Please read and send in as full a discussion as possible at earliest date.

Canadian Society of Civil Engineers.

INCORPORATED 1887.

ADVANCE PROOF—(*Subject to revision*).

N.B.—This Society, as a body, does not hold itself responsible for the statements and opinions advanced in any of its publications.

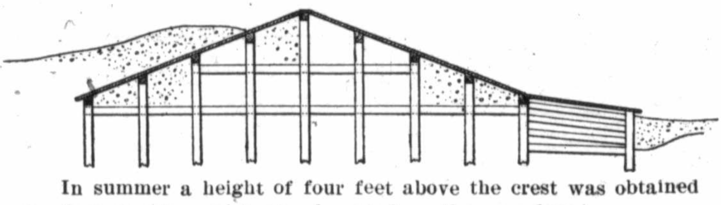
DESCRIPTION OF A DAM AND ACCOMPANYING WORKS BUILT FOR THE WATER COMMISSIONERS, LONDON, ONT., AT SPRINGBANK.

By J. A. Heaman, S. Can. Soc. C.E.

To be read April 24th, 1902.

The following description and accompanying drawings show the nature of the works built for the Water Commissioners, London, Ont., under the superintendence of John M. Moore, Esq., Engineer of the Commission. These consist of a concrete dam, retaining walls, etc., which are part of the power plant of the London Waterworks located at Springbank, about five miles below the city on the Thames River. Mr. John Kennedy, Engineer of the Montreal Harbour Commission, was the consulting engineer on this work.

The dam, which the new structure replaces, was a timber one, a sketch of the section of which is shown. On the general plan, also, is shown in broken lines a plan of the dam after failure. It was built when the Water-works were constructed in 1878, and was a crib work and pile structure which needed constant care and repair to keep safe and water-tight.



In summer a height of four feet above the crest was obtained by flash boards, which are also used on the new dam.

The Thames River, at the City of London, is formed by the junction of two branches, and, about a mile below the city, there occurs a sharp bend in the river. The Grand Trunk Railway crosses at this point, and the bed is further contracted by the piers and abutments of the bridge. The river originally, until straightened by the Railway Company on building this bridge, followed a wide valley in a devious course, and this had the effect of allowing it to find relief during freshets. Now, however, during heavy freshets, the water rises to such a level as to flood a considerable portion of the suburb of London West. This is further accentuated by the ice in spring forming a jamb at the bridge, which it has frequently been found necessary to relieve by blasting.

The annual ice jamb and the flooding of London West, which has, by many people, been attributed, unjustly, to the Water-works dam, nevertheless caused the Engineer to provide the large relief gates shown, so as to relieve the new structure, if possible, from any suspicion of being the cause of the flooding.

By means of flash boards the water can be raised to a height of four feet above the crest of the dam, and this is done when the condition of the river is such that this increased head will not back the water so as to damage property above the dam.

These flashboards were a feature of the old dam, and, as applied to the new structure, their design is very similar to that which proved efficient in the old. They are erected from a scow, which is floated from side to side along the crest of the dam. Two men are sufficient for the actual work of erection, which is as follows: The standard is hooked into an eye in the steel plate protecting the crest and then lifted towards a vertical position until the brace bar, which is also attached by hook and eye, will engage with it. The lowest board is then locked into position by a couple of two and a half inch nails, and this procedure is continued right across the dam if the water is low, and the other boards attached as it rises. It is possible to attach the standards and flashboards with nine inches of water going over the crest. The stop logs can be used to bring the water to a suitable level for erecting. The standards for the flashboards are spaced six feet centre to centre.

The cause of the failure of the old dam is ascribed by Mr. Moore to the ice from the jamb coming down the river in large pieces (some being as great as nine feet square) when the water was not sufficiently high to carry it clear of the dam, but allowed it to strike with the force given it by the current. These gradually smashed or loosened the planking of the crib or apron, and the filling then washed out, after which the piles were, one by one, either broken or washed away. The section which failed is indicated on drawings.

This danger from the ice in spring necessitated the dam being of the heavy section shown by the drawings. It will also be noticed that it was thought necessary to protect the crest with steel boiler plate, a quarter inch thick, extending right across the dam and anchored to it.

Besides the dam proper, the contract included two concrete retaining walls and a concrete arched flumeway, so that all the river works are now of a permanent character.

In removing the old dam the timbers were found to be in a splendid condition where under water, but the tops of the piles and the timbers above were considerably decayed.

The bed of the river on which the dam is constructed is a clay hard pan, which gave a good foundation in which there was no danger of failure, except in one place where a vein of fine loose gravel was found, as shown on drawings. Excavation only discovered increasing instability, and it was decided to consolidate it by pounding concrete dry into the wet gravel. This seemed to effect its purpose, and the superstructure was built on this bed. The gravel filling, both in front and rear of dam, was very carefully made at these points. The back filling seemed to compact in such a way as would not be possible with any water working through, and two seasons have justified the conclusion that the dam is water-tight.

The dam is built in sections about fifty feet long, the joints being made of sheet iron covered with a coating of sand and pitch to prevent the concrete forming a perfect junction. The object of this was to allow for any expansion on contraction without cracking.

The centre pier in the dam was built by the Commissioners on the advice of the Engineer, who contemplates the building, at some future date, of a bridge across the river on the substructure thus formed by the piers and abutments of the dam.

In the work two kinds of concrete were specified, namely: First and second class concrete. First class was used where concrete would be exposed to the action of water or the weather, and second class for foundations. The components of the concretes were as follows:—

FIRST CLASS CONCRETE.

One part Portland cement.
Three parts sand.
Four parts screened gravel.
Two parts broken stone.

SECOND CLASS CONCRETE.

One part Portland cement.
Three parts sand.
Five parts screened gravel.
Three parts broken stone.

The regulations for mixing and placing were precise. Concrete was not dumped from a height, but was lowered in buckets so as not to allow particles of mixture to become separated after mixing. It was deposited in layers nine inches deep and rammed with a fifteen pound rammer and at the same time prodded with a pointed bar so as to consolidate the mass. These operations were continued until moisture and cement appeared on top.

In second class concrete, stones, averaging nine inches diameter, were set in the concrete by hand, sufficient room being left between them to allow concrete to fill all vacancies, and particular care was taken in ramming it around them.

The method of mixing adopted was as follows: The sand and cement were measured out on a large platform and thoroughly mixed dry by being turned at least twice over with shovels. The corresponding quantities of broken stone and gravel were also measured out and mixed with the above. Then the whole was thrown by shovellers into a "gravity mixer," the water being supplied at the top of the mixer and controlled by a man operating it. The mixer is a steel box, of about fifteen inches by eighteen inches section, crossed by staggered bars, which seemed to rather intimately mix the mass in its descent.

No number of layers whose total depth would exceed twenty-four inches were allowed to be laid in one day unless for some special cause, and at least twenty-four hours were allowed to elapse before a succeeding layer was laid. No thin edges, to bring work up to the proper section, were allowed, and all layers were carried through the section so that each might be consolidated within itself before permanent setting took place.

The specifications for Portland cement were modelled on those of the Canadian Society of Civil Engineers.

The figures given below, although not up to the standard specified, may be taken as a sample of the results of the tests on one of the brands of cement used on the work.

TEST OF BEAVER CEMENT (NEAT).

Aug. 13.—Twenty-four hours in air six days in water.
1st. briquette broke at 434 lbs. per square inch.
2nd. briquette broke at 423 lbs. per square inch.
3rd. briquette broke at 436 lbs. per square inch.
4th. briquette broke at 438 lbs. per square inch.
5th. briquette broke at 334 lbs. per square inch.
Average 413 lbs. per square inch.

Fineness.—The residue on a 100 mesh seive from a 10 oz. specimen was ½ oz.; on a 70 mesh seive was practically nothing. The sand employed was clean, sharp pit sand free from clay or loam. Gravel was all screened, and any sand, loam or stones larger than two inch diameter removed. The broken stone was broken so as to pass through a two inch diameter ring, and was screened in order to be free from dust and small stone particles. By these means it was always certain that a definite amount of binding material was in the concrete, that there should be no excess of sand, and what there was should be of good quality. Precautions also were taken to sort stone and gravel so as to have as nearly as possible equal amounts of different sizes in each batch.

The top of dam was formed to section shown in drawings, the outer nine inches being put on in sections at one loging. Extra care was taken in loging and pounding this portion. The face was afterwards steel trowelled to a smooth surface.

Piers and abutments were built as shown, being formed in moulds of two inch matched and dressed plank, dressed side being painted and placed inside against concrete. The moulds were removed as soon as concrete had set sufficiently to allow it, and the face was then floated with steel trowels before permanent setting had taken place. Moulds were firmly kept in place by bolts and anchors. The holes left by these, and also any soft spots showing, were carefully raked out and filled with cement mortar before floating.

In front of the dam a filling of fine gravel and stone was put in. This was thoroughly pounded and rammed as placed in position, being so consolidated as to be watertight.

Below the dam a timber apron was constructed of round timber, green pine and elm being used for this purpose. The logs were framed, notched and gained together, drift bolted at all intersections and through bolted at ends of timbers, with three-quarter inch diameter bolts. Timbers running across stream were not less than twenty-four feet long, and were laid so as to break joint. The other timbers were in one length, and drift bolts of three-quarter inch square iron were driven through three timbers on every course. The last row of sleepers or covering sills were flattened to grade lines to receive planking.

On the lowest, or mud sills, which were bedded in well pounded gravel, was a floor of logs spaced about nine inches apart, and on these timbers and between them was a bed of fine gravel pounded and rammed so as to be water-tight. On this floor was built the crib work specified above, which was filled with large stones bonded together and filled in with gravel. When the crib work was brought up to the required grade two thicknesses of two inch rock elm plank was laid on it, being twice nailed to each bearing with heavy spikes through holes bored in plank to avoid splitting. The upper planking was in one length and the lower course was laid with joints broken. A heading piece was placed along head of planking to form a finishing joint with concrete of dam.

Below the apron a filling of stone, hand placed and bonded, was put in, as shown.

This apron was designed to carry water some distance from the dam before any scouring action, due to eddies, could take place, and the foot of it was again protected by the rip rap of stone. The section of the dam also is such as to bring the water down to the apron with a motion nearly parallel to its surface.

In ordinary levels the water on the lower side of the dam will act as a cushion for the flow and at least partially relieve the apron.

Owing to the proximity of the tracks of the London Street Railway to the works, and the right, possessed by the Water Commissioners, of having their supplies switched from the Grand Trunk Railway over the electric road to Springbank, it was possible for the contractor to import his coal, cement, etc., in car load lots right to the dam and thus save transhipment.

Sand, gravel and stone boulders, suitable for breaking, were all found on the property of the Water Commissioners, and the contractor was allowed to use this material under the direction of the Engineer.

The above circumstances make it possible to build a concrete construction at a minimum cost, and this, of course, was a large factor with the Engineer in working out his plans.

Bids for the work were asked for in bulk, but contractors were also required to state prices per section. The accepted tender was as follows:—

Section I.—North abutment, sluiceway and piers..	$ 8,132 00
Section II.—Dam and timber apron..	23,913 00
Section III.—South pier, flumeway and retaining wall east of Pump House..	7,305 00
Section IV.—Retaining wall west of Pump House..	4,470 00

A total of $44,050.00 for the whole contract.

This price was supposed to be on a basis of $5.50 per cubic yard for first class concrete and $5 per cubic yard for second class concrete, and extras and reductions were allowed for at these prices.

An estimate of the quantity of concrete in the various sections is as follows:—

Section I.—1st Class, 819½ cubic yards; 2nd Class, 469 cubic yards.

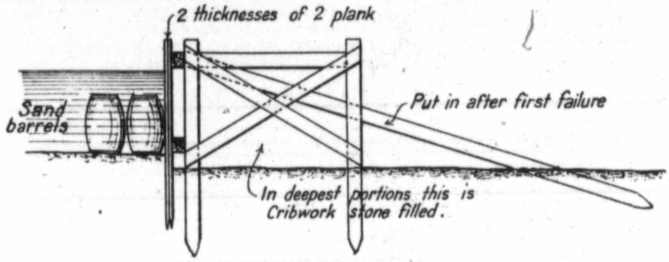
Section II.—1st Class, 794 cubic yards; 2nd Class, 2,136 cubic yards.

Section III.—1st Class, 1,178 cubic yards.

Section IV.—1st Class, 750 cubic yards.

Total:—1st Class, 3,541½ cubic yards; 2nd Class, 2,605 cubic yards.

During the construction, although the season was a favourable one for operations on the Thames River, the contractor suffered considerable loss by repeated failures of his coffer dams and temporary works. The coffer dam was built of a section similar to that shown in sketch, and the piles and sheet piling were nearly all driven by a heavy maul operated by hand. The inadequacy of this construction was frequently shown by a portion of the dam washing away, and the loss in labour, pumping, material, etc., thus entailed was considerable, to say nothing of the delay to the progress of the work.



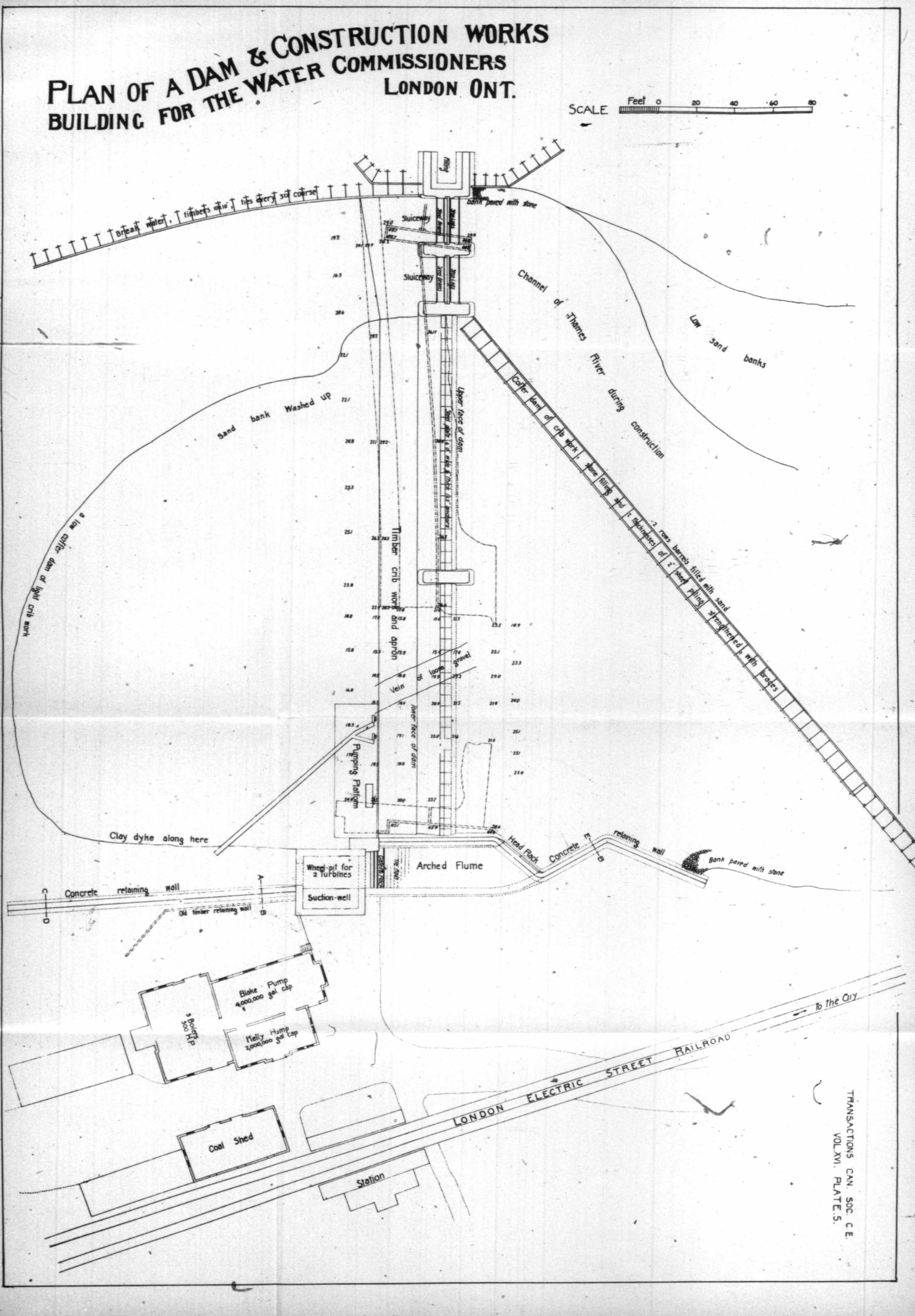
Shortly before one failure a head of five feet was observed, and with this it seemed on the point of failing along the whole length until relieved by the collapse of a thirty foot section.

The sectional drawings accompanying this description were made from the contract plans with the addition of the alterations that were made during the progress of the work. The general plan was made partly from survey during the construction and partly from existing plans and working drawings.

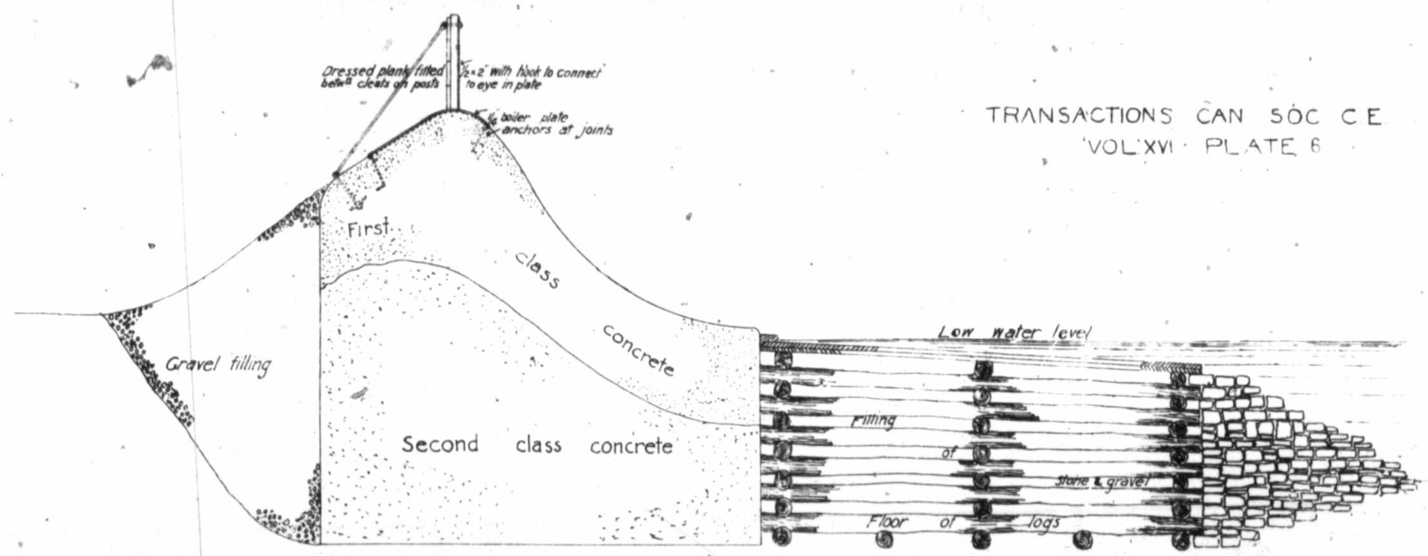
Elevations of bed of river and foundations are given above datum in all cases.

TRANSACTIONS CAN. SOC. C.E.
VOL.XVI. PLATE.5.

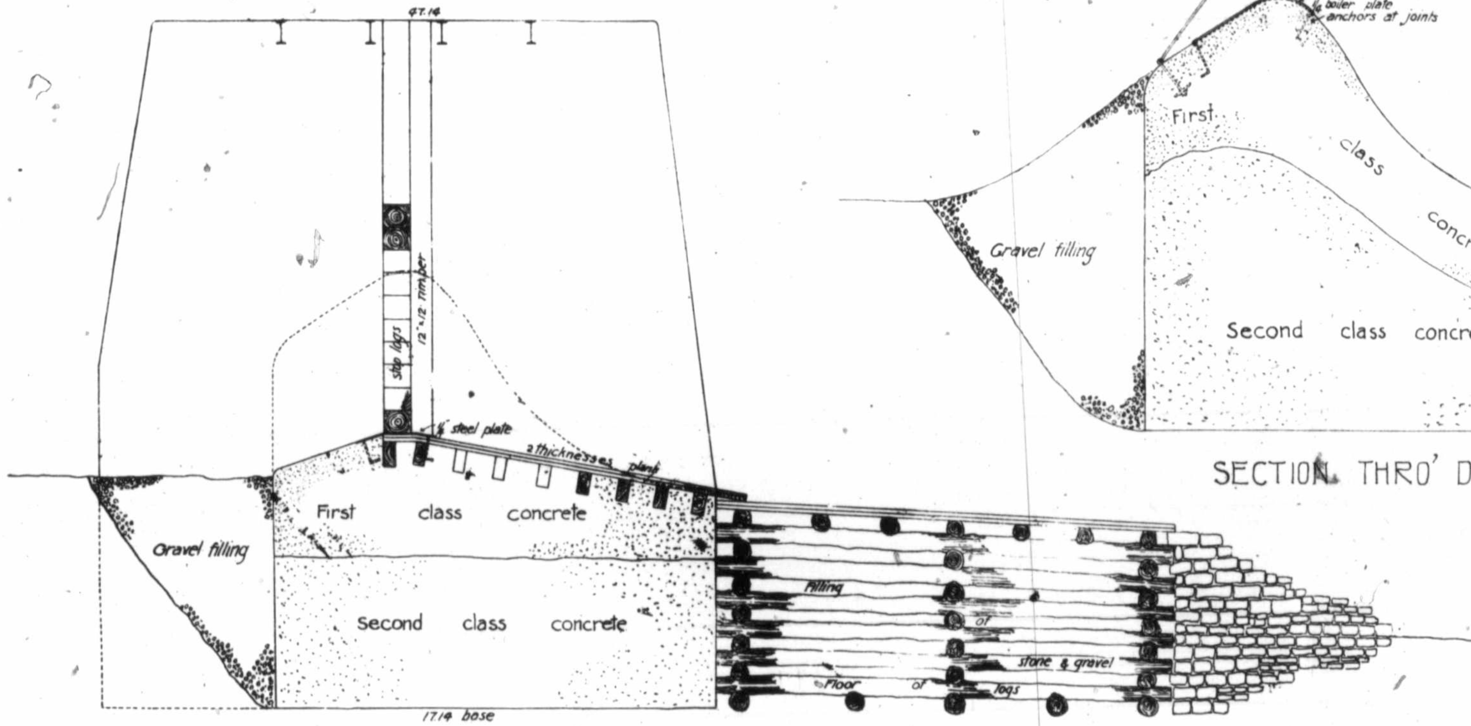
PLAN OF A DAM & CONSTRUCTION WORKS BUILDING FOR THE WATER COMMISSIONERS LONDON ONT.



TRANSACTIONS CAN SOC C E
VOL XVI PLATE 6



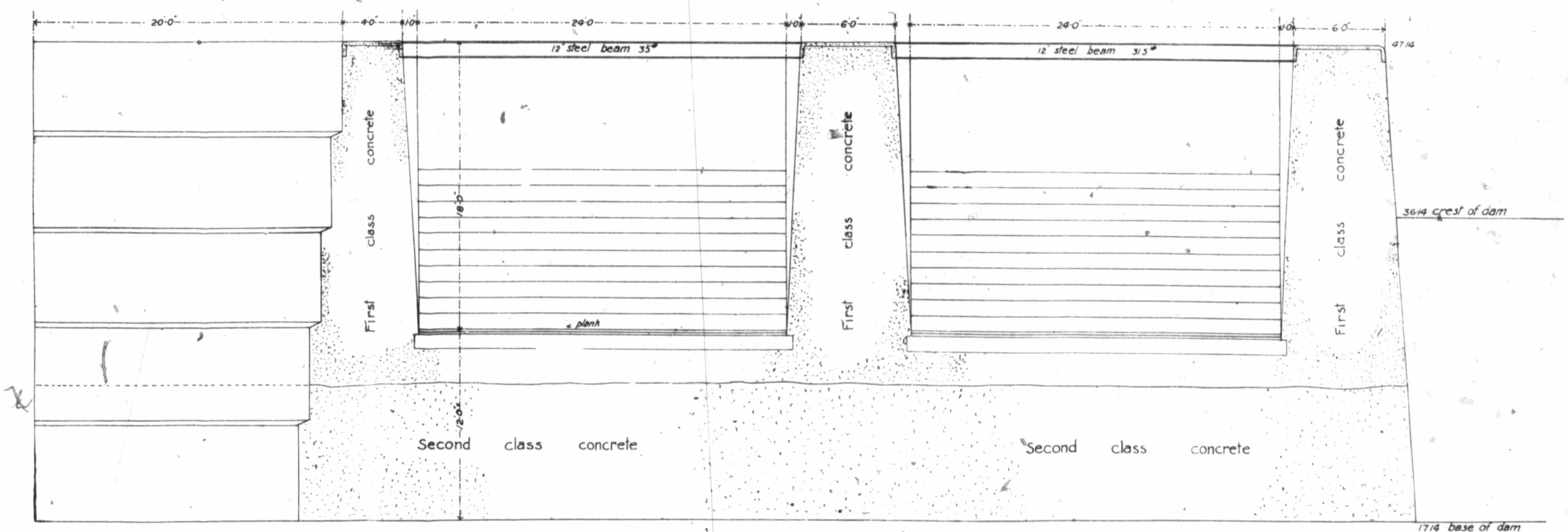
SECTION THRO' DAM



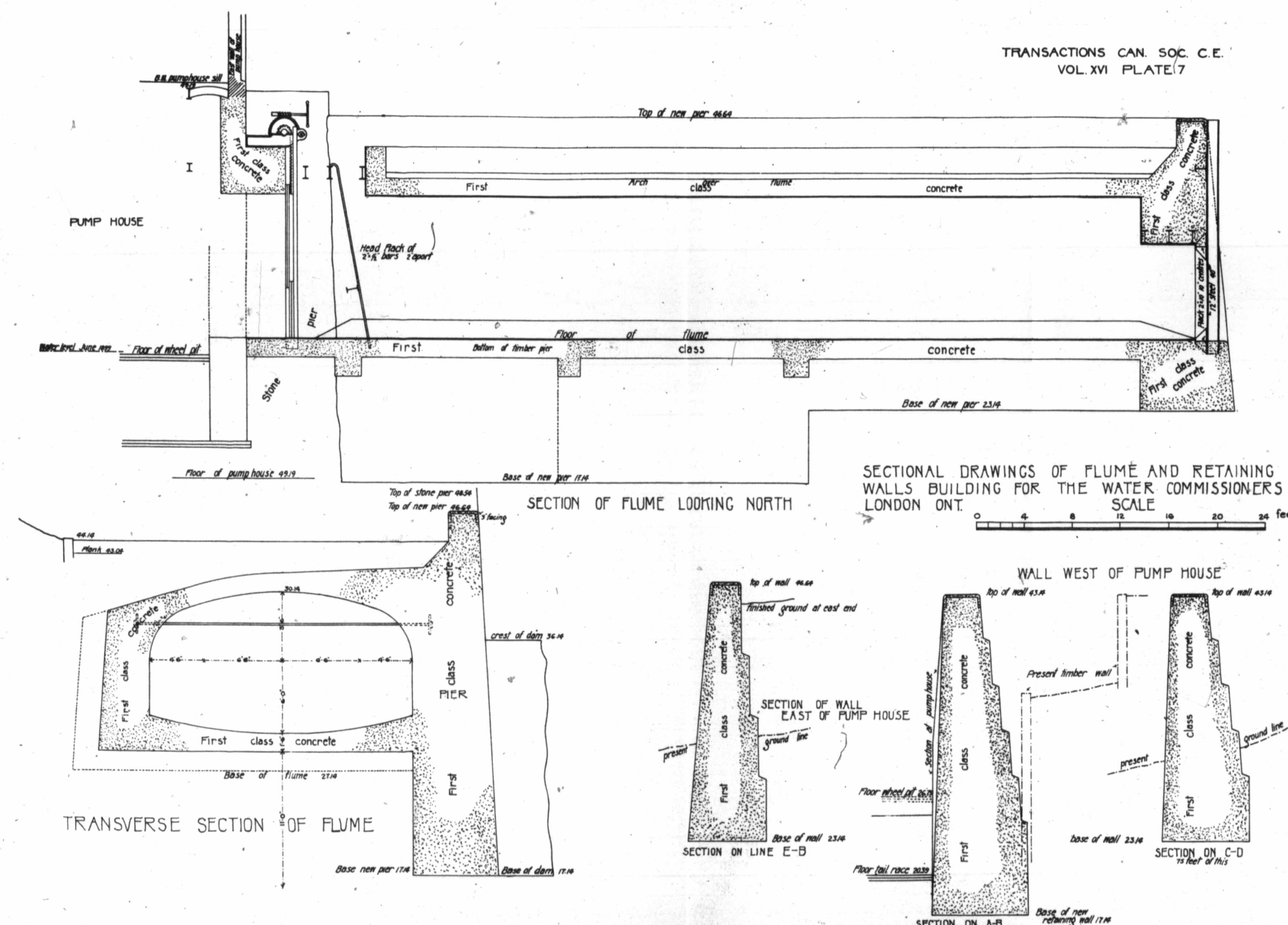
TRANSVERSE SECTION THRO' SLUICEWAY

SECTIONAL DRAWINGS OF DAM AND SLUICEWAY
BUILDING FOR THE WATER COMMISSIONERS
LONDON ONT.

0 4 8 12 16 20 24 feet



SECTION THRO' SLUICEWAY, PIERS AND ABUTMENT



SECTIONAL DRAWINGS OF FLUME AND RETAINING WALLS BUILDING FOR THE WATER COMMISSIONERS LONDON ONT.