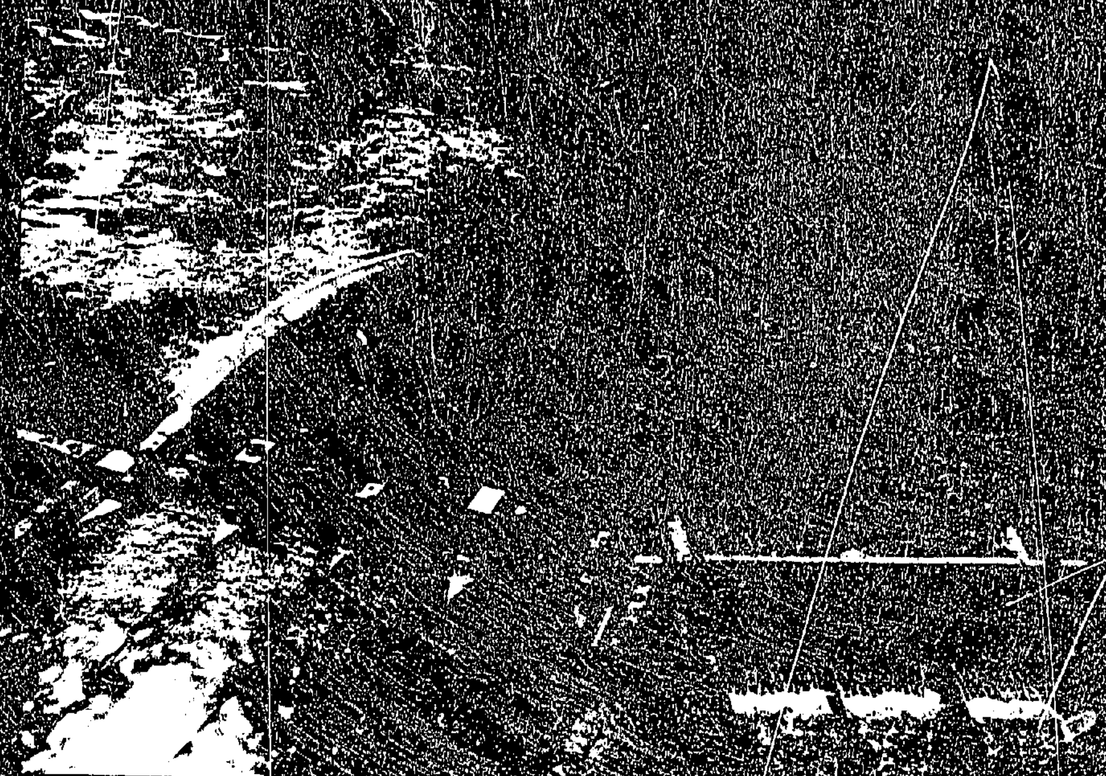






Flow conditions [illegible]
[illegible]

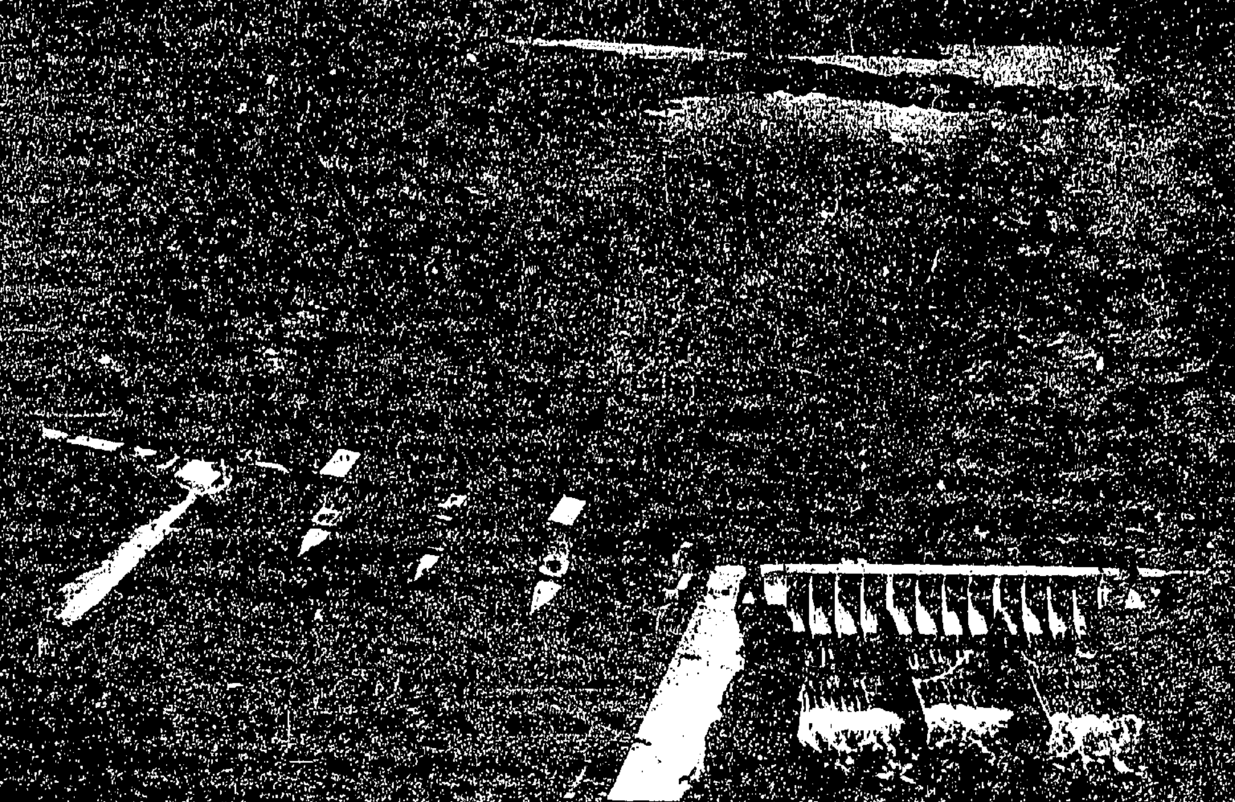




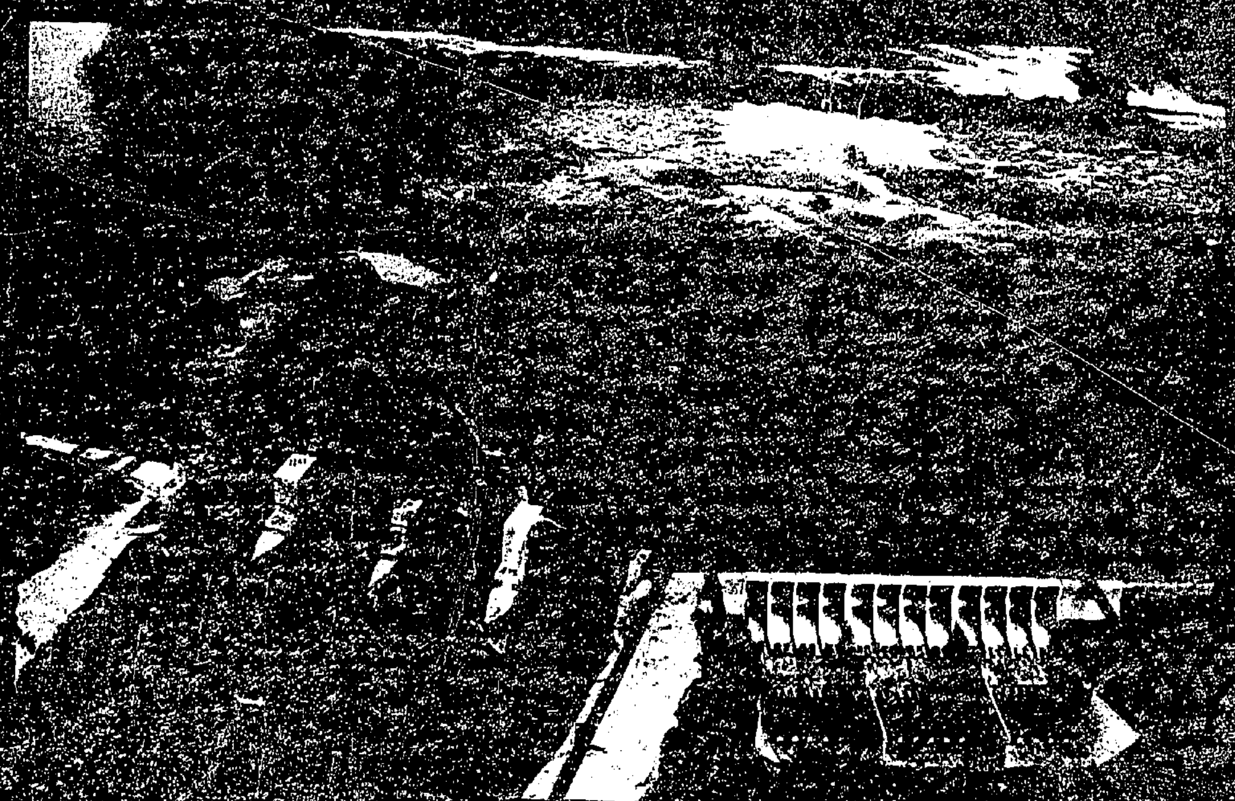
Layout No. 12 - Flow conditions with [illegible]
Intake Q - 10,000 [illegible]

Layout No. 12 - Silt [illegible]
[illegible]

Layout No. 19 - Flow conditions
Intake 4 - 10 cfs



[illegible] conditions with [illegible]




Layout No. 30 -
Intake