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LIAO RIVER UNDER INTERNATIONAL ORGANIZATION

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Synopsis.

This paper is a sequel to the author's three previous articles on the same subject dealing with the general feature of the scheme and details of construction. In the following are given: (1) Progress of works under way, (2) Works to be taken in hand, (3) Depletion of water source and its remedies, (4) Investigation of silt contents in Liao water and comparison with foreign rivers of similar nature, (5) Several surveys, (6) Summer flood studies, (7) First trial of flexible ferro-concrete mattress.

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Since the appearing of the auther's three articles concerning the same subject particularly with regard to the general outline of the scheme with the details of construction works and their specifications in this journal, certain progress in actual jobs has been made and the auther now thinks to make public a part of his Annual Report for 1926 wherein what is being done under his charge as the Engineer-in-Chief of the Upper Liao River Conservancy and to what extent is stated together with several proposals and suggestions under the following categories:—

(1) Works under direct management. (2) Works under contract. (3) Works to be taken in hand. (4) Silt analysis. (5) Survey. (6) Summer flood and (7) Schedule of inspection of the works.

(1) WORKS UNDER DIRECT MANAGEMENT.

i. Bank protection work at the head of diversion channel at Erh-tao-chiao.

While the present contractors are delaying to complete the works it was found that the riparian land provided with an ample margin of safety on the right bank of the Shuang-tai-tzu channel at the head of diversion channel at Erh-tao-chiao has been caved and lost away to a remarkable extent due to the flanking and natural scouring action of the strong river current and that the protection work against further caving is of urgent necessity in order to prevent (1) the probable sudden escaping or splitting of the said channel which might become a fatal blow to the present scheme, (2) any further loss of the Conservancy's land purchased from the private owners and also (3) a gradual deterioration of the proper alignment of the general course in the vicinity of the transition point where the diversion channel is joined to the present Shuang-tai-tzu channel. Such being the case immediate step was taken to commence the bank protection work in question as the direct work of the Engineer-in-Chief who started the actual job early in September soon after the partial arrival at the site of the building materials such as cement, broken stone, steel wires, ropes, scaffold lumbers etc. and also of the equipments and implements necessary for the fabrication of reinforced concrete blocks which are to compose the main body of the bank protection mattress and he completed in hurry the bank protection work for the portion of channel where the natural

caving action is most severe to the extent of 500 ft. along the river bank within 77 days since the commencement of the job, independently of the contractor's delay, although the remaining portion 1 000 ft. long which is to be carried out in co-ordination with a short length of the bank protection work under the present contract and must wait till the contractors are about to complete their works. The expense, estimated at M.$ 46 007, for completing the bank protection work in question for the entire length of 1 500 ft. is to be covered by the refunding made from the Lower Conservancy. The said estimate of the undertaking is about 30 % cheaper than when done by the present contractors and if paid for on the basis of the unit prices under the present contract.

Flexible ferro-concrete mattress adopted for bank protection.

The type of constructions which we call the flexible ferro-concrete mattress with underlining of fascine mat is the main feature of the pending bank protection work being the first trial in the Liao River. Previous to laying the said mattress the natural river bank was cut to a slope of 1 vertical to 2 horizontal (viz. what we call 1:2 slope) with a flat berm 35 ft. wide formed at the level of low water (108 ft. Ying-kou datum) and at the foot of the said slope to provide for receiving entire width of 60 ft. of the concrete mattress to be laid on thus newly dressed portion of the bank. The continuous fascine mat 4 inches thick was prepared and laid on the slope and berm dressed as above stated, this being the lining of the concrete mattress. The fascine mat being ready the precast rectangular concrete blocks 2 ft. long 6 inches wide and 5 inches thick each and reinforced with four No. 12 galvanized steel wires inserted along and inside of four long edges and also provided with two small holes made, while being cast, in the middle plane of each block are knitted together, in break joint, on the fascine mat by passing No. 4 ($\frac{1}{4}$ inch dia.) galvanized steel wire through the said holes, thus making up one continuous flexible sheet of concrete mattress for any length and width. The flexibility viz. susceptibility of deformation in any ways is the main characteristic of this type and the mattress is expected to settle down and fit the form of new river bed when any natural scouring occurs in front of the bank once covered with this system hence no checking or anchoring arrangement is provided against sliding down of the mattress

as a whole.

The annexed **Plate 1** shows the entire view of the mattress finished for 500 ft. in this season as taken on the 17th Nov. 1926.

Lower left portion represents concrete mattress laid on the bank slope cut to 1:2 slope fading to mere white zone behind and to the right of two standing figures.

Middle portion extending from the foot of the bank to the side of the dredger is the same continuous mattress laid on the low flat berm cut to the level of low water and making up entire width of 60 ft.

The amount of bank protection mattress executed during the season for the length of 500 ft. and the width of 60 ft. reached to 3 414 square yards as shown in the itematized list below.

Progress during 1926.

Reinforced Concrete Block Fabricated for the Use of Flexible Mattress.

Items	Quantities fabricated pcs.	Quantities used pcs.	Balance for succeding Use, pcs.
Concrete Block	36 156	29 026	7 130

Flexible Mattress Laid.

Concrete Mattress 3 414 sq. yd....500 ft. long & 60 ft. wide.

Building Materials Bought for Fabricating Concrete Mattress.

Items	Quantities received	Quantities used	Balance
Cement (380 lbs. per barrel)	bbls. 1 000	bbls. 453	bbls. 547
Broken stone (dia. 8"-2")	fang 152	fang 129	fang 23
Galvanized Wire (No. 12)	coils 180	coils 71	coils 109
,, ,, (No. 4)	150 ,,	47 ,,	103 ,,
,, ,, (No. 15)	20 ,,	9 ,,	11 ,,
Soap	pcs. 500	pcs. 420	pcs. 80
Willow Fascine	bundles 5 985	bundles 2 870	bundles 3 115

Equipments Bought.

Items	Number	Size
Wooden plank for sole plates	240 pcs.	8'×.1'×1'
Sole Plates	1 350 doz.	
Shovel	1½ ,,	

Items	Number	Size
Scoop	1½ ,,	
Plank (for making boxes)	10 pcs.	1.2′ × .11′ × 9′
Wooden Pile	120 ,,	30 ft. long
,, ,,	100 ,,	26 ,, ,,
,, ,,	100 ,,	24 ,, ,,
Diving Apparatus	1 set	
Pump for above	1 ,,	
Manila Rope	3 coils	1″
,, ,,	2 ,,	1/2″
,, ,,	2 ,,	1/4″
Steel Wire Rope	3 ,,	7/8″

Main reasons to adopt flexible reinforced concrete mattress.

The main reasons of our having adopted the flexible concrete mattress are as follows:

(1) In Liao the river bed consisting of very fine and almost pure sand is easily eroded by the river current so that if rigid and permanent revetment work is tried it must be very expensive and is beyond the reach of Conservancy's fund, on the contrary if the bank protection is done with semipermanent flexible concrete mattress the cost of both the first construction and the maintenance is quite cheap and is feasible with the Conservancy's available fund.

(2) Bank protection by means of Groins & Jetties which usually tend to deflect the current and more or less affect the interests of the opposite bank is a cause of complaint from the local people living on that side, while with our system the caving bank is merely pitched or covered with very thin concrete mattress which is smooth enough in merely guiding the current as it was and there is no room of raising any claim for the riparian owners and dwellers.

(3) The concrete mattress being very thin structure merely laid on the slope of the caving bank no confinement or contraction of water way is effected by its application and affects the regime of the river or the navigation in no ways.

(4) The only maintenance which is required for the flexible concrete mattress is the supplementing of its width according to the extent of the after scour in front of the once covered river bank, as the mattress is allowed to settle down to follow and suit itself to the new form of the river bed

without being lost away in parts or in totto, the annual cost of maintenance usually remaining within 2.5% of the first cost of construction.

Reasons to prefer direct work.

The reasons of executing this extra job as the Engineer-in-Chief's direct work instead of contract are (1) not to overburden the delaying present contractors with such hurry works, (2) to save about 30% of the cost of the undertaking if paid for by sticking to the present contract unit prices, (3) to avoid the troubles arising from their mutual interference if new contractors enter into the work site in addition to the present contractors.

ii Dredging operation & its effects.

The dredging by machines at Tang-chia-wo-pu, the head of the inlet of the worst pass between Tang-chia-wo-pu and San-chia-ho 24 miles long, which is a mere temporizing measure to draw as much water as possible to Liao till the opening of the New Cutting Line " A ", was resumed on the 12th May 1926 when the water gauge was reading 114.5 ft. of Yingkow datum there and was continued until the 26th of July when the gauge was reading 118.5 ft. to the effect that on 9th of June we were drawing only 116 cub. ft. of water per second out of the total river water of 731 cub. ft. and we were obliged to make additional application of hand dredging as an auxiliary means as the water fell day by day; on 29th of June after the help of hand dredging the share was 240 cub. ft. out of 1 087 cub. ft., while on the 26th of July it was 3 342 cub. ft. out of 10 924 cub. ft. when the gauge was reading 118.5 ft. and the dredging was suspended.

It is to be noted that in the last summer the total river water at Tang-chia-wo-pu fell to 497 cub. ft. per second on the 21st of June which is the minimum low water discharge in Summer in so far as the records since the inauguration of our gauge observation in 1921 are concerned as is illustrated further on under the heading of the depletion of water source.

How the worst pass of Upper Liao in question viz. the reach between Tang-chia-wo-pu and San-chia-ho 24 miles as a whole is going on is worth while to be mentioned here. It seems that although the said reach as a whole is increasing in its channel capacity, as is reported by the survey department, in so far as the cross-sectional areas below low water line are

concerned, to the extent of the scouring of 6 492 fangs per annum while 4 467 fangs per annum in average are being dredged by the Conservancy, the partial reach upstream viz. between Tang-chia-wo-pu and Sa-lin, the middle point of the worst pass and which is just out of the tidal limit, is silting annually to the extent of 9 164 fangs irrespective of the said dredging which is being done mainly at the head of the inlet channel at Tang-chia-wo-pu as is illustrated further on under "Survey." This is the reason why the drastic measure viz. the opening of the New Cut line "A" is of urgent necessity in order to surely take back Liao water to the utmost extent and to give up the dredging which is being done at present merely as a temporizing measure till the New Cut is opened.

In July 1927 it is expected that the present contractors shall complete and open the New Cutting and it is advisable that we should take rather negative policy for the dredging in 1927 and save as much expense as possible to meet the shortage of fund, by seeing that at any rate this must be the last year to do any dredging if necessary.

The amount of inland junk transport for down cargoes only, as calculated by the Japanese Chamber of Commerce, reached to 130 404 tons for beans and bean cakes alone that arrived to Newchwang in 1926 and the total number of junks which sailed up and down and passed the dredging site at Tang-chia-wo-pu during this season is 14 441 as calculated by our field staff stationed there.

The works done during the season are summarized as follows:

The work done by the dredgers during 1926.

The work done by the Priestman dredger No. 1.

Working site	Tang-chia-wo-pu
Advance distance of dredger	1 300 ft.
Length of channel dredged	683 ,,
Width of ,, ,,	40 ,,
Depth of ,, ,,	4 ,,
Amount of materials dredged	212 440 cub. ft.
Actual working hours	496½ hours

The work done by "Tao-ho" dredger.

Working site	Tang-chia-wo-pu
Advance distance of dredger	300 ft.
Length of channel dredged	477½ ,,
Width of ,, ,,	40 ,,

Depth of ,, ,,	4 ft
Amount of materials dredged	46 260 cub. ft.
Actual working hours	204½ hours

Hand dredging.

Dredging by manual labour	23.960 cub. ft.

Résumé of the work done by the "Tao-ho", the Priestman dredger and hand dredging.

Working site	Tang-chia-wo-pu
Advance distance of dredger	1 600 ft.
Length of channel dredged	1 160½ ,,
Width of ,, ,,	40 ,,
Depth of ,, ,,	4 ,,
Amount of materials dredged	282 660 cub. ft.
Actual working hours	701 hours

iii Winter quarter for dredging fleet.

Having failed to build a temporary dry dock for dredging fleet due to shortage of fund we were obliged to remain satisfied with tying up the dredger "Tao-ho" in the bend of Shuang-tai-tzu channel just in front of the bank protection work newly executed and to constantly cut away the river ice around the hull during winter in order to prevent any damage from strain due to freezing and two Priestman dredgers were taken on flat foreshore at "Tang-chia-wo-pu". Two Japanese junk at Erh-tao-chiao, one coal junk at Tang-chia-wo-pu and one boarding junk at Sa-lin were taken on flat foreshore at respective places. All of the above are to get caulking before the ice melting in the coming Spring at respective places.

(2) WORKS UNDER CONTRACT.

The progress in 1926 of the New Cutting Line "A" and Weir & Lock under the contract was far from being ideal due to the contractors being unable to realize the recruiting and supplementing of sufficient number of working force notwithstanding the repeated requests of the Engineer-in-Chief to increase the number of the actual workers so as not to loose very high time for working, moreover to make the thing worse, we met with Summer flood in the latter part of August viz. a little before the time of completion once extended that is the end of August 1926 which made a harm to such an extent that nearly one month's delay was caused there-from, although the

coming of a high water in this season was not a thing unexpected. So the works executed in this season remains within the sphere shown in the following list. (See **Plate 2**)

i Progress during 1926.

Earth work.

Location	
Lock & Weir	40 fang
Upper section at Erh-tao-chiao (560 ch.—725 ch.)	39 337 ,,
Middle section at Erh-shih-li-pu (280 ch.—560 ch.)	50 410 ,,
Lower section at Chia-shin-tzu (0 ch.—280 ch.)	40 464 ,,
Total	130 251 fang
Earth work executed since the start of the work, ...	396 529 fang

Parts of weir & lock.

Concrete	
Class "C" Pier, Abutment & Lock wall	26 341 cub. ft.
,, "C" Pier foundation	3 062 ,, ,,
,, "D" Lock foundation	13 618 ,, ,,
Concrete sheet pile driving (Not yet grouted)	487 pcs.
Grouting of sheet pile	337 ,,
Wooden pile driving	
Pier foundation (20 ft. long)	450 pcs.
Lock, Abutment & Wall foundation (15 ft. long)	42 ,,
Knitting of concrete mattress	2 856 sq. yd.
Rip-rap	599 fang

N.B.—The certificate of the Engineer-in-Chief for the works executed during 1926 shows the progress of approximately 20%.

Such being the case the present contractors have to do great deal of works yet as is calculated from the following list of entire progress obtained as from the start of the works in 1924 wherein the progress percentages are inserted for individual items of jobs.

ii Progress percentage of entire works at the end of 1926.

	Total work of each item	Work done at the end of 1926	Percentage of work done for each item	Remarks
	F.	F.		
Earth work "A" Line	669 448	370 804	55%	
Upstream section	140 116 "	116 068 "	83%	(725 ch.—560 ch.)
Middle ,,	235 895 "	140 338 "	59%	(560 ch.—280 ch.)
Downstream ,,	281 848 "	114 398 "	41%	(280 ch.— 0 ch.)
Excavation Lock & Weir	91 654 "	25 725 "	28%	For diversion channel & foundation.

	c.f.	c.f.		
Concrete	265 389	111 276	42%	
Class "A"	12 442 "	508 "	4%	For Pier & Abutment.
" "B"	35 000 "	28 358 "	81%	For Concrete floor of weir.
" "C"	145 725 "	34 508 "	24%	For Pier, Abutment & Lock wall.
" "D"	72 222 "	50 672 "	70%	For Lock foundation & Concrete floor of Lock & Weir.
	pcs.	pcs.		
Concrete sheet pile (Fabrication only)	915	847	93%	
Concrete sheet pile driving	915 "	487 "	53%	
Grouting of sheet pile	914 "	337 "	37%	
Wooden pile (20 ft. long)	450 "	450 "	100%	For Foundation
(15 " ")	1 254 "	1 208 "	96%	" "
Concrete block	66 055 "	66 055 "	100%	For the Bank protection & the rip-rap cover.
	sq.yd.	sq.yd.		
Knitting above	7 308	2 856	39%	
	F.	F.		
Rip-Rap	1 110	960	86%	

In summarizing the above we see that at the end of 1926 the earth works reached to 396 529 fangs which is a little over 52% of the total earth work in so far as the volume of cutting is concerned. The Engineer-in-Chief's last certificate for payment is $ 495 358.53 viz. approximately 39 % of the entire contract sum of $ 1 277 500.00 including the cost of both the earth work and the structures of Weir & Lock and this latter percentage stands for the actual value of the works in so far executed.

(3) WORKS TO BE TAKEN IN HAND.

i Bank protection works for sharp bends.

Soon after the completion of the New Cutting by the present contractors, the bank protection works for sharp bends, which course we were obliged to follow on account of the stout opposition of the local people against sticking to our ideal location of the New Cut, must be taken in hand as the alignment of the new channel tends to deteriorate, if these sharp bends are left alone, by flanking and scouring action of the river current. Also, direct loss to the Board will result due to the caving away of the riparian land which is the property of the Conservancy Board obtained at big expense and with many difficulties met in the process of purchasing it from the individual

owners who were very selfish and antagonistic to our scheme aiming at general welfare.

The sharp bends that require immediate care are the following reaches:— 203 ch.+57—213 ch.+88, 221 ch.+36—232 ch.+70, 239 ch.+17—248 ch.+68, 255 ch.+30—266 ch.+51, 324 ch.+65—326 ch.+36, 336 ch.+15—338 ch.+11, 349 ch.+35—361 ch+8, 369 ch.+56—379 ch.+94, 398 ch.+46—401 ch.+52, 409 ch.+41—419 ch.+6, 494ch.+94—518 ch.+86. totalling 11 163 ft. costing $184 636, at $16.54 per ft.

These bends are to be protected by means of flexible, reinforced concrete mattress similar to that applied in the Shuang-tai-tzu channel at the head of diversion channel at Erh-tao-chiao under direct management of the Board in the same way as was done there in 1926 for the sake of economy due to the fact that direct works are 30% cheaper than those done by the contractors and if paid for on the basis of the present contract unit prices.

Refunding from the Lower Conservancy is to cover the expenses for the execution of these works which were not included in the present contract on account of shortage of fund, when the present contract was concluded, viz. before the said refunding effected.

The execution of still further accessory works, such as the prolongation for certain lengths adjoining the upstream and down-stream ends of the aforesaid bank protection works at the sharp bends, as well as the Bank Protection Works at the bends of mild curvature, must wait until we are able to realize certain revenues as itematized further on.

ii The necessity of building temporary dock upstream.

Failing to build a temporary dock to accomodate for the dredging plants in the vicinity of our New Cut due to shortage of fund made it impossible to examine, clean & paint the exterior side of the hull of the dredgers for a few years past. We are just in time to take in hand the building of the temporary dock at Ho-yen in the New Cut soon after the completion of the cutting by the present contractors as these dredgers at our disposal which are the only and minimum equipments necessary for maintaining the upstream navigable channel and the works in question after their completion, and it must be a quite risky job if the said dock be built in the vicinity of Ying-kou port and the dredgers which are not safe for self-propelling be obliged to go up stream

and come down to be docked here in Ying-kou in every working season, not to mention the loss of time and money for the Board from such repeated trips which are needless, if otherwise, every year.

Such being the case the temporary dock is to be located in the old river arm in Ho-Yen at 239 ch. and built of wooden grillage for a base area of 120 ft. × 60 ft. with the top of the grillage at 99 ft. Ying-kou datum.

The cost of building the dock is estimated at $5 000 which is 30% cheaper than when done by the present contractors and if paid for under the basis of the present contract unit prices.

The expense for building the said dock is to be covered by the refunding from the Lower Conservancy.

iii Maintenance of works.

As a matter of fact, the maintenance is no less important than the first construction with such great hydraulic works as ours, when we consider that the banks of the New Cutting are left unprotected except at the very sharp bends. We were obliged to follow this course on account of the egoism of the local people, who drove our alignment out of the ideal position, and as a consequece, we must apply the costly, semi-permanent revetments, in order to prevent the severe caving action of the river current.

Banks of milder curvature were left unprotected on account of shortage of fund. These banks must be properly shielded with revetment works in due time, as they are liable to be attacked and scoured by the river current. This current action not only tends to deteriorate the river channel into as crooked a course as the original one which we abondoned as being worthless but also threatens the stability of the levees. In other words, a certain fund must be placed at our disposal every year, so that we may be able to care for the curved portions of our new river, repair and maintain the entire works in good shape, in order to keep the stability of the new channel, not to mention the prime necessity of repair and maintenance of the bank protection works at the sharp bends executed at the start as aforesaid requiring annually 2.5% of the cost of first construction when calculated from the experiences in the past.

The chief items entering into the maintenance are:—

(1) Execution, repairs and maintenance of the bank protection works for

the curved reach not yet touched.

(2) Repair and maintenance of the bank protection works completed at the start for the sharply curved portions, and at the head of diversion channel.

(3) Repair and maintenance of embankments and culverts on both sides of the cuttings.

(4) Watching and controlling of Lock and Weir gates.

(5) Periodical painting and repair of Lock and Weir gates, stopping of any leaks.

(6) Temporary dredging of shoals to form at scattered points of the navigable channel, and periodical removal of the silts liable to occur at or near the Weir & Lock site.

(7) Management of the foreshores, the levee sites, and the hinterland which are the Conservancy's lands.

(8) Policing the entire works and lands.

These are the items which require annual running expense in order not to stultify the works done by the Conservancy and their aims. Unless some special funds are newly created, the available sources from which certain revenues may be derived are:—

(a) Rent of the Conservancy's land viz; the revenue due to leasing the foreshore, the levee, and the hinterland.

(b) Customs duty charged on the tonnage of the inland navigation junks viz. 2 Candereen per ton at present.

As to the first source of revenue, viz. (a), His Excellency Tung Tao-yin proposed to the Board his wish to make the Tung-shan-tang Guild lease the Conservancy's land in question under certain conditions. This matter was brought up for investigation of the special committees appointed at the Board Meeting held on the 15th June 1926. The three special committees are headed by Mr. Van Ess, Mr. Hao, and myself.

His Excellency Tung Tao-yin's proposal with regard to the lease of the land, and the draft of amendment for the same, drawn up by the Engineer-in-Chief, are as follows:—

Tao-Yin's Proposal.

(1) No trees to be planted on any part of the land, and, if be leased,

only crops or the like may be cultivated thereon.

(2) All the lands, including the levee, fore-shore, and hinter land, will be leased to the "Tung-shan tang" as a whole, the rents of which will be paid to the Board through the Tao-Yin's Yamen.

(3) Half of the rentals is to be paid before March of every Solar year, with the other half detained by the tenant for duties and other expenses.

The land will be leased to subtenants at the rate of half rent comparing with that of adjoining land.

The Engineer-in-Chief's Draft Amendment.

(1) Conservancy's land will be leased to the Tung-shan-tang Guild.

(2) The term of lease shall be for five years and renewable in every five years if agreed upon to do so one year before the termination of the term.

(3) Rent shall be fixed at 80% of the usual rate prevailing in the locality placed under similar conditions as the Conservancy's land in question, under the assumption that the land may be sublet to the riparian farmers at 90% of the usual rent and remaining 10% may go to the guild, and the said rent as a whole shall be paid to the Board through the Tao-yin's Yamen viz. one half of the rent is to be paid before March of every Solar year and the other half to be paid before the end of the year.

(4) The afore-said rent at 80% of the usual rate may be lowered 10% viz. at 70% when the total net annual payment to the Board is more than M. $ 20 000 after deducting the said 10%.

(5) The land except Levee may be planted with willows on the condition that the priority is given to the Board in buying those willows at reasonable prices when required for the Conservancy works.

(6) Any damage to the levee and the boundary marks shall be repaired gratis by the tenants.

(7) No claim from the tenants shall be accepted for the damage to the crops sustained due to the operation of the Conservancy's staff for the repair and maintenance of the works.

(8) On neglect of paying rents at the fixed term or of any duty, the license of lease shall be cancelled and no claim to any redemption will be accepted by the Board.

(9) Cultivation of the levee is prohibited but the tenants may seed and grow the hay grass and cut the hay in due time leaving and maintaining gang way 9 ft. wide along the centre line of the levee and no plowing of the levee shall be allowed.

N. B.—Conservancy's land in question is 11 255 mous.

Meeting of the Special Committees at which this matter shall be discussed and decided is to be held yet.

As to the second source of revenue, viz. (b), it is advisable to raise the Customs Duty of inland navigation junks which is 2 candereen per ton at present to five candereen per ton. This will bring the Customs scale for the inland navigation junks in parity with that applied to the sea going junks, and at the same time, increase the revenue to be used for the maintenance of the Upper Conservancy's Works.

N. B.—The total number of junks which sailed up and down & passed the dredging site at Tang-chia-wo-pu in 1926 is 14 441 as counted by our staff stationed there, & the amount of down cargoes only reached to 130 404 tons during this season for beans & bean cakes alone that arrived to Ying-kou as calculated by the Japanese Chamber of Commerce.

iv Depletion of water source and its remedies.

Although it is needless to say that any river improvement works are of no use when the water source of the river in question becomes cut off, and the elaborate works done in the past are thus stultified it is worth while here to recall the attention of the Board to the effect that the stream flow of Liao is gradually decreasing. Especially so in the early part of Summer, when the navigation requires as much water as possible, due to gradual depletion of water source on account of the increasing tendency of new irrigation projects ubiquitously laid out in the Liao Valley consuming so much water before the usual rainy season sets in.

It is to be noted that the irrigation projects contribute substantially to the agricultural development of the interior, and hence it could hardly be checked or tabooed by any policy, in the cultivation of rice, cotton, vegetables, kaoliang and other cereals. All these plants urgently require so much water during the usual season of drought which lasts throughout May, June,

and July and just before the usual rainy season in Manchuria. During the drought, large throngs of people on bare feet, including farmers and local officials of the highest rank, eagerly pray for the precious rain, but which, sorry to say, brings no visible effect to the drying plants.

Irrigation interest, usually supposed to counteract the navigation, is growing with irresistible force, as the irrigation enterprise is a way of developing the interior country, which augments the agricultural produce at the expense of navigation facility, although, the latter is no less important factor than the former for the development of the interior.

Such being the case, it is advisable to create a new medium by which both the irrigation and the navigation interests could be harmonized and both may be carried out on a large scale without any drawback. The new medium, which is sure and ideal, was pointed out and suggested in my annual report for 1920, viz; to resort to the scheme of impounding the surplus rain water which is going to waste during the usual rainy season of Manchuria, which comes late in the Summer, usually. The said impounding may be effected by selecting a few points in the upstream country at which wide and deep reservoir of big storage capacity can be created most economically by building dams there. It is easy to retain, therein, the surplus water, which is not only useless, but is harmful to the valleys lower down during freshets, and to control and let it down bit by bit, so as to be favourable for both irrigation and navigation when water is needed for them, not to mention the subsidiary benefits of hydroelectric power which can be easily and cheaply created as a natural consequence of the building of the said dams, by utilizing water heads there as had been and are being done successfully in other countries.

Reconnaissance survey for finding out the most suitable points for the reservoir sites is an urgent need for the Board in protecting their own scheme already executed, or about to be finished, at such an enormous sum of money. Any hesitation or delay would moan carelessness and negligence on the part of the Board in safeguarding the works already done by them, for the general welfare of the country. The first step towards accomplishing the reservoir scheme is the reconnaissance survey, and the Board must have the results of such survey in hand as soon as possible, as the reservoir project must be

based on the data obtained from it.

How popular the irrigation is for rice culture in South Manchuria may be seen from the following table, as investigated, roughly in 1924, by the expert of the South Manchuria Railway Company:—

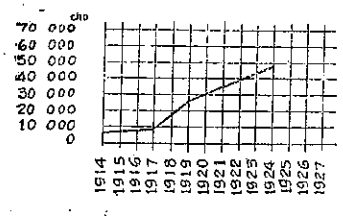
Area of irrigated land in South Manchuria.

(A)	Within South Manchuria Railway Area	71.74 cho
(B)	In Kwantung Leased Territory	363.46 ,,
(C)	In other parts of South Manchuria	46 110.00 ,,
	Total	46 545.20 cho

From the above table it can be learned that the total irrigated area in South Manchuria reached to 46 545 cho: 775 750 mous, the rate of increase of the irrigation project since 1914 being as is shown below:—

1914	5 571 cho
1917	7 875 ,,
1919	25 359 ,,
1924	46 545 ,,

The following diagram better shows the remarkably increasing tendency of the irrigated areas in South Manchuria since 1914:—



The irrigated areas in the valley of Liao alone amounted to 22 002 cho: 366 700 mous as itematized below and is more than double that we had in 1919.

Irrigated land in the drainage area of Liao (1924).

Name of Hsien (Prefecture)	Area in cho	Name of Hsien (Prefecture)	Area in cho
Ying-kou	180	Hai-cheng	300
Pan-shen	500	Pen-chi	750
Liao-chung	100	Liao-yan	50
Hsin-min	3 100	Shin-yan	5 408
Shang-wu	400	Shin-chin	2 000
Tieh-ling	576	Fu-shun	1 000
Fang-ku	1 480		
Kung-ping	250		
Kai-yuan	666		
Liao-yuan	150		
Shwang-shen	32		
Tung-liao	1 600		
Li-shu	1 200		

Total: 22 002 cho: 366 700 mous approximately as calculated by the expert of South Manchuria Railway Company as representing the situ-

Kwai-ta	720	ation in 1924.
Shi-an	300	
Shi-feng	1 000	

The fact that the minimum river water in Summer just above Tang-chia-wo-pu as observed on June 21, 1926, to be 497 cub. ft. per sec. is far less than the minimum of 1 610 cub. ft. as observed on July 3, 1922 is a good indication for the gradual depletion of river water due to increase of irrigation projects and may serve as a hint to the necessity of relief by means of the impounding scheme.

At the Board meeting held on the 28th October, 1920, it was resolved that the reservoir scheme shall be postponed until the completion of the present restoration scheme. Now that the present scheme of the new cutting is nearly completion, we are just in time to come back and take up the impounding scheme. This is the reason why I shall recall the attention of the Board to promptly and kindly consider this subject bearing such great importance upon the effect of the New Cut with Weir and Lock.

v Excessive salt spoiling water supply and its remedy.

One more evil effect we are having from the depletion of fresh water discharge of Liao is that the source of the present water supply for the town of Ying-kou which is depending upon Liao water filtred and pumped up to high head at Tien-chuang-tai and led to the town through iron pipes under pressure is suffering from excessive salinity caused by the remarkable decrease of fresh river water coming down from Upper Liao. The salinity reached from .1% to .33% as determined by the S.M.R.W. Hospital Ying-kou in the Summer 1926 which is high enough to corrode the supply pipes and the water supplied is not only discolored and bad to taste and is far beyond the legal allowable limit of chlor contents for drinking purpose but also it is quite unfit for medical and certain industrial uses during the extreme low water season in question and such bad state continued longer than 40 days in 1926. This is due to the fact that scanty fresh water coming from upstream is overcome by the tide water from the sea although in the former days when there was abundant fresh water discharge the latter was not affected by the salt to an appreciable extent.

How scanty was the fresh water flow, at Tien-chuang-tai, coming from

up-rivers may be seen from the discharge table inserted under the heading of discharge measurements, to the effect that on 21st of June 1926 we had only 391 cub. ft. per sec. for the sum of discharges of three rivers viz. Liao-ho proper, Tai-tzu-ho and Hun-ho, while daily average total discharge for the month of June is calculated to be 505.0 cub. ft. per sec. from the said three rivers. It is no wonder that such scantiness of stream flow is making trouble for the water supply of Ying-kou as well as for the navigation in general.

Such harm to the water supply of the big town containing so much population as 100 000 cannot now be neglected when considered from the stand point of general welfare and it is a problem bearing serious importance upon prosperity of the port which is the aim of the Conservancy. The direct remedy for the above can be effected by increasing the stream flow of fresh water from Upper Liao, that is, the same means as for remedying navigation difficulty in question as aforesaid.

vi Proposed inauguration of waterway connecting Liao with Sungari.

Apart from the aforesaid reservoir scheme there is another way of remedying the depletion of Liao water that is by opening a new canal connecting Sungari to Liao.

The proposed plan inceptive to the construction of a canal between Liao and Sungari seems to have been conceived by great men of resourceful mind in former days and the problem was also taken up by the late Mr. W.R. Hughes, M. INST. C.E. Engineer-in-Chief of the Liao River Conservancy Board and by Tuchun (Military Inspectors General) of the Three Eastern Provinces of Manchuria. In the event of the proposed waterway connection scheme between the two great rivers having been realized, the interest of the river navigation will be raised to a higher level and the value of the river improvement will be much appreciated seen from the stand point of the Liao River Conservancy Board. Therefore, it deserves not only to attach much significances to the problem but also by means of the above waterway connection. It is most probable that the river water in Sungari can be easily led into the Liao, thereby relieving the difficulty with which the Liao rives is now being vexed by the scantiness of water. The hope is entertained that this scheme is feasible if a route between Ting-chia-tun and Tao-nah is selected

for the canal connecting Tao-lu-ho, a tributary of Sungari, with Upper Liao and it is why I lay emphasis upon the investigation in concrete form concerning the canal in question together with the reservoir problem above refered to.

It is to be added that some years ago His Excellency the Military Inspectors General of Three Lastern Provinces' request to make me investigate the matter concerning the said connection scheme through the Late Hsih Taoyin had been received and it seems to me that by the realization of the scheme the new canal which can also perform the double function viz., serving for irrigation as well as drainage of the surrounding countries may be quite beneficient toward encouraging the improvement and development of the interior where the new settlement are being established ubiquitously under the auspices of the Chinese Government. The Engineer-in-Chief may be able to see the site soon after the pending works are completed.

(4) SILT ANALYSIS.

Liao River water is so high in its suspended silt that the river may be classed as one of the muddiest in the world, when considered from the results of our silt measurement as follows.

i Site of silt observations.

Samples of river water were taken daily at noon at Chia-hsin-tzu for Liao proper, at Erh-tao-chiao for Shuang-tai-tzu channel, at Tang-chia-wo-pu for Shuang-tai-tzu channel, Main Liao as well as Minor Liao, and at San-chia-ho for Minor Liao, main Liao as well as Tai-tzu-ho, as from April to October 1925 and at every 5 days for Feb., March, Nov. and Dec. 1925 and Jan., Feb. and March, 1926.

ii Total number of water samples taken.

Samples of river water were taken at the surface, mid-depth and two feet from the bottom in the thalweg, by sucking about 500 cubic centimeters of river water by means of garden syringe attached to the sounding rope and sent down to respective depth, the total number of the sample thus collected amounting to 6 238 for the season from Feb. 1925 to March 1926 and each sample being numbered.

iii Silt treatment.

Water samples are filtered one by one through two filter papers previously cut to equal weights and entirely over-lapped inside of the funnel inserted into the mouth of empty bottle, leaving the silt contents to dry on the filter paper. When the said silt contents together with the filter papers are tolerably dry the lower filter paper is separated and the silt well wrapped in the upper filter paper is to be quite well dried with the said lower or check filter paper side by side to the same humidity. After thorough drying the excess in weight of the upper filter paper containing the silt over the lower filter paper is measured by means of chemical balance sensitive to one milligramme. This excessive weight is the weight of the silt contained in each water sample of so much quantity as measured previous to filtering. The results of weighing the silt in each sample are reduced to so much milligrammes in every 100 grammes of respective water sample, or in other words 1 000 milligrammes stand for 1% and 2 000 milligrammes stand for 2% and so forth.

iv Silt diagram.

Three weights or percentage of silts in one set of three water samples taken on the same day at same station are averaged and plotted in a diagram one for each station as in the plates from No. 3 to No. 5 here attached (each plate contains several diagrams), the results of measurement which seem doubtful, being plotted with dotted line; the ordinates viz. the said average amount of silt contained, in milligramme, in every 100 grammes of water sample correspond to dates in abscissa. (March 1925 to February 1926).

Plate 3 is the diagrams for Liao River at Chia-shin-tzu & Shuang-tai-tzu channel at Erh-tao-chiao.

Plate 4 is the diagrams for Shuang-tai-tzu channel below Tang-chia-wo-pu, Liao River above Tang-chia-wo-pu & Liao River below Tang-chia-wo-pu.

Plate 5 is the diagrams for Liao River above San-chia-ho, Liao River below San-chia-ho & Tai-tzu-ho above San-chia-ho.

v Investigation of the results of silt measurements.

In comparing the silt diagrams we find at a glance that there is diversity

of silt percentages not only in different rivers under consideration but also in the same river at different stations, and in order to make the comparison definitely the average silt content for each river at each station was calculated, or in other words monthly average percentage of silt in each river throughout the year extending from March 1925 to February 1926 was calculated and tabulated as in the following list. The average for 12 months are put in the last column of the list below.

Monthly average percentage of silt.

April 1925—March 1926.

Station & River name	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average for 12 Months
Liao above Tangchiawopu	.476	.359	.599	.674	.636	.234	.164	.093	.027	.016	.004	.011	.274
Liao below Tangchiawopu	.497	.371	.614	.646	.623	.262	.166	.108	.017	.014	.004	.013	.278
Shuangtaitzu below Tangchiawopu	.503	.351	.621	.622	.673	.237	.154	.099	.013	.017	.007	.011	.276
Liao above Sanchiaho	.381	.328	.712	.633	.645	.220	.150	.094	.016	.025	.044	.020	.272
Liao below Sanchiaho	.191	.133	.418	.357	.335	.059	.069	.047	.021	.032	.060	.039	.147
Taitzuho at Sanchiaho	.085	.042	.251	.238	.226	.026	.032	.034	.008	.015	.028	.016	.083
Shuangtaitzu at Erhtaochiao	.553	.365	.749	.821	.690	.266	.158	.068	.024	.031	.015	.039	.315
Liao at Chiashintzu	.211	.151	.217	.256	.323	.068	.059	.160	.094	.045	.013	.021	.135

NOTE:—Figures denote number of grams of silt per 100 grams of water.

For reference's sake the silt percentages for the individual water samples taken at different depths are tabulated respectively for each river at each station as follows:—

Monthly average silt content, (percentage), at various depths.

April 1925 - March 1926.

"Liao-ho" above "Tang-chia-wo-pu"

Month	Average Surface	Average Middle	Average Bottom	Average for Surface, Middle & Bottom.
1925				
April	.499	.472	.465	.476
May	.352	.366	.353	.359
June	.558	.585	.622	.599
July	.637	.681	.669	.674
August	.606	.629	.680	.636
September.	.232	.234	.237	.234
October	.165	.168	.159	.164
November	.088	.090	.102	.093

Month	Average Surface	Average Middle	Average Bottom	Average for Surface, Middle & Bottom
1926				
December	.034	.030	.017	.027
1926				
January	.021	.019	.009	.016
February	.005	.005	.003	.004
March	.006	.010	.018	.011
Average for 12 months	.267	.274	.278	.274
"Liao-ho" below "Tang-chia-wo-pu"				
1925				
April	.503	.523	.459	.497
May	.355	.375	.382	.371
June	.641	.613	.592	.614
July	.623	.614	.711	.646
August	.630	.592	.646	.623
September	.227	.228	.233	.262
October	.160	.164	.174	.166
November	.117	.096	.110	.108
December	.017	.023	.012	.017
1926				
January	.012	.017	.011	.014
February	.005	.004	.004	.004
March	.010	.014	.015	.013
Average for 12 months	.275	.272	.279	.278
"Shuang-tai-tzu" Below "Tang-chia-wo-pu"				
1925				
April	.450	.543	.519	.503
May	.326	.384	.356	.351
June	.565	.637	.646	.621
July	.618	.588	.659	.622
August	.671	.694	.657	.673
September	.235	.234	.244	.237
October	.148	.154	.159	.154
November	.091	.111	.096	.099
December	.013	.014	.012	.013
1926				
January	.027	.014	.011	.017
February	.005	.008	.008	.007
March	.010	.012	.009	.011
Average for 12 months	.263	.283	.281	.276
"Liao-ho" above "San-chia-ho"				
1925				
April	.323	.409	.412	.381
May	.302	.313	.368	.328
June	.700	.704	.731	.712
July	.536	.733	.646	.633

Month	Average Surface	Average Middle	Average Bottom	Average for Surface, Middle & Bottom
1925				
August	.473	.531	.930	.645
September	.180	.230	.251	.220
October	.127	.127	.175	.150
November	.067	.101	.113	.094
December	.020	.019	.010	.016
1926				
January	.020	.015	.040	.025
February	.027	.029	.049	.044
March	.013	.017	.030	.020
Average for 12 months	.232	.269	.313	.272
"Liao-ho" below "San-chia-ho"				
1925				
April	.160	.205	.200	.191
May	.097	.136	.159	.133
June	.277	.439	.548	.418
July	.252	.354	.465	.357
August	.234	.351	.418	.335
September	.031	.057	.090	.059
October	.042	.062	.099	.069
November	.038	.041	.061	.047
December	.014	.024	.026	.021
1926				
January	.019	.035	.042	.032
February	.029	.040	.112	.060
March	.023	.036	.058	.039
Average for 12 months	.101	.148	.190	.147
"Tai-tzu-ho" at "San-chia-ho"				
1925				
April	.066	.094	.096	.085
May	.033	.044	.051	.042
June	.113	.324	.316	.251
July	.159	.266	.296	.233
August	.115	.260	.303	.226
September	.019	.022	.038	.026
October	.027	.026	.039	.032
November	.021	.034	.048	.034
December	.011	.005	.008	.008
1926				
January	.014	.018	.013	.015
February	.023	.028	.033	.028
March	.020	.011	.017	.016
Average for 12 months	.052	.094	.105	.083
"Shuang-tai-tzu" at "Erh-tao-chiao"				
1925				
April	.521	.519	.607	.553

Month	Average Surface	Average Middle	Average Bottom	Average for Surface, Middle & Bottom.
1925				
May	.370	.343	.358	.365
June	.742	.729	.761	.749
July	.882	.773	.808	.821
August	.663	.639	.799	.690
September	.246	.272	.261	.266
October	.147	.164	.164	.158
November	.063	.062	.080	.068
December	.036	.017	.020	.024
1926				
January	.021	.024	.048	.031
February	.007	.011	.026	.015
March	.036	.044	.038	.039
Average for 12 months	.311	.300	.331	.315
"Liao-ho" at "Chia-shin-tzu"				
1925				
April	.178	.200	.255	.211
May	.142	.143	.167	.151
June	.204	.218	.229	.217
July	.210	.231	.320	.256
August	.231	.347	.339	.323
September	.067	.062	.073	.068
October	.053	.060	.065	.059
November	.118	.239	.125	.160
December	.075	.095	.113	.094
1926				
January	.037	.033	.065	.045
February	.004	.013	.020	.013
March	.018	.024	.020	.021
Average for 12 months	.111	.139	.149	.135

NOTE:—Figures denote number of grams of silt per 100 grams of water.

Silt contents at various stages of tide.

It is a matter of fact that in a tidal compartment of the river the silt contents suspended in the river water varies according to the state of tide the maximum being usually at the half or quarter tide and the minimum at slack stage usually as is illustrated in the **Plates 10 & 11** wherein the results of silt measurements of Liao River at Chia-shin-tzu and San-chia-ho respectively made at every one hour are plotted covering various stages of tides extending for a little over one day tide. Therefore generally in determining the yearly or monthly average silt percentage we must measure the silt contents in the water samples taken at as much different stages of tide as possible in order

to get fairly reliable results and this is the reason why we took the water samples at all stations daily for the rivers in question at fixed hour or at noon throughout the year so as we may be able to strike mechanically at every possible stages of tide there.

In the lower portion of the diagram on the **Plates 9 & 10** average silt contents at every hour are plotted in full line while the broken line, the broken and dotted line and the dotted line stand respectively for the silt contents at the point 2 ft. below the surface, the mid-depth and the point 2 ft. above the river bottom. In the top part the gauge heights (as ordinates) refered to Ying-kou datum and corresponding to the time interval marked at the bottom (as abscissa) is plotted in full line.

It is easy to notice that among three rivers under consideration viz., Tai-tzu-ho, Liao and Shuang-tai-tzu river, Tai-tzu-ho shows the least percentage of silt viz., only .083% and Shuang-tai-tzu at Erh-tao-chiao shows the largest percentage viz., .315% and that Liao water flowing down past Tang-chia-wo-pu with the silt of .274 or .278 tends to drop its silt burden on its way to above San-chia-ho to the hint that the channel between Tang-chia-wo-pu and San-chia-ho is being silted up in harmony with the fact that the survey department roughly calculated the silting of low water channel in the reach from Tang-chia-wo-pu to Sa-lin to amount to 9 164 fangs per year and finally that when it unites with Tai-tzu-ho it again drops in its silt percentage down to .147% and keeps nearly same percentage till Chia-hsin-tzu. Liao water entering Shuang-tai-tzu channel with the silt of .276 or .274% gains more silt up to .315 seemingly due to steep gradient in the Shuang-tai-tzu channel, tidal action or some other causes which are yet to be investigated.

vi Conclusion.

From the above a very important conclusion may be drawn that the Shuang-tai-tzu water so rich in its silt burden reverted to our New Cut must be prevented to deposit its silt on the bed of the New Cut and if left alone finally to fill up the new channel, mainly, by means of at least periodical scouring power created by closing the Weir gates at Erh-tao-chiao in order to raise the water surface there and induce steep hydraulic gradient which is the effective motive to develop a powerful sweeping action to check sedimentary

matter to deposit in the new channel or to sweep away the silt once dropped. Our Weir gates which are 12 ft. high are to serve for the said important function by their skilful manipulation, although the hope is entertained that certain natural scouring action due to increased tidal range in the New Cut may render great help for maintaining the new channel as well as the present channel in the lower reach.

It is to be noted that the mean velocity of 4.41 feet per second in Shuang-tai-tzu channel is able to carry 2% of silt in suspension from our observation there.

vii Comparison of silt contents in foreign rivers.

For reference' sake silt percentages in a few foreign rivers are reported by the authorities are here put in:

Name of River	Location	Average Percentage	Remarks
Colorado	Yuma, Ariz., U.S.	0.760	Average of the mean average percentages of silt (by weight) for ten years ending with 1921 by U.S. reclamation service.
Rio Grande	San Marcial N. Mex., U.S.	1.660	Mean percentages of silt from 1897 to 1912 as given by Mr. W.W. Follett.
Zuni	Zuni reservoir N. Mex., U.S.	1.880	Calculated from the silt deposited in the reservoir and stated to be somewhat less than the actual amount in suspension by Mr. H. F. Robinson.
Mississippi	Cairo to gulf U.S.	0.800	Annual mean by weight as given by Messrs. B. F. Thomas & D.A. Watt.
Nile	Africa	0.313	Ditto
Danube	Austria	0.283	Ditto
Po	Italy	1.380	Ditto
Rhone	France	0.870	Ditto
Ganges	India	1.493	Ditto
Loir	Tours, France	0.060-0.467	By weight as given by Professor A. Hess.
Yellow	China	0.400	Normal silt burden at the low water stages by Mr. J. R. Freeman though other details are not given.
Yellow	China	4.500	Mean of eighteen samples taken at six different localities from July 31st to September 2nd 1919 stated by Mr. J.R. Freeman.
Hai Ho	Tientsin, China	0.142	Average by weight of annual percentages for surface as from 1892 to 1922 as given by Mr. T. Pincione.
,,	,,	0.192	Ditto for bottom.

Name of River	Location	Average Percentage	Remarks
Huangpu	Shanghai, china	0.005-0.100	By weight as reported by Mr. H. von Heidenstam.
Ishikari	Tsuishikari, Hokkaido, Japan	0.018	By weight as reported by Dr. B. Okazaki; then the Chief Engineer, Ishikari Riv. Improv. Works, being the average of one year as from March 1902 to Feb. 1903 inclusive. The river is one of the two biggest in Japan draining 6 000 sq. miles.

(5) SURVEY.

i Cross-section survey.

With a view to roughly determine the change of river bed below low water level in the reach of Liao between Tang-chia-wo-pu viz. the head of inlet channel and San-chia-ho viz. the junction of three rivers 24 miles long which is the worst pass in the upper Liao, rough cross-section surveys were made in April 1926 and 515 cross-sections of the low water channel viz. at every 250 feet were taken and plottod, to the effect that in the portion from San-chia-ho to Sa-lin we found that the scouring of 83 446 fangs has occurred since 1920 or 15 656 fangs per annum, while in the portion from Sa-lin to Tang-chia-wo-pu the silting of 48 844 fangs has occurred in the same interval as above viz. 9 164 fangs per annum. The latter silting has taken place mostly in a portion below Liu-Chien-Fang which is about a mile below Tang-chia-wo-pu viz. the point where the dredging operation is concentrated notwithstanding the intermittent dredging is being done every year at the head of the inlet channel to the extent of 4 467 fangs per annum on average.

The resultant change of river bed below low water line for the said entire reach of 24 miles as a whole is therefore an increase of sectional area viz. scouring of 6 492 fangs per annum but not a silting and it is to be noted that the silt of 4 467 fangs per annum or average is being dredged every year by the Conservancy since 1920 when the Engineer-in-Chief took up the interests of the whole works from the Tao-yin Yamen.

ii Discharge measurements.

In parallel with the dredging operation at Tang-chia-wo-pu several discharge measurements were performed by Mr. T. Matsuda assistant Engineer, during this season and we found that we met with extreme low water in this

Summer which is up-to-date in so far as our records since 1921 are concerned as was stated under the heading of " Depletion of Water Source." The share of water between Shuang-tai-tzu channel and Liao proper as actually measured at several stages is itematized in the list below.

Date	Gauge heights (Ying-kou datum) feet	Total Discharge at above Tang chia-wo-pu cub. ft. p.s.	Discharge in Shuang-tai-tsu channel cub. ft. p.s.	Discharge in Liao below diversion point cub. ft. p.s.
June 9	112.59	731.00	615.00	116.00
,, 21	112.10	497.00	430.00	67.00
,, 29	112.85	1 087.00	847.00	240.00
July 9	113.28	1 471.50	1 110.20	361.30
,, 26	118.50	10 924.00	7 582.00	3 342.00

Gurley & Price patent current meter was used in the measurement of discharge.

As the result of extreme low discharge of upper Liao in this season it seems that the regime of the river has been remarkably changed during low stages so that the discharge equation established in the former years cannot be applied in this year with correctness particularly for low water stage so we tried to reduce an equation for discharge rating curve from the results of the actual measurements done by Mr. T. Matsuda in this season by means of the method of Least Square to the effect that with the new equation thus obtained, $y=110.33+0.078\sqrt{x}$, or, $x=(y-110.33)^2 \times 164.365$, the low water discharges could be calculated out with tolerable accuracy although for a high stages there is not much difference in the results worked out from either the new equation or the old one.

In the calculation of annual run off of Liao at above Tang-chia-wo-pu in 1926 the daily discharges for the stages lower than 117.435 ft. Ying-kou datum were computed from the above equation and for stages higher than 117.435 ft. Yingkow datum the following equation, $y=111.44+0.066\sqrt{x}$, or $x=229.60$ $(y-111.44)^2$, reduced from the results of observations in 1923, 1924 and 1925 with the said current meter as itematized below:

No.	Name of river	Date	Station	Gauge height (reduced to Ying-kou Datum)	Discharge in cub. ft. per sec.	Mean velocity in feet per sec.	Remarks
		1923	At above				
1	Liao-ho	Oct. 8	Tangchiawopu.	115.8	1 364		

		1924						
2	,,	July	21	—do—	122.4	8 471	3.58	Stationary
3	,,	,,	23	—do—	121.4	7 060	3.32	Falling
4	,,	,,	25	—do—	120.3	4 975	2.81	,,
5	,,	,,	27	—do—	119.9	4 753	2.83	,,
6	,,	Sept.	25	—do—	116.1	1 547	1.76	,,
7	,,	,,	27	—do—	115.9	1 481	1.74	,,
8	,,	Oct.	14	—do—	115.6	1 277	1.77	Stationary
		1925						
9	,,	Apr.	23	—do—	119.8	4 206	2.92	Falling
10	,,	May	22	—do—	115.3	976	1.92	,,
11	,,	June	20	—do—	120.1	5 184	3.55	Rising
12	,,	July	22	—do—	117.6	2 510	2.76	Falling
13	,,	Oct.	30	—do—	115.9	1 291	1.83	,,
		1926						
14	,,	June	9	—do—	112.5	116	0.98	Stationary
15	,,	,,	21	—do—	112.1	67	0.83	,,
16	,,	,,	29	—do—	112.9	241	1.39	Falling
17	,,	July	9	—do—	113.3	361	1.65	,,
18	,,	,,	26	—do—	118.5	3 342	2.46	,,
		1923		Below				
19	Shuangtaitsz	Oct.	8	Tangchiawopu.	115.8	3 144		
20	,,	July	21	—do—	122.4	20 331	4.24	Stationary
21	,,	,,	23	—do—	121.4	17 236	4.00	Falling
22	,,	,,	25	—do—	120.3	12 094	3.84	,,
23	,,	,,	27	—do—	119.9	11 268	3.50	,,
24	,,	Sept.	25	—do—	116.1	3 576	2.21	,,
25	,,	,,	27	—do—	115.9	3 239	2.19	,,
26	,,	Oct.	14	—do—	115.6	3 017	2.32	Stationary
		1925						
27	,,	Apr.	23	—do—	119.8	10 414	3.38	Falling
28	,,	May	22	—do—	115.3	2 850	2.11	,,
29	,,	June	20	—do—	120.1	12 084	3.89	Rising
30	,,	July	22	—do—	117.6	5 577	2.87	Falling
31	,,	Oct.	30	—do—	115.9	3 111	1.92	,,
		1926						
32	,,	June	9	—do—	112.5	616	1.53	Stationary
33	,,	,,	21	—do—	112.1	430	1.42	,,
34	,,	,,	29	—do—	112.9	846	1.66	Falling
35	,,	July	9	—do—	113.3	1 110	1.80	,,
36	,,	,,	26	—do—	118.5	7 581	2.92	,,

Discharge of Liao at above Tang-chia-wo-pu (1926)

Drainage area at Tang-chia-wo-pu	68 600	sq. miles
Yearly total discharge	161 914 092 480	cub. ft.
Average daily discharge	5 134.2	cub. ft. p. s.
Maximum discharge	41 596.6	,, ,,
Minimum ,, (in Summer)	497.0	,, ,,
,, ,, (Under ice, March 11, 1925)	364.0	,, ,,

Discharge of Liao at below Tang-chia-wo-pu (1926)

Yearly total discharge	45 395 130 240.0	cub. ft.
Average daily ,,	1 439.5	cub. ft. p. s.
Maximum discharge	12 091.8	,, ,,
Minimum ,, (in Summer)	67.0	,, ,,
,, ,, (Under ice, March 11, 1925)	94.1	,, ,,

From the discharge rating curves (See **Plate 6**) the annexed daily discharge table were prepared. (See **Table A.**).

As to the principal tributaries of Liao viz. Hun-ho and Tai-tzu-ho the number of actual discharge measurements are very few and the data are still meager; however for reference' sake the results in so far obtained are put in the following list expecting that certain corrections and supplements shall be made in due course of time when more frequent actual measurements are tried.

Discharge of Tai-tzu-ho (1926)

AT S.M.R.W. CROSSING AT LIAO-YANG.

Equation of discharge rating curve	$x=821.568\ (y-160.48)^2$ for stages higher than 161.4 ft.
	$x=61.62\ (y-158.0)^2$ for stages lower than 161.4 ft.
Drainage area	3 364 sq. miles
Yearly total discharge	78 571 814 400 cub. ft.
Daily average	2 491 ,, p.s.
Maximum	92 834 ,, ,, in Summer
Minimum	320 ,, ,, ,,

Discharge of Hun-ho (1926)

AT S.M.R.W. CROSSING AT MUKDEN.

Equation of discharge rating curve	$x=973.23\ (y-216.98)^2$ for stages higher than 217.35 ft.
	$x=9.94\ (y-213.67)^2$ for stages lower than 217.35 ft.
Drainage area	3 147 sq. miles
Yearly total discharge	182 727 964 800 cub. ft.
Daily average	5 794.3 ,, p.s.
Maximum	59 820 ,, ,, in Summer
Minimum	0 Cub. ft. p.s.

(6) SUMMER FLOOD.

Probable coming of high water in Liao in 1926 was forecast by the

Engineer-in-Chief in his annual report for 1925 and unfortunately this forecast was realized by the rain fall of 226.1 m.m. in South Manchuria since the middle part of August as observed by the Branch Meteorological station of Kwangtung Provincial Government which resulted in the high flood submerging the entire work site under water. The flood was of rather prolonged nature as is seen from the following list of gauge reading at Erh-tao-chiao.

Gauge reading at Erh-tao-chiao, (1926)

August	19th	113.00 feet	August	26th	115.00 feet
〃	20th	114.30 〃	〃	27th	114.90 〃
〃	21st	115.10 〃	〃	28th	115.20 〃
〃	22nd	116.10 〃	〃	29th	115.90 〃
〃	23rd	116.70 〃 (Maximum)	〃	30th	116.50 〃
〃	24th	115.70 〃	〃	31st	116.40 〃
〃	25th	115.40 〃	Sept.	1st	116.30 〃
			〃	6th	113.00 〃

The warning as to the most probable coming of the flood was issued to the work site by the Enginner-in-Chief on the 17th of August and the river water at the stage of 113.00 ft. Yingkou datum viz. at bankful stage at Erh-tao-chiao began to rise on the 19th and finally reached to 116.70 ft. on the 23rd which was the culmination of this flood and it was still keeping the stage of 116.40 ft. on the 31st although it fell back to the bankful stage of 113 ft. on the 6th of September.

The said flood ranks the third in its height among the known high floods since the inauguration of our gauge observation at Erh-tao-chiao in the Upper Liao as may be seen from the following list, and it made harm to our works in causing a delay of nearly one month's job as was stated previously.

Yearly Highest Water Stage at Erh-tao-chiao.

1921	July	24th	117.30 feet
1922	Aug.	9th	116.60 〃
1923	〃	21st	118.00 〃
1924	〃	29th	115.30 〃
1925	〃	27th	112.80 〃
1926	〃	23rd	116.70 〃

Cycle of high precipitation and flood.

The diagram of periodic cycles which the heavy rainfall and the high flood take is shown on **Plate 7** in so far as we could have data in hand (See

Plate 8 & **9**) and it is from this diagram that the Engineer-in-Chief's forecast as to the probable coming of flood was based.

The combination diagram **Plate 7** prepared in combining the results of water gauge observations made in the past few years in Liao Valley and the meteorological observations made in 21 years past by the Kwan-tung Provincial Branch Meteorological Observatory Yingkou seems to give in so far the hints as to the general tendency summarized as follows:—

(1) In the lower reach of Liao-ho very high flood usually comes in a year having annual precipitation of more than 600 m.m. which is quite close to average annual precipitation in 21 years past at Yingkou.

(2) In a year having annual precipitation of less than 500 m.m. at Yingkou the high water does not overflow to a remarkable extent or no overflow at all.

(3) Annual precipitation of less than 500 m.m. occurs once in every 6 to 7 years.

(4) Annual precipitation of more than 600 m.m. usually occurs once in every two or three years, sometimes in 2 consecutive years and rarely in 3 consecutive years.

(5) Annual precipitation of more than 800 m.m. occurred 5 times in 21 years past.

(6) Annual precipitation of more than 1 000 m.m. occurred 3 times in 21 years past.

(7) SCHEDULE OF INSPECTION OF THE WORKS.

The Engineer-in-Chief visited and inspected the Conservancy works during the season as under:—

May 5th–9th.	Supervising works of new cutting including driving of wooden foundation piles and concrete sheet piles for weir & lock at Erh-tao-chiao under contract and also checking the newly erected automatic tide gauge of "Richard" type in Shuang-tai-tzu channel at Erh-tao-chiao.
June 16th–July 25th	Inspecting Niu-chia-tun stone yard arrangement. Inspecting stone quarry at Ta-shih-chiao from which broken stone are taken.
Aug. 22nd	Examining broken stone for the Bank Protection Work collected at Ta-Shih-Chiao quarry.
Sept. 5th–9th	Supervising works of new cutting including foundation pile driving for Weir & Lock and earth works at Lin-chia-wo-pu, Hoi-kwang-tzu, Shuang-chin-tzu and Erh-shih-li-pu under Contract and the fabrication

	of concrete block for bank protection mattress under administration at Erh-tao-chiao.
Sept. 19th	Supervising loading of junks with broken stones at Niu-chia-tun stone yard to be sent upstream for bank protection work.
Oct. 3rd	Inspecting stone yard at Niu-chia-tun.
Oct. 15th—17th	Inspecting the earth work of cutting line "A" at Yui-chia-lo-pu, Ho-yen and San-chia-pu that is a section 5½ miles from Chia-shin-tzu, the lowest end of the cut, and wherein the earth work force is concentrated to attack these principal dry places in the cut at present.
Nov. 2nd—6th	Inspecting bank protection work at Erh-tao-chiao, driving and grouting of concrete sheet piles and excavation of foundation for Weir & Lock at Erh-tao-chiao and also earth works along the whole of the cutting line "A".
Nov. 20th	Inspeting stone yard at Niu-chia-tun.

The Clerk of the Engineer-in-Chief's Office visited the work site during this season as under:—

Nov. 18th—20th	The Clerk, Mr. H. Yamamoto visited the camp at Erh-tao-chiao to check the amount of Conservancy's building materials kept for the bank protection work.

TABLE A—(1)

DISCHARGE TABLE FOR LIAO-HO AT TANG-CHIA-WO-PU 1926.

Date	Gauge height	Discharge for Liaoho at above Tangchia-wopu.	Discharge for Liaoho at below Tangchia-wopu.	Date.	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu.
Jan.				Feb.			
1	112.9	641.2	124.1	1	112.7	544.5	97.3
2	112.9	641.2	124.1	2	112.7	544.5	97.3
3	112.9	641.2	124.1	3	112.7	544.5	97.3
4	112.9	641.2	124.1	4	112.7	544.5	97.3
5	112.9	641.2	124.1	5	112.6	499.1	88.5
6	112.9	641.2	124.1	6	112.6	499.1	88.5
7	112.9	641.2	124.1	7	112.6	499.1	88.5
8	112.9	641.2	124.1	8	112.6	499.1	88.5
9	112.9	641.2	124.1	9	112.6	499.1	88.5
10	112.9	641.2	124.1	10	112.6	499.1	88.5
11	112.9	641.2	124.1	11	112.6	499.1	88.5
12	112.9	641.2	124.1	12	112.6	499.1	88.5
13	112.9	641.2	124.1	13	112.6	499.1	88.5
14	112.9	641.2	124.1	14	112.6	499.1	88.5
15	112.9	641.2	124.1	15	112.6	499.1	88.5
16	112.9	641.2	124.1	16	112.5	459.7	77.9
17	112.9	641.2	124.1	17	112.5	459.7	77.9
18	112.9	641.2	124.1	18	112.5	459.7	77.9
19	112.9	641.2	124.1	19	112.5	459.7	77.9
20	112.9	641.2	124.1	20	112.5	459.7	77.9
21	112.9	641.2	124.1	21	112.5	459.7	77.9
22	112.8	591.8	109.9	22	112.5	459.7	77.9
23	112.8	591.8	109.9	23	112.5	459.7	77.9
24	112.8	591.8	109.9	24	112.5	459.7	77.9
25	112.8	591.8	109.9	25	112.5	459.7	77.9
26	112.8	591.8	109.9	26	112.5	459.7	77.9
27	112.8	591.8	109.9	27	112.5	459.7	77.9
28	112.8	591.8	109.9	28	112.5	459.7	77.9
29	112.7	544.5	97.3				
30	112.7	544.5	97.3				
31	112.7	544.5	97.3				
Average daily discharge in cub. ft. per second		620.7	118.3			487.3	84.8
Monthly total discharge in cub. ft.		1 662 482 880.	316 854 720.		1 178 876 160.	205 148 160.	

TABLE A—(2)

Date March	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu	Date April	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu
1	112.5	459.7	77.9	1	115.4	4 192.2	1 143.4
2	112.6	499.1	88.5	2	115.6	4 530.9	1 249.0
3	112.6	499.1	88.5	3	115.5	4 359.9	1 195.6
4	112.6	499.1	88.5	4	116.7	6 628.6	1 913.6
5	112.6	499.1	88.5	5	117.1	7 490.1	2 190.2
6	112.6	499.1	88.5	6	117.2	7 713.6	2 261.8
7	112.6	499.1	88.5	7	117.6	8 711.0	2 542.6
8	112.6	499.1	88.5	8	118.4	11 121.8	3 244.1
9	112.7	544.5	97.3	9	118.8	12 437.4	3 626.7
10	112.7	544.5	97.3	10	119.6	15 286.8	4 453.7
11	112.7	544.5	97.3	11	118.7	12 102.2	3 529.7
12	112.7	544.5	97.3	12	118.6	11 769.3	3 431.6
13	112.9	641.2	124.1	13	118.4	11 121.8	3 244.1
14	113.3	858.2	184.5	14	118.2	10 492.7	3 061.9
15	113.5	978.5	219.5	15	118.2	10 492.7	3 061.9
16	113.7	1 106.8	256.7	16	118.4	11 121.8	3 244.1
17	113.8	1 173.8	276.1	17	118.2	10 492.7	3 061.9
18	114.1	1 386.9	339.7	18	118.0	9 879.7	2 881.4
19	114.1	1 386.9	339.7	19	117.6	8 711.0	2 542.6
20	114.1	1 386.9	339.7	20	117.7	8 998.0	2 627.4
21	114.2	1 461.8	362.1	21	117.4	8 155.4	2 380.6
22	114.0	1 313.9	318.1	22	117.1	7 490.1	2 190.2
23	113.8	1:173.8	276.1	23	117.0	7 269.8	2 119.6
24	114.6	1 781.5	459.1	24	116.8	6 839.0	1 980.7
25	114.2	1 461.8	362.1	25	116.6	6 421.5	1 846.7
26	113.6	1 041.7	233.3	26	116.4	6 017.0	1 788.5
27	113.7	1 106.8	256.7	27	119.4	6 017.0	1 788.5
28	114.1	1 386.9	339.7	28	116.3	5 819.8	1 655.6
29	114.2	2 436.4	603.5	29	116.1	5 435.1	1 533.9
30	114.4	2 696.2	682.5	30	116.0	5 247.6	1 474.8
31	114.6	2 969.1	765.1				
Average daily discharge in cub. ft. per second		1 092.9	252.4			8 412.2	2 442.2
Monthly total discharge in cub. ft.		2 927 223 360.	676 028 160.			21 804 422 400.	6 330 182 400.

TABLE A–(3)

Date	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu	Date	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu
May				June			
1	115.8	4 882.7	1 359.0	1	113.2	1 335.0	281.0
2	115.3	4 882.7	1 359.0	2	113.0	1 154.0	230.0
3	115.7	4 705.7	1 303.9	3	112.9	1 069.0	207.0
4	115.5	4 359.9	1 195.6	4	112.7	907.0	162.0
5	115.4	4 192.2	1 143.4	5	112.8	986.0	183.0
6	115.2	3 866.7	1 041.4	6	112.6	832.0	148.0
7	115.1	3 708.8	992.5	7	112.6	832.0	148.0
8	115.1	3 708.8	992.5	8	112.4	690.0	105.0
9	114.8	3 255.1	852.2	9	112.5	766.0	130.0
10	114.7	3 110.4	808.0	10	112.4	690.0	105.0
11	114.6	2 969.1	765.1	11	112.6	832.0	148.0
12	114.5	2 831.0	723.2	12	112.4	690.0	105.0
13	114.4	2 696.2	682.5	13	112.4	690.0	105.0
14	114.3	2 564.6	641.8	14	112.4	690.0	105.0
15	114.2	2 436.4	603.5	15	112.4	690.0	105.0
16	114.1	2 311.5	566.2	16	112.3	625.0	88.0
17	114.0	2 189.8	530.1	17	112.3	625.0	88.0
18	113.8	1 956.4	460.3	18	112.2	562.0	72.0
19	113.7	1 844.6	427.7	19	112.2	562.0	72.0
20	113.6	1 736.1	388.7	20	112.2	562.0	72.0
21	113.5	1 630.8	365.8	21	112.1	503.0	58.0
22	113.5	1 630.8	365.8	22	112.1	503.0	58.0
23	113.5	1 630.8	365.8	23	112.1	503.0	58.0
24	113.4	1 528.9	336.5	24	113.1	1 243 0	255.0
25	113.3	1 430.3	307.4	25	113.3	1 430.0	307.0
26	113.3	1 430.3	307.4	26	113.5	1 631.0	366.0
27	113.4	1 528.9	336.5	27	113.6	1 736.0	389.0
28	113.5	1 630.8	365.8	28	113.0	1 154.0	230.0
29	113.4	1 528.9	336.5	29	112.9	1 069.0	207.0
30	113.3	1 430.3	307.4	30	112.7	907.0	162.0
31	113.1	1 242.9	254.8				
Average daily discharge per second in cub ft.		2 608.1	660.8			882.3	158.3
Monthly total discharge in cub. ft.		6 985 535 040.	1 769 886 720.			2 286 921 600.	410 313 600.

TABLE A—(4)

Date	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu	Date	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu
July				August			
1	112.5	766.1	129.8	1	120.3	18 023.6	5 249.7
2	112.5	766.1	129.8	2	119.4	14 547.5	4 239.6
3	112.7	907.5	162.1	3	118.9	12 777.2	3 725.2
4	112.6	831.9	147.5	4	118.8	12 437.4	3 626.7
5	113.7	1 844.6	427.7	5	119.7	15 665.6	4 565.0
6	114.0	2 189.8	530.1	6	119.8	16 046.7	4 675.4
7	113.9	2 071.4	495.1	7	118.8	12 437.4	3 626.7
8	113.6	1 736.1	388.7	8	118.7	12 102.2	3 529.7
9	113.3	1 430.3	307.4	9	118.9	12 777.2	3 725.2
10	113.0	1 154.4	230.4	10	119.2	13 826.5	4 030.7
11	113.0	1 154.4	230.4	11	119.4	14 547.5	4 239.6
12	112.8	986.4	183.3	12	118.9	12 777.2	3 725.2
13	112.6	831.9	147.5	13	119.5	14 914.8	4 345.9
14	112.6	831.9	147.5	14	120.4	18 432.3	5 368.0
15	112.6	831.9	147.5	15	120.9	20 546.9	5 982.1
16	112.5	766.1	129.8	16	120.8	20 115.7	5 857.5
17	112.4	690.5	105.6	17	120.2	17 619.5	5 132.6
18	112.9	1 068.6	206.7	18	120.1	17 217.7	5 014.6
19	113.3	1 430.3	307.4	19	120.8	20 115.7	5 857.5
20	114.3	2 564.6	641.8	20	122.5	28 084.7	8 170.2
21	114.4	2 696.2	682.5	21	123.7	34 511.8	10 037.0
22	114.2	2 436.4	603.5	22	124.6	39 762.1	11 558.9
23	116.7	6 628.6	1 913.6	23	124.8	40 981.3	11 913.6
24	117.2	7 713.6	2 261.8	24	123.8	35 076.0	10 200.0
25	118.2	10 492.7	3 061.9	25	122.4	27 579.5	8 023.8
26	118.5	11 443.3	3 337.2	26	121.9	25 120.5	7 310.0
27	118.4	11 121.8	3 244.1	27	120.8	20 115.7	5 057.5
28	118.0	9 879.7	2 881.4	28	122.1	26 089.4	7 590.6
29	118.2	10 492.7	3 061.9	29	123.0	30 681.4	8 919.9
30	118.4	11 121.8	3 244.1	30	124.0	36 219.4	10 526.4
31	120.2	17 619.5	5 132.6	31	122.7	29 107.3	8 501.2
Average daily discharge in cub. ft. per second		4 080.7	1 116.8			21 621.2	6 294.4
Monthly total discharge in cub. ft.		10 929 746 880.	2 991 237 120.			57 910 222 080.	16 858 920 960.

TABLE A—(5)

Date	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu	Date	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu
Sept.				Oct.			
1	121.5	23 235.5	6 772.4	1	116.5	6 217.6	1 782.8
2	120.7	19 688.2	5 733.4	2	116.5	6 217.6	1 782.8
3	120.3	18 023.6	5 249.7	3	116.4	6 017.0	1 719.1
4	119.8	16 046.7	4 675.4	4	116.5	6 217.6	1 782.8
5	119.4	14 547.5	4 239.6	5	116.3	5 819.8	1 655.6
6	119.1	13 470.6	3 926.0	6	116.1	5 435.1	1 533.9
7	118.9	12 777.2	3 725.2	7	116.0	5 247.6	1 474.8
8	118.6	11 769.3	3 431.6	8	116.2	5 625.8	1 594.2
9	119.5	14 914.8	4 345.9	9	116.1	5 435.1	1 533.9
10	119.6	15 286.8	4 453.7	10	116.0	5 247.6	1 474.8
11	119.1	13 470.6	3 926.0	11	115.7	4 705.1	1 303.3
12	118.7	12 102.2	3 529.7	12	115.7	4 705.1	1 303.3
13	118.6	11 769.3	3 431.6	13	115.6	4 530.9	1 249.0
14	118.8	12 437.4	3 626.7	14	115.5	4 359.9	1 195.6
15	119.3	14 184.7	4 134.5	15	115.5	4 359.9	1 195.6
16	118.8	12 437.4	3 626.7	16	115.3	4 027.8	1 091.2
17	118.5	11 443.3	3 337.2	17	115.3	4 027.8	1 091.2
18	118.7	12 102.2	3 529.7	18	115.2	3 866,7	1 041.4
19	119.1	13 470.6	3 926.0	19	115.4	4 192.2	1 143.4
20	119.5	14 914.8	4 345.9	20	115.5	4 359.9	1 195.6
21	118.1	10 182.8	2 949.3	21	115.4	4 192.2	1 143.4
22	117.8	9 287.3	2 711.1	22	115.4	4 192.2	1 143.4
23	117.6	8 711.0	2 542.6	23	115.3	4 027.8	1 091.2
24	111.5	8 430.9	2 461.4	24	115.2	3 866.7	1 041.4
25	117.1	7 490.1	2 190.2	25	115.2	3 866.7	1 041.4
26	117.6	8 711.0	2 542.6	26	115.2	3 866.7	1 041.4
27	118.3	10 805.0	3 152.4	27	115.2	3 866.7	1 041.4
28	118.0	9 879.7	2 881.4	28	115.2	3 866.7	1 041.4
29	117.3	7 940.5	2 334.7	29	115.1	3 708.8	992.5
30	117.0	7 269.8	2 119.6	30	115.0	3 554.3	945.0
				31	115.0	3 554.3	945.0
Average daily discharge in cub. ft. per second		12 560.0	3 661.7			4 618.7	1 277.8
Monthly total discharge in cub. ft.		32 555 520 000.	9 491 126 400.			12 370 726 080.	3 422 459 520.

TABLE A—(6)

Date Nov.	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu	Date Dec.	Gauge height	Discharge for Liaoho at above Tangchia-wopu	Discharge for Liaoho at below Tangchia-wopu
1	115.0	3 554.3	945.0	1	114.4	1 617.7	409.5
2	114.9	3 403.1	898.6	2	114.3	1 538.8	385.1
3	115.0	3 554.3	945.0	3	113.9	1 242.8	297.0
4	115.5	4 359.9	1 195.6	4	113.9	1 242.8	297.0
5	115.0	3 554.3	945.0	5	113.8	1 173.8	276.1
6	115.0	3 554.3	945.0	6	113.8	1 173.8	276.1
7	115.0	3 554.3	945.0	7	113.8	1 173.8	276.1
8	115.0	3 554.3	945.0	8	113.8	1 173.8	276.1
9	115.0	3 554.3	945.0	9	113.8	1 173.8	276.1
10	115.0	3 554.3	945.0	10	113.9	1 242.8	297.0
11	115.0	3 554.3	945.0	11	113.9	1 242.8	297.0
12	115.0	3 554.3	945.0	12	113.8	1 173.8	276.1
13	115.2	3 866.7	1 041.4	13	113.9	1 242.8	297.0
14	115.3	4 027.8	1 091.2	14	113.7	1 106.8	256.7
15	115.6	4 530.9	1 249.0	15	113.7	1 106.8	256.7
16	115.6	4 530.9	1 249.0	16	113.6	1 041.7	233.3
17	115.7	4 705.1	1 303.3	17	113.6	1 041.7	233.3
18	115.7	4 705.1	1 303.3	18	113.5	978.5	219.5
19	115.9	5 063.5	1 416.9	19	113.5	978.5	219.5
20	115.6	4 530.9	1 249.0	20	113.5	978.5	219.5
21	115.4	2 515.3	686.0	21	113.5	978.5	219.5
22	115.1	2 225.3	595.5	22	113.5	978.5	219.5
23	115.0	2 132.6	567.0	23	113.5	978.5	219.5
24	114.7	1 866.2	484.8	24	113.5	978.5	219.5
25	114.2	1 461.8	362.1	25	113.5	978.5	219.5
26	114.2	1 461.8	362.1	26	113.5	978.5	219.5
27	114.2	1 461.8	362.1	27	113.5	978.5	219.5
28	114.0	1 313.9	318.1	28	113.5	978.5	219.5
29	114.1	1 386.9	339.7	29	113.5	978.5	219.5
30	114.0	1 313.9	318.1	30	113.5	978.5	219.5
				31	113.5	978.5	219.5
Average daily discharge in cub. ft. per second.		3 213.5	861.4			1,110.0	257.7
Monthly total discharge in cub. ft.		8 329 392 000.	2 232 748 800.			2 973 024 000.	690 223 680.
Average daily discharge in cub. ft. per second through a year.						5 134.2	1 439.5
Yearly total discharge in cub. ft.						161 914 092 480.	45 395 130 240.

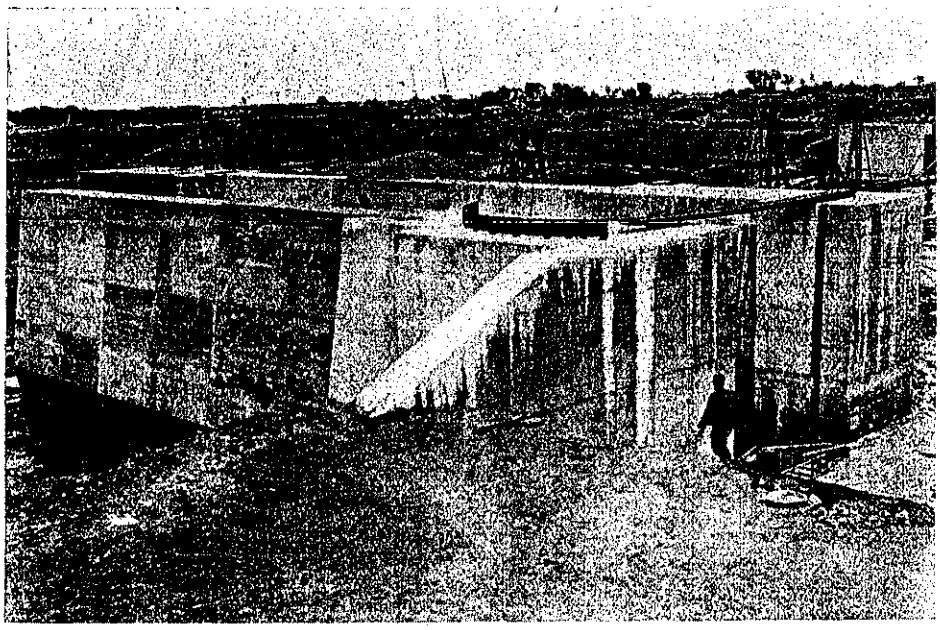
Remark:

For calculation of discharge between January 1st. and March 28th. and between Nov. 21st.. and December 31st. 60 percent of that corresponding to the actual gauge height is taken.

Pl. 1

Concrete mattress bank protection work.

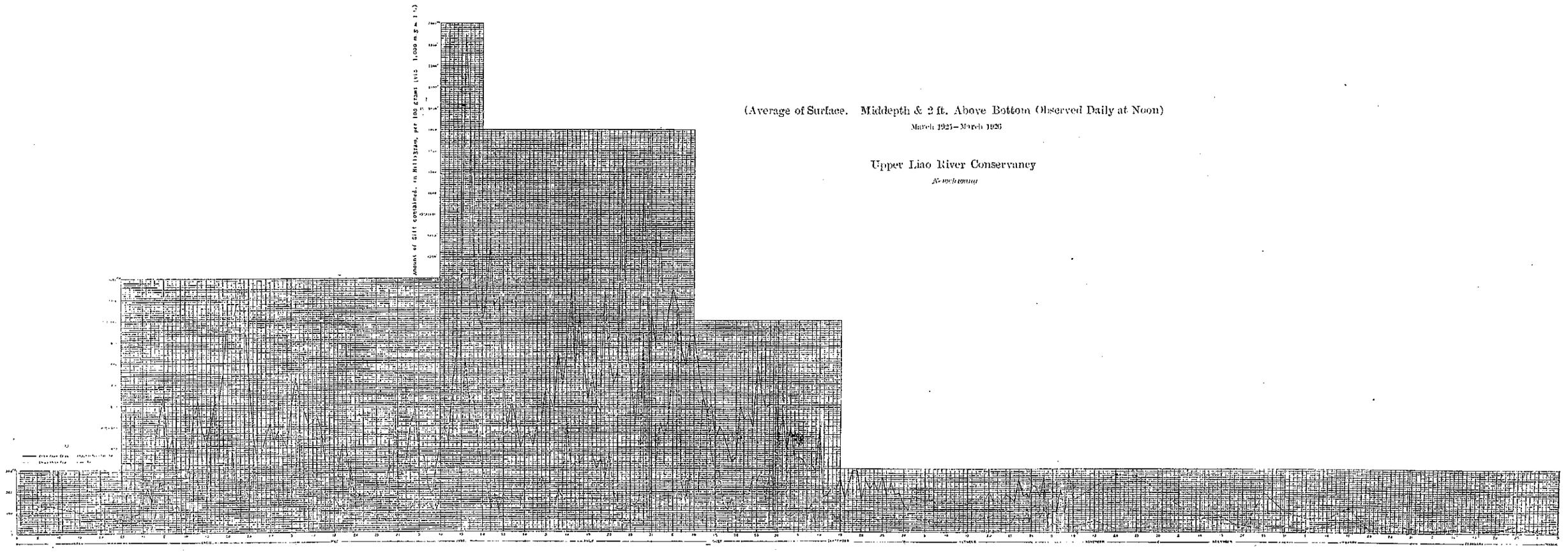
Pl. 2



The picture taken in May 1927, shows the concrete side walls of the lock chamber at Erh-tao-chiao, almost completed, black strip of steel upon top of land wall being a part of mechanism for operating the lock gates.

An isolated wall appearing near the upper right corner of the picture is a portion of side wall on the opposite bank of the weir under construction and is 300 ft. apart from the lock site.

Pl. 3 Silt diagrams for Shuang-tai-tzu Channel at Erh-tao-chiao and Liao-ho at Chia-shin-tzu.



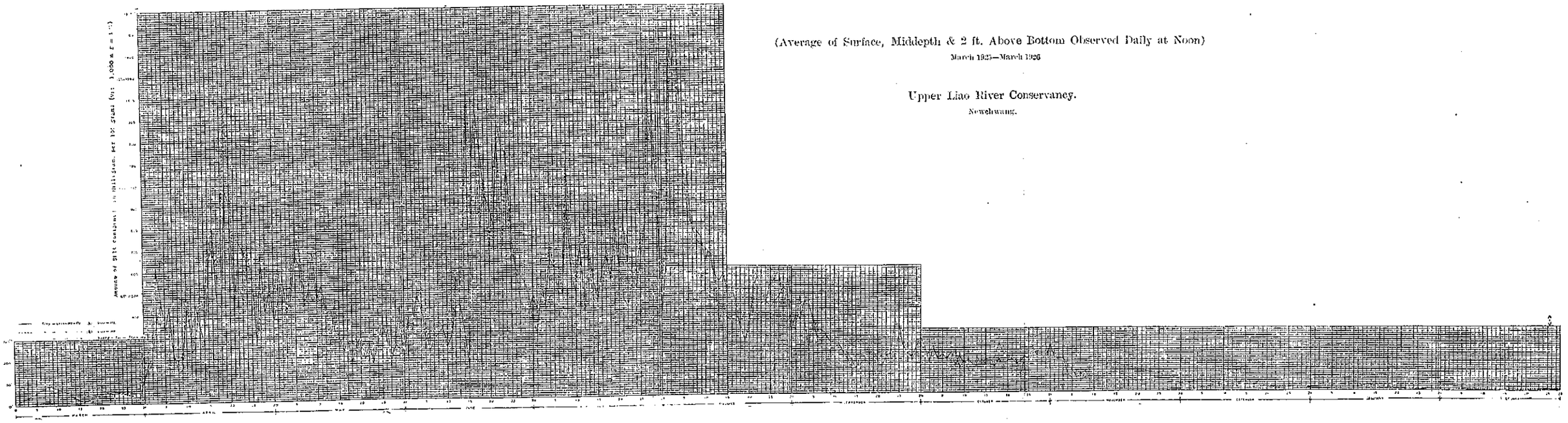
(Average of Surface, Middepth & 2 ft. Above Bottom Observed Daily at Noon)

March 1925–March 1926

Upper Liao River Conservancy

Newchwang

Pl. 4. Silt diagrams for Liao-ho and Shuang-tai-tzu channel at Tang-chia-wo-pu.



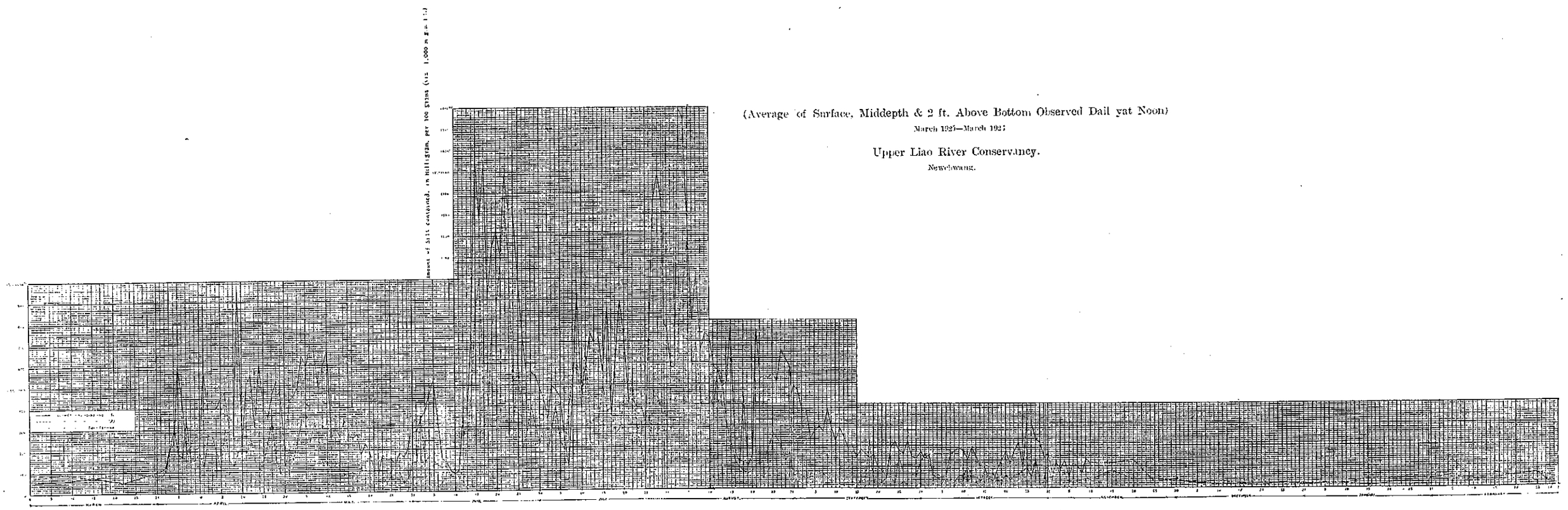
(Average of Surface, Middepth & 2 ft. Above Bottom Observed Daily at Noon)

March 1925—March 1926

Upper Liao River Conservancy.

Newchwang.

Pl. 5. Silt diagrams for Liao-ho and Tai-tzu-ho at San-chia-ho.



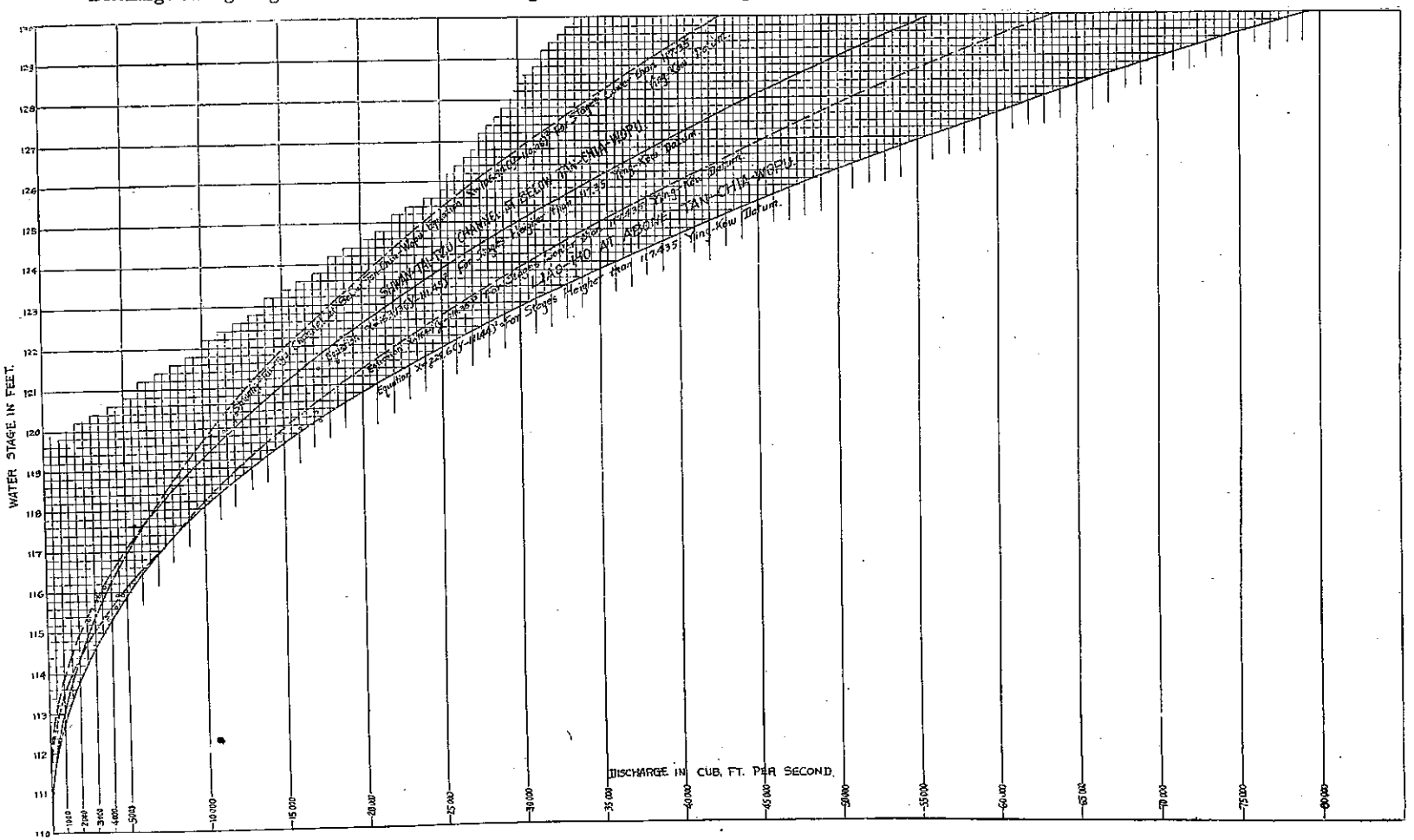
(Average of Surface, Middepth & 2 ft. Above Bottom Observed Dail yat Noon)

March 1925—March 1926

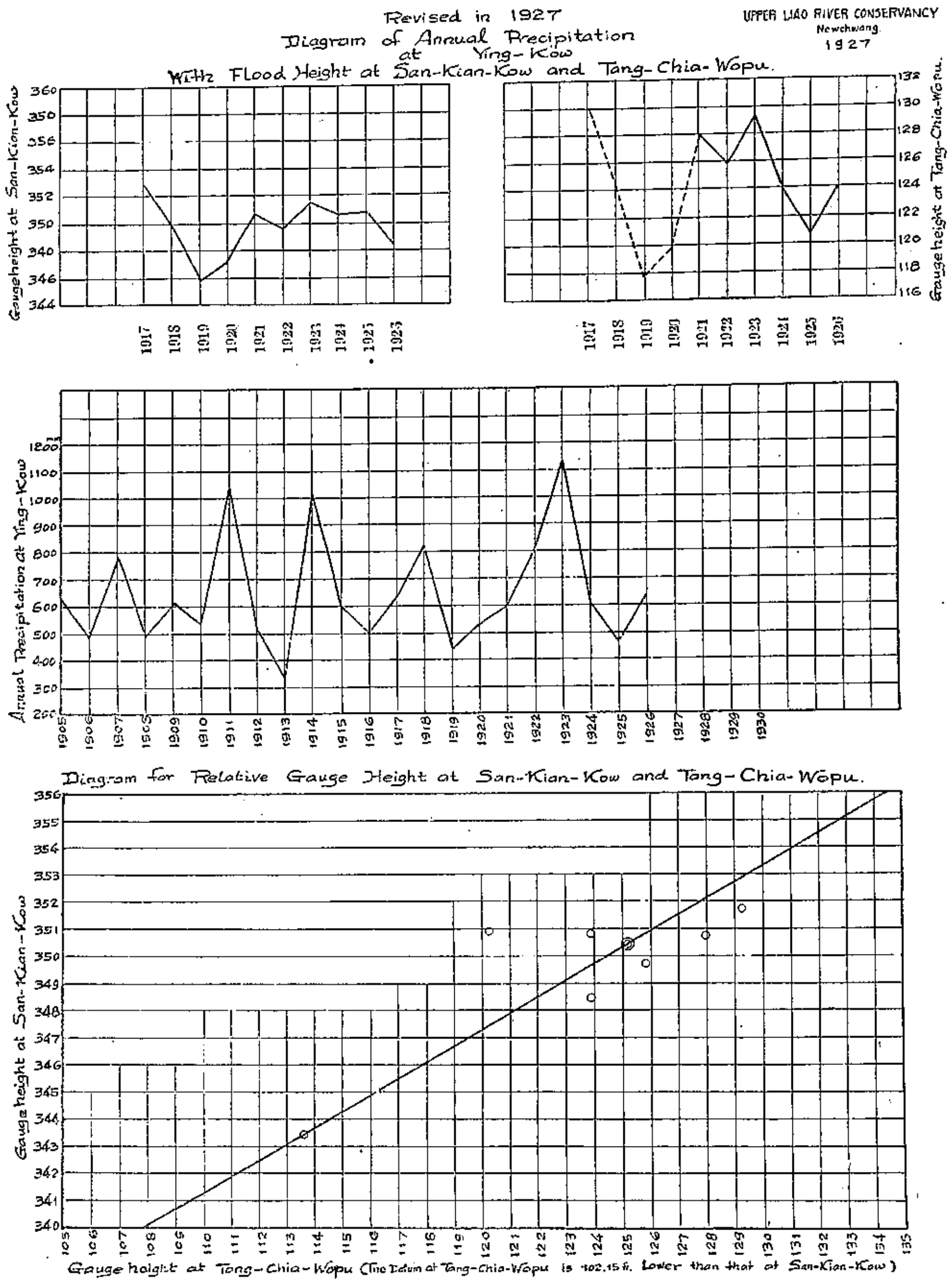
Upper Liao River Conservancy.

Newchwang.

Pl. 6 Discharge rating diagram for Liao-Ho and Shuang-tai-tzu channel at Tang-chia-wo-pu.

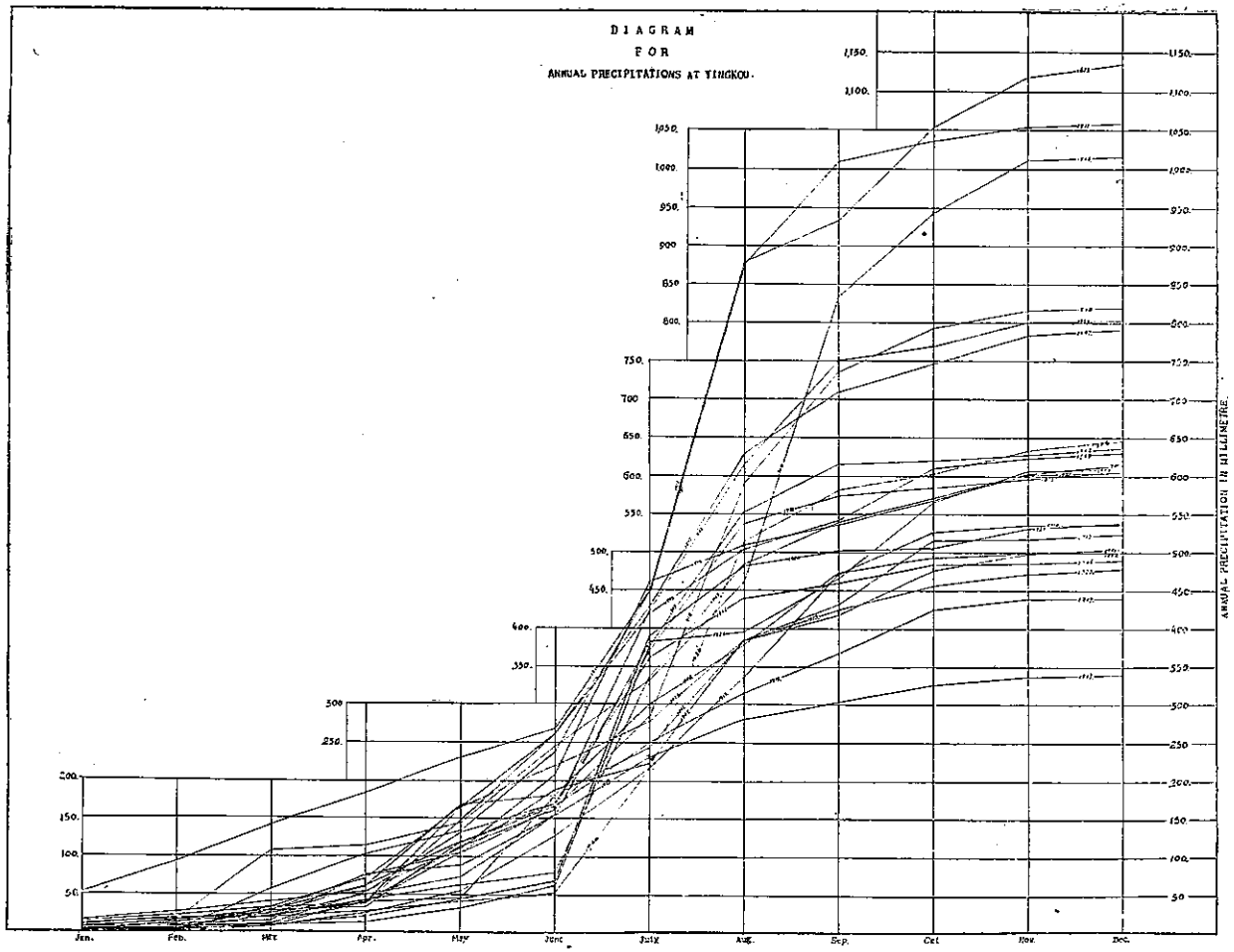


Pl. 7 Combination diagram for precipitation and flood height.



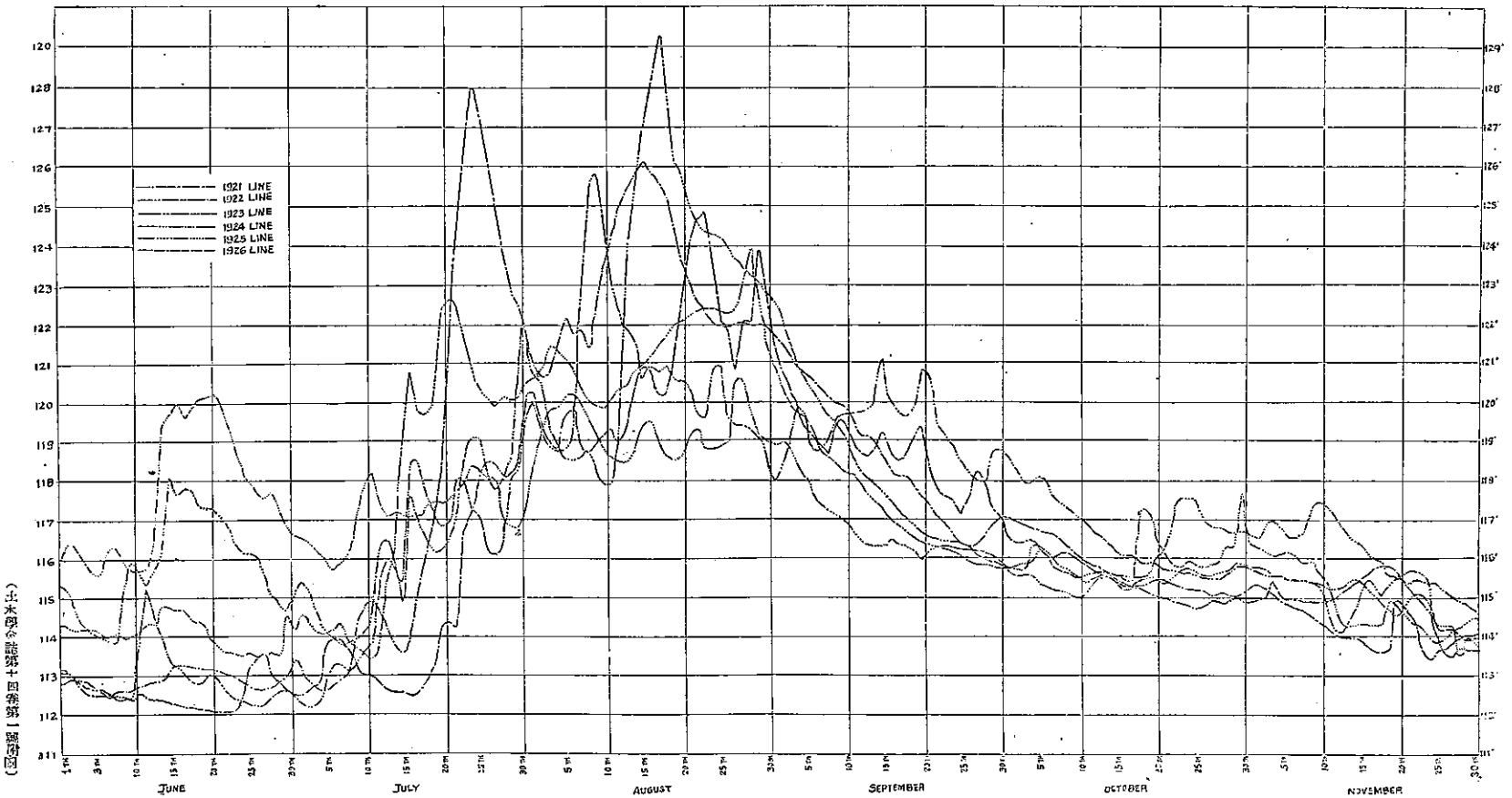
(土木學會誌第十四巻第1號附図)

Pl. 8 Rainfall diagram at Yingkou.



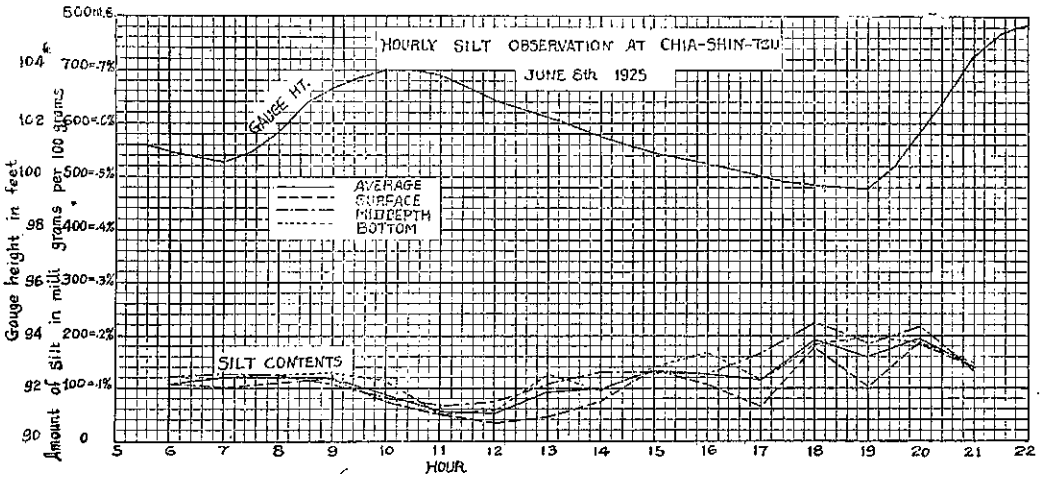
(土木學會誌第十四卷第一號附圖)

Pl. 9 Comparative gauge diagram for summer flood at Tang-chia-wo-pu.



(中央觀象臺彙報第十四卷第一號附圖)

Pl. 10 Hourly silt diagram of Liao at Chia-shin-tzu.



Pl. 11 Hourly silt diagram of Liao at San-chia-ho.