a report to the Water Conservation Royal Commission, sketched out (for the district) a general scheme, portion of which has since been carried out, viz.—the Warren Weir and offtake cutting into the Burlong Creek, together with cuttings to lead this water into the Gunningbar and Crooked Creeks. The total length of the Gunningbar, Duck, and Crooked Creeks, influenced by the Warren Weir, is upwards of 1000 miles. The survey was made in 1894; Contract works were commenced in May, 1895, and finished in April, 1896.

(II.) Warren Weir Works.

Site of the Works.—Three miles above Warren the Burlong Creek approaches to within 1000 feet of the river, which at this place resembles a horseshoe in shape, the distance across the neck being about 100 yards, and the distance round the bend being about three-quarters of a mile. It was decided to cut a new channel across this narrow neck, build a timber weir in the new channel, cut an offtake channel from the river to the creek, and place an earthen dam across the existing river channel just below the offtake to the creek. This dam diverts most of the river water over the weir, while a smaller proportion passes out through the offtake into the Burlong Creek.

Weir Cutting.—The lower end of the cutting was excavated to a sufficient depth to allow pile driving to be commenced, and this was then carried on simultaneously with the excavation. The upper end of the cutting was removed as soon as the work at the lower end became confined to a small area, the ends of the cutting at the river banks being left intact, to prevent flooding of the working in the river. This greatly increased the difficulty and cost of excavating the cutting at the lower side of the weir, since the road out was rendered very steep and confined. The deepest portion of the excavation is at the watercushion, where it is about 6 feet below the usual water level in the river. The pile driving in the lower portion of the work opened cracks which formed springs: the water from these was at first pumped out by hand, but subsequently with a 4 inch steam rotary pump. The ends of the cutting were removed when the timber work of the weir was almost completed. The excavated material was utilised to form the seat of the dam across the river, a connecting bank from the weir to the dam, and a spoil bank on either side of the weir cutting. The spoil banks have a front batter of 1½ to 1, and slope backward from the cutting so as to run the rain water away, and prevent the formation of gutters down the sides.

Timber Weir.—The weir is constructed of timber crib work, and is 180 feet long on the crest between the side slopes of the cutting. The

central 20 feet of the crest is finished at R.L. 634, or 12 feet above the height at which the river ceases to flow ; thence on either side it rises in 6 steps each of 1 foot, the first 5 steps being 10 feet and the last step 30 feet long. The central cross section has 3 drops each of 3 feet, and one of 6 feet, the latter forming a watercushion 10 feet wide by 3 feet deep. Transversely the weir is divided into three sections, the central of which is 80 feet long, and 3 feet lower than the outer sections. The piles are of ironbark from the Dubbo-Telgandra forest, 16 inches in diameter at the small end, in 8 rows 10 feet apart, except at the sides of the weir ; seven of these rows extend up the banks to carry the protective sheathing. The piles were driven to a minimum depth of 10 feet in the solid ground, each row being driven before the corresponding step was excavated in order to prevent the earth being split off, but nevertheless large cracks opened up from pile to pile during driving, owing to the unyielding nature of the ground. As it was exceedingly desirable to preserve the solidity of the ground, holes 1 foot in diameter by 6 feet deep were accordingly bored before driving the succeeding piles, and the cracking was then found to be very much reduced.

The bearers consist of round gum logs, 12 inches in diameter, dressed for the floor logs, and bolted longitudinally from pile to pile. Inclined longitudinal struts from pile to pile were also specified originally, but these would have necessitated a series of deep trenches, with risk of the formation of underground waterways, and since the weir has ample strength without them, they were accordingly omitted.

The faces of the steps are formed of long straight gum logs 12 inches in diameter, adzed on two sides, and bolted to the upstream sides of the piles. The logs were laid in long lengths breaking joint at the piles, and connected with diagonal scarf joints. At the junction between the transverse and longitudinal vertical faces, one log was halved across the other, forming a "pig-sty" corner.

The floor logs are of local pine, 12 inches in diameter at the small end, faced into the heartwood on the two touching sides, and trimmed for the bearers and holding-down ties.

The holding-down ties are of 10-inch gum logs, bolted to the piles at both ends, except at the top row where the up-stream end of the tie is let into a tapered recess. If necessary, the ties can be removed, and the floor logs, which are not bolted down, can be raised so that the cribs may be repacked.

The sides of the cutting for a height of 20 feet above the weir are protected by pine logs, dressed and laid in a similar manner to the floor logs.

The whole of the weir is surrounded by a curtain of sheet piling 4 inches thick and 10 feet deep, with edges dressed to make a close-fitting joint. The piles were carefully driven whilst dry, and subsequently when wet they swelled, making a water-tight joint. An extra row of piles and sheeting, forming an open apron, was driven on the down-stream side of the weir. The crest is formed of squared timber. The whole of the work is securely bolted together.

Gravel filling was placed behind the face logs of the cribs, and in front of the sheet piling at the crest. The cribs were filled up and the material carefully rammed in thin layers before the floor logs were laid, but the only gravel obtainable was very fine, and the back of the

face logs was accordingly sheeted with 1½ rebated pine cleating. Most of the gravel on the upstream side of the crest was soon washed out; it was at first replaced with clay in bags, but afterwards with proper stone pitching. A large cavity was also eroded between the row of sheeting at the toe of the weir and the protective curtain. This was filled in and patched with stone, the pitch being continued for some distance below the apron. The banks below the weir are fretting away, partly owing to the lapping of the oscillating and disturbed waters, and partly to the fact that until the whole of the crest is covered, the strong, narrow current through the lower portion of the weir crest is projected into a much wider mass of sluggish water, and a very strong back eddy on either bank is set up. The velocity of approach of the current in the cutting above the weir rises to 5 miles per hour.

Offtake.—The offtake cutting is nearly 1000 feet long, 12 feet wide on the bottom, with side slopes of 1½ to 1, the level of the bed of the offtake being 1 foot higher than that of the lowest bay of the weir crest. From the lower end of the offtake cutting to the water level in the Burlong Creek, there is a fall of 7 feet, so that protective works were required at this point. It has never been clear to the author why the bed of the offtake channel, and thus necessarily the weir, was placed at such a height above the bed of the Burlong Creek. The weir is 12 feet high, whereas one 5 feet high with a deeper offtake channel combined with a regulator, would, in the author's opinion, have been equally effective, cheaper, and for many reasons, preferable. Such a weir could easily have been built in the bed of the river, thus saving the cost of the weir cutting. It is very doubtful if a weir under these conditions is required at all A fresh of 5 feet is but a small one, and any interference with the low river flow must always cause considerable trouble with riparian holders on the lower river.

The cutting was made through the same class of tenacious clay found in the weir cutting, the excavated material being used to form the dam across the river. The outlet and inlet of the cutting are finished at the same level.

At the lower end of the cutting there is a timber overfall 19 feet 4 inches wide with 3 drops, each of 3 feet 4 inches, the lowest one forming a watercushion. The crest is 1 foot 4 inches, the floor of the first drop 6 feet, the second floor 7 feet, and the floor of the watercushion 20 feet in width. There are three longitudiual rows of piles; those in the two outer rows are long enough to carry the 3 inch hardwood sheeting of which the sides are formed. The bearers consist of 12-inch x 9-inch gum, and the flooring and faces of the drops of 4-inch gum planking. There are two rows of sheet piling, one at the crest and extending three-quarters the way up the sides of the cutting, and the other at the lower end of the watercushion. The intersections of the vertical sides with the exposed sheet piling of the front side wings form two triangles projecting into the cutting. The first fresh to go through the cutting was 7 feet deep at the inlet, but only 3 feet deep at the crest of the overfall. This diminution in depth was not gradual, the greater part of it taking place in a most remarkable manner 250 feet up-stream from the crest. The velocity of approach at the crest was over 11 feet per second, and this rapid current striking against the

triangular projecting faces of the front sheeting caused severe eddies which cut into the bank as far as the sheeting extended. The hard crest also caused a downward strike along the piles; so that the water eventually found its way round and inside the sheet piling and caused the failure of the structure. The current was blocked at the upper end of the cutting by means of a bag dam. Had it not been for the exceedingly tenacious nature of the bed of the cutting, nothing could have prevented a deep excavation being cut back to the river, the course of which would temporarily, at least, have been diverted. The excavated material was very carefully replaced and an apron of 3 inch gum planking laid in the bed in front of the crest and continued up the sides to the top of the cutting. This reconstruction stood until a much heavier fresh caused a second failure, back eddies excavating the material from behind the vertical sides. These have since been removed and the sheeting laid level with the side of the cutting, and the altered structure has withstood several severe freshes without failure.

Earthen Dam.—The dam across the old course of the river was placed immediately below the inlet to the offtake channel. It is 2 feet above the maximum flood level, 20 feet wide on top, with an up-stream batter of 3 to 1, and a down-stream batter of 2 to 1, and is formed of the material taken from the weir and offtake cuttings. The site was cleared of all *debris* and loose material; a considerable portion of this area consisted of a large hole 10 feet below the level at which the weir ceases to flow. On the left the weir bank is composed of stiff clay; this was rough picked, whilst the right bank, which is sandy loam, was stripped, and a trench was cut into either bank to form a key for the dam.

Soon after the weir cutting was commenced, the seat of the dam was filled in up to the surface of the water with stiff arenaceous clay therefrom, but even with this firm material the toes of the bank spread out to great distances, the batter being as flat as 6 to 1 in places. Had the black surface loam from the offtake cutting been used for this purpose, very great difficulty would be experienced owing to the manner in which such material melts down as soon as it is placed in water. The small stream which was flowing at the time when the work was resumed was easily blocked, and the front of the dam was at once brought up in thin consolidated layers to about 8 feet above the water level. The river at this time had almost stopped running, and since there was little danger of the impounded water overtopping the newly-formed bank, the rest of the dam was brought up to the level of the front, and the whole taken up uniformly to the top. Each layer sloped inwards to the centre, and was well consolidated by cart traffic, so well indeed that in two years the settlemeut has been imperceptible. After the dam was brought up to its full height, the faces were cleaned down to a uniform batter. A number of small springs broke out along the right bank of the river, extending from the toe of the dam for a distance of 50 yards down-stream; but when the author visited the dam in June last, these springs had become less vigorous than when they first appeared. The spring water does not pass through the dam, but by seepage under the dam and through the right bank of the river. Wing embankments connect the dam to the spoil bank at the weir on the right bank, and to the bridge approach on the left bank. These are of

similar cross sections, and were consolidated in the same manner as the main dam.

Bridge over Offtake.—A three-span timber bridge at a skew of 30° carries the main road over the cutting.

Improvement Channels at the Overflow.—The channel connecting the Burlong Creek to the Gunningbar Creek is $2\frac{3}{4}$ miles long, 9 feet wide on the bottom, with side slopes of $1\frac{1}{2}$ to 1, and has a fall of 3 feet per mile.

The channel to the Crooked Creek is $1\frac{1}{4}$ miles long, 12 feet wide on the bottom, with side slopes $1\frac{1}{2}$ to 1, and has a fall of 1·12 feet per mile. The spoil banks were made in a similar manner to those at the weir cutting.

The beds of both creeks for a about 1 mile were excavated, where necessary, down to the grade line of the channels; standing timber and *debris* were also removed.

The channel to the Gunningbar was designed to carry twice as much water as the one to the Crooked Creek. The steep hydraulic grade of the former causes a very strong current in the channel, which is being continually increased both in depth and with. Except for the interference with the supply for the Crooked Creek, this enlargement is a decided advantage. The other channel shows signs of silting along its bed.

There has been no high flood in the river since the weir was constructed, and the effect of such an one still remains to be seen. There is, however, no doubt that the weir offtake channel diverts in times of fresh more water than is required or is desirable, and a regulator must eventually be built to control the flow. The importance of this work will not be fully realised by many of the inhabitants of the district until other necessary channels and works are made, such as cuttings to the Duck and Crooked (No. 3) Creeks, and regulators built at the Warren Weir offtake and at necessary places on the channels and creeks, to give an equitable division of available river water. When this is done the author is convinced that it will prove so beneficial that many similar works will be undertaken in differents parts of the colony.

Cost of Work.

Warren Weir and Offtake.

	s.	d.	
Excavation	1	1	per cubic yard
Piles	3	3	per lineal foot
Bridge Girders	3	3	,, ,, ,,
Round Timber, adzed two sides ...	1	1	,, ,, ,,
Round Timber, adzed one side ...	1	0	,, ,, ,,
Sawn Timber in walings, etc. ...	3	0	per cubic foot
Sheet Piling—driven	3	9	,, ,, ,,
Pine Cleating	4	3	,, ,, ,,
Gravel Filling	5	0	,, ,, yard
Ironwork	0	4	per lb.
Total cost, about £6500	0	0	

Improvement Channel.—Excavation, $8\frac{1}{2}$d. per cubic yard. Total cost, about £2100.

The author was Resident Engineer during the construction of these works.