J. D. Watt 1955.

The Resident Engineer,
Ministry of Works,
ALEXANDRA.

(5)

IDA VALLEY IRRIGATION.

In accordance with the instructions attached to your P.W.45 of 22.9.55, I have reviewed -

(1) The hydrology of the Hope's Creek catchment, and possible yields from various schemes.

(2) The runoff records of the Manorburn and Poolburn catchments and possible future yields.

(3) Three proposals for diverting water from Hope's Creek either directly into the Manorburn Dam or into different sections of the Upper Bonanza Race.

(4) A proposal for improvements to the Bonanza Race to reduce leakage losses.

(5) The general water supply position and the possibility of extending the existing reticulated area.

(6) The financing of the proposals.

You will find that the order in which I have dealt with the various items is slightly different from that set out in your instructions.

I have also gone to the length of making out estimates of cost of the various schemes. These were not asked for specifically, but I felt that is was impossible to compare or evaluate the various proposals unless this were done. Wherever possible the unit prices were based on figures taken from the Department's Handbook of Cost Information or on recent contract prices in Central Otago. Such prices were adjusted to allow for the isolation of the locality and the long haulage on certain items. It should be noted that there is, at Sandpit Flat, a deposit of fine gravel and sand which obviates the long cartage on portion of the concrete aggregates.

HYDROLOGY OF HOPE'S CREEK WATERSHED:

Up till 1950 the yield of Hope's Creek at the Stone Hut had been regarded as at least equal to that of the Manorburn Dam catchment. This belief had been based on the observations of settlers and others, and on the results of occasional low flow gaugings. However, the installation of a temporary measuring weir in February, 1950, and a permanent one a few months later, at a site about 30 chains below the Stone Hut itself, showed that the position was otherwise.

Until the recorder was installed in January 1951, staff readings at the weir were taken approximately twice weekly. Comparisons sinc 1.5.50 are as follows:-

| Year. | Manorburn Dam Nett Yield. A. | Hope's Creek. B. | B/A % |
|---|---|---|---|
| 1950-51 | 6710 | 5820 | 86.8 |
| 1951-52 | 22280 | 17150 | 76.7 |
| 1952-53 | 14680 | 10830 | 73.8 |
| 1953-54 | 15160 | 10960 | 72.3 |
| 1954-55 | 9940 | 7200 | 72.4 |
| 1955-56 (3 mths). | 6760 | 5020 | 74.2 |
| | 75530 ac.ft. | 56980 ac.ft. | |

Overall percentage B/A = 75.4%

(F)

Between 24.3.50 and 11.6.51, gaugings were taken at a temporary weir near the Upper Tunnel site (Proposal 4 b in the report of 24.5.49), and the flows there were found to be 74% of those at the Stone Hut weir.

At the proposed race intake (Proposal 2) the flows can be taken as 85% of the Stone Hut flows.

The relative catchment areas are:-

| | | |
|---|---|---|
| Upper Tunnel intake | - | 14.7 sq. miles. |
| Proposed race intake | - | 18.5 sq. miles. |
| Stone Hut Weir. | | 23.7 sq. miles. |

For the purpose of estimating the creek flows at these three points the following percentages of the Manorburn nett gains are being adopted.

| | | |
|---|---|---|
| Hope's Creek at Upper Tunnel intake | - | 57% |
| Hope's Creek at proposed race intake | - | 64% |
| Hope's Creek at Stone Hut weir. | - | 75% |

Up till 1950 or thereabouts it had been considered reasonable to rely on the long term averages of the Manorburn and Poolburn runoffs to determine what future possibilities might be. However, the continuance of drought conditions up to the end of last irrigation season has cast an entirely different light on the picture, and has shaken one's faith in the use of long term averages with respect to these catchments. The same position holds with the adjoining catchment of Hope's Creek.

Only once during the past nine irrigation years has the Manorburn catchment shown a gain equal to or exceeding the average gain of the previous 28 years. In fact the average nett gain over those nine years was only 13,250 acre feet as against the previous 28-year average of 21,680 acre feet.

The position was the same in the Poolburn catchment, where the past nine years showed an average gain of 3,300 acre feet as compared to the previous 14-year average of 6,090 acre feet. The conditions were all the more remarkable in that these drought years were preceded by an exceptionally wet one which ensured that both dams were full at the beginning of the irrigation season of 1945-46. The Manorburn Dam has been full or overflowing only three times in its life of 37 years and the Poolburn Dam twice during its life of 23 years.

Figures of the average annual Manorburn nett gain, taken at five-yearly intervals are as follows:-

| | | |
|---|---|---|
| 1925 | - | 21,400 acre feet. |
| 1930 | - | 19,990 acre feet. |
| 1935 | - | 20,230 acre feet. |
| 1940 | - | 21,210 acre feet. |
| 1945 | - | 21,310 acre feet. |
| 1950 | - | 20,550 acre feet. |
| 1955 | - | 19,630 acre feet. |

On the face of things the variation during the years might be held to be slight, but a detailed examination of conditions during the past 10 years shows the position to be otherwise.

In determining the future possibilities of Hope's Creek, if diverted into the Manorburn Dam by one of the tunnel schemes, one may take as a basis, either -

(a) the average Manorburn gain over 37 years.

or (b) some lesser figure which gives a truer gauge of recent conditions.

As both tunnel schemes are costly ones, I consider that (a) is too optimistic a view to take.

I propose basing my calculations on the results of the past 10 years. On 1.10.45 both the Manorburn and Poolburn Dams were in the rare position of being full, as a result of the heavy runoff in 1944-45 and the early part of 1945/46. Again, both dams were practically empty on 30.4.55. The Manorburn supply position was:-

| | | |
|---|---|---|
| Stored in dam at 1.10.45. | - | 41640 acre feet. |
| Nett gain from 1.10.45 to 30.4.55. | - | 127220 acre feet. |
| | | 168860 acre feet. |
| Left in dam at 30.4.55. | | 860 acre feet. |
| Total available. | | 168000 acre feet. |
| Average quantity available per season over 10 irrigation seasons. | - | 16,800 acre feet. |

This figure is 85½% of the average nett gain during the past 37 years.

If the capacity of the Manorburn Dam was increased by approximately 50%, or if equivalent storage could be obtained in Hope's Creek (this is not possible), the average annual value of Hope's Creek at the Upper Tunnel could be set at 16,800 x .57 = 9560 acre feet. However, with the present Manorburn storage, and only limited storage at the tunnel intake, a safe figure cannot exceed that based on the average Manorburn gain for the 10 years from 1.5.45 to 30.4.55.

i.e. 15,070 x .57 = 8590, say 8600 acre feet.

Conditions this season promise to be better than in any of the previous nine years, except 1951-52. Since May 1st, the Manorburn nett gain has been 18,560 acre feet, and further valuable runoff can be expected.

I have chosen the Upper Tunnel Scheme with its three-mile tunnel instead of the Lower Tunnel Scheme (tunnel two miles, and dam 110 ft. high) as it is not only cheaper but has also a limited amount of work above ground. This is a distinct advantage at that elevation.

There can be much room for argument as to what is a reasonable figure to adopt. This is dependent on the probabilities of the return of similar drought conditions, and on a decision as to the restriction of supplies that irrigation schemes can be expected to bear in lean periods.

The adopted figure could range between 11,400 acre feet (computed from the Manorburn 37 year average) and 6,520 acre feet, which is based on the average of the worst five consecutive years, i.e. between 1.5.46 and 30.4.51. It will be seen that the proposed figure of 8,000 acre feet is a conservative compromise.

On the other hand it could be based on 57% of the average gain between 1.10.45 and 30.4.55, i.e. 7,240 acre feet.

I am adopting 8,000 acre feet.

Throughout such a 10 year period the Manorburn Dam would have sufficient capacity to cope with the combined inflows.

DIVERSION RACE (PROPOSAL 2 - 1949):

Detailed examination of the daily flows in Hope's Creek, during the five years in which records have been kept, shows that some other basis for computing the value of this scheme is necessary. In general it provides for the use of spring and early summer flows. On account of its nine mile length, there would be little value in attempting to divert any water when the creek flow fell below three cusecs, as seepage and evaporation losses would account for too large a proportion of flows of three cusecs and less.

For a race of 25 cusec capacity the following would have been the position during the past five seasons.

Flows worth diverting at race intake during irrigation season - 15th September to 30th April.

| | 1950-51 | 1951-52 | 1952-53 | 1953-54 | 1954-55 |
|---|---|---|---|---|---|
| September. | 230 | 800 | 510 | 570 | 500 |
| October. | 380 | 1280 | 940 | 1020 | 410 |
| November. | 340 | 940 | 980 | 280 | 180 |
| December. | 360 | 1160 | 320 | 60 | 200 |
| January. | - | 450 | - | - | - |
| February. | - | 50 | - | - | - |
| March. | - | - | 340 | - | - |
| April. | - | - | 960 | 200 | - |
| | 1310 | 4680 | 4050 | 2130 | 1290 acre feet. |

Average annual diversion = 2690 acre feet.

This is half of the average Manorburn gain for the same periods.

It will be noted that the figures for 1950-51 and 1954-55 are less than half the average for the five years.

If flows during the irrigation season only (i.e. from 15th September to 30th April) are considered, the past five seasons are the driest consecutive ones encountered in the history of the Manorburn Dam, the average gain being 5,380 acre feet.

If the average of the past nine seasons is taken, the gain is 6,000 acre feet.

In the nine seasons the first three lie above this average, the next two below, followed by two above the average. The present season, the tenth one, promises to be well above average. If it be conceded that no particular harm will result from two consecutive years of short supply, the estimated average flow available for diversion at the race intake can be set at some figure between 2,690 acre feet (as shown above) and 3,000 acre feet, which is 50% of the nine year Manorburn average.

I propose adopting 2,800 acre feet, which it so happens, was the estimated figure given on Page 2 of the report of 24.5.49.

As I have indicated, these computations are based on the construction of a 25 cusec capacity race.

The quantities of water available for diversion in races of 20 and 30 cusec capacity have also been computed, with the following results:-

Irrigation Seasons.

| | 1950-51 | 1951-52 | 1952-53 | 1953-54 | 1954-55 | Average. |
|---|---|---|---|---|---|---|
| 20 cusec race | 1290 | 4260 | 3770 | 2010 | 1280 | 2520 |
| 25 cusec race | 1310 | 4680 | 4050 | 2130 | 1290 | 2690 |
| 30 cusec race | 1310 | 5000 | 4260 | 2210 | 1290 | 2815 |

As will be seen, there is little advantage in other than a 20 cusec race in the lean years of 1950-51 and 1954-55. In good years such as 1951-52 the 25 cusec race shows in a better light, but there appears to be no justification for any increase in race size beyond this figure.

Summarised, the estimated average annual yields from Hope's Creek for the various schemes are:-

| | | |
|---|---|---|
| Tunnel Scheme 4 b | - | 8000 acre feet. |
| 25 cusec race | - | 2800 acre feet. * |
| Stone Hut available for Scheme 5 | - | 10270 acre feet. |

* To this would be added the capacity of any dam built near the site of the Intake of 4 b.

Details of these schemes will be given later.

MANORBURN AND POOLBURN CATCHMENTS:

As shown earlier, the Manorburn Catchment over the past 10 years has been able to supply an average annual quantity of 16,800 acre feet. The position at the Poolburn Dam was:-

| | | |
|---|---|---|
| Nett gain from 1.10.45 to 30.4.55 | - | 30,650 acre feet. |
| Quantity in dam at 1.10.45. | | 20,800 acre feet. |
| | | 51,450 acre feet. |
| Left in dam at 30.4.55. | | 450 acre feet. |
| Total available for diversion. | | 51,000 acre feet. |
| Average annual yield | = | 5,100 acre feet. |

If no Hope's Creek water is brought into the system, the supply position (adopting the results of the last 10 years) is:-

| | | |
|---|---|---|
| Manorburn Dam | - | 16,800 acre feet. |
| Poolburn Dam | - | 5,100 acre feet. |
| From weirs. | - | 900 acre feet. |
| | | 22,800 acre feet. |
| Less race losses (27½%) | | 6,200 acre feet. |
| Available for sale. | | 16,600 acre feet. |

The figure for race losses is the actual average over the past 10 years.

If the 18" supply for Ida Valley is retained, the present nett requirements are:-

| | |
|---|---|
| Ida Valley (12,185 acres) | 18,270 acre feet. |
| Galloway | 3,010 acre feet. |
| Total. | 21,280 acre feet. |
| Nett shortage. | 4,680 acre feet. |

If the Ida Valley quota were reduced to 15", a figure which recent years have shown as a feasible one, the nett requirements are:-

| | | |
|---|---|---|
| Ida Valley | - | 15,230 acre feet. |
| Galloway | | 3,010 acre feet. |
| Total. | | 18,240 acre feet. |

This still leaves an annual nett shortage of 1,640 acre feet.

If the Ida Valley quota were 16" the nett shortage would be 2,655 acre feet.

POSSIBLE DEVELOPMENTS OF HOPE'S CREEK:

These are now reduced to three in number, with a possible new one which is now under investigation. They are.

(A) Upper Tunnel Scheme (Scheme 4 b, 1949).

(B) Race from Hope's to head of Bonanza Race (with or without small storage dam).

(C) Dam below Stone Hut Flat with tunnel and race feeding into Bonanza Race (Scheme 5, 1949).

(a) UPPER TUNNEL SCHEME:

This entails the driving of a tunnel three miles long from Hope's Creek to the Narrows at the Manorburn Dam, and the construction of a small intake dam capable of so regulating floods that all the Hope's Creek runoff can be diverted through the tunnel.

An excellent site for a small arched dam exists about 10 chains below the proposed tunnel intake and a storage capacity of approximately 600 acre feet can be obtained with a height of 37 feet. If the height of the dam is increased above 39 feet, a subsidiary dam, on an adjoining low saddle, becomes necessary.

The proposed tunnel invert level at intake is 2,415 feet and the m nimum crest level of the dam is 2,452 feet, or 4 feet above present crest level of the Manorburn Dam. With an unlined tunnel cross-section of 7ft.6ins. x 6 ft., a minimum discharge of 25 cusecs could be maintained when both dams were full.

Its capacity, on a grade of 1 in 1000, when there is no heading up at either inlet or outlet will be approximately 80 cusecs.

The estimate provides for concrete lining 9 inches thick on a length of 3,000 feet, this being a reasonable assumption in this class of country.

Estimated Cost.

| | | |
|---|---|---|
| Driving tunnel (7'6" x 6') | 16000 ft. @ £18 | £288,000.0.0. |
| Lining tunnel | 3000 ft. @ £17 | 51,000.0.0. |
| Accommodation (Single) | | 6,000.0.0. |
| Access Roads. | | 5,000.0.0. |
| Intake Dam - excavation etc. | | 1,000.0.0. |
| concrete in place, 400 c.yds. | | 10,000.0.0. |
| Supervision and contingencies. | | 24,000.0.0. |
| | | £385,000.0.0. |

(b) RACE TO HEAD OF BONANZA RACE:

As surveyed, this race commences near the top of the falls about two miles above the Stone Hut, and traverses some two and a half miles of moderate side slopes, studded with rocky outcrops, before reaching easier ground beyond the Hut itself. About two and a half miles farther on it crosses a saddle, at what is known locally as Sandpit Flat, and then drops for some 60 chains down a gully. For another three and a quarter miles it follows a rocky hillside to a point about 30 chains below the intake of the Bonanza Race. Here it is to be piped across the Manorburn into that race.

As it is difficult to construct a tight race in some of the rocky ground, encountered on part of the course, I have considered lining, with gunite, the first two miles of open race above the Stone Hut. The cost of such lining is high, and, as a later discussion will show, it requires a substantial saving in both maintenance charges and race losses to justify its use. Frost action, at this altitude of over 2000 feet can cause damage to thin linings in the conventional trapezoidal race, and I suggest that the lined section be constructed with a semicircular bottom. This permits of the easier placement of the light reinforcing and gives a more rigid lining at the invert, the point where most damage is likely to occur. The thicker conventional concrete lining (reinforced) would be more resistant to frost action, but the extra cost would rule it out.

In the first five miles the grade is 4' per mile, and in the last 3¼ miles 7.2' per mile.

For estimate purposes, I have adopted the following cross-sections:-

| Grade p.m. | Type. | Bottom width. | Water depth. | Interior Side Slopes. |
|---|---|---|---|---|
| 4 ft. | Unlined. | 5 ft. | 1 ft.4 ins. | ½ to 1 on inner side. |
| 4 ft. | Lined. | 2ft.6ins. rad. | 2 ft.3 ins. | 1 to 1 on bank side. |
| 7.2 ft. | Unlined. | 4ft.6ins. | 2 ft.3 ins. | On level ground in earth and gravel. 1 to 1 both sides. |

The costs of excavation of normal race sections vary from £10 to £50 per chain. At the saddle where cuts of up to 13 feet are encountered; the cost of a short length is £200 per chain.

Estimated Cost (Unlined Race).

| | | | |
|---|---|---|---|
| Intake Weir and Gates. | | | £850.0.0. |
| Pipe lines (reinforced conc. - rubber joints) | | | |
| 30" dia. 2450 feet @ £4.10.0. | | | 11025.0.0. |
| 24" dia. 450 feet @ £4.0.0. | | | 1800.0.0. |
| Race excavation (includes trimming) | | | |
| Earth and gravel. | 14000 c.yds.@ 7/-: | 4900 | |
| Broken rock. | 8000 c.yds.@ 15/-: | 6000 | |
| Solid rock. | 7000 c.yds.@ 24/-: | 8400 | 19300.0.0. |
| Culverts under race and race crossings. | | | 1400.0.0. |
| Accommodation. | | | 4000.0.0. |
| Access roads. | | | 3000.0.0. |
| Supervision and contingencies. | | | 4625.0.0. |
| | | | £46,000.0.0. |

Provision has been made for the piping of the first 28 chains of race from the intake weir, this section being steep and broken.

If gunite lining of the first two miles of open race, i.e. to 2M 28 CH, is resorted to, the earthwork quantities could be reduced by 1500 cubic yards, and excavation costs by £1400. The nett increase in expenditure is thus £10600.

With an unlined race it is estimated that race losses, for an annual diversion of 2,800 acre feet, will be 500 acre feet. Of this, 40% or 200 acre feet can be expected to occur in the first two miles. If all this loss could be prevented by gunite lining, the cost of the additional water delivered into the Bonanza Race would be £28.6.0. per acre foot.

The overall position is:-

Delivered into Bonanza Race (no lining) - 2,300 acre feet.
Capital cost per acre feet - £20.

Delivered into Bonanza Race (with lining) - 2,600 acre feet
Capital cost per acre feet - £22.

The saving in race losses requires to be of the order of 400 acre feet before the respective costs of water delivered into the Bonanza Race begin to even up. On the grounds of first cost only it is difficult to justify the expenditure on lining. However there is another side of the problem. The race is in an isolated area where it would be neither feasible or economic to patrol it daily or at frequent intervals. If the upper section is made secure by lining, only occasional inspections of the length need be made. The middle section is in much tighter and safer country, while the lower end can be kept under the eye of the raceman who patrols the Upper Bonanza Race. A saving in operating costs of £120 (a conservative figure) justifies a capital expenditure of £3,500.

As was stated earlier, flows of less than three cusecs were not counted on in assessing the annual value of Hope's Creek under this scheme of diversion. If the first two miles are lined it would be worth while diverting flows between two and three cusecs, with an additional annual yield of at least 100 acre feet. The total saving of 300 acre feet justifies an expenditure of a further £6,000. The total of £9,500, coupled with the ability to irrigate another 180 acres from the extra supply of 300 acre feet, makes lining an economical proposition.

Small Storage Dam:

A storage dam near the site of the intake of Tunnel 4 b can be operated in conjunction with this race. In the proposals of 7.3.51, a dam with a capacity of 1600 acre feet, with height above stream bed of 51 feet was envisaged. The section in the stream channel is rock bound, but adjacent to this is a low saddle approximately 40 feet above stream bed. Here a subsidiary dam, preferably an earth bank with impervious core, is necessary for dam heights above 39 feet. Further inspection of the site throws some doubt on rock levels in the saddle, and if the rock continues to dip into the hill face as surface indications seem to indicate, the cost of the subsidiary dam could be substantial. For present purposes, I am estimating for a dam 43 feet in height. This necessitates only a low subsidiary dam without any particular complications. The storage capacity is only 1070 acre feet. However, rough trials have shown that, on account of substantial increases in the size of the gravity abutments and of the subsidiary dam, the cost per acre for a higher dam would not be any less.

Taking the worst five years from 1950 to 1955, the dam would augment the race supplies by its storage of 1070 acre feet plus an additional 200 acre feet trapped in the dam throughout the irrigation season.

Estimated Cost:

| | |
|---|---|
| Arch Dam with small gravity abutment. | |
| Concrete in place - 500 c.yds. @ £25 | £12,500.0.0. |
| Excavation etc. | 1,500.0.0. |
| Subsidiary Dam. | |
| Concrete core wall - 40 c.yds. @ £25 | 1,000.0.0. |
| Earth embankment - 500 c.yds. @ £1 | 500.0.0. |
| Excavation, etc. | 500.0.0. |
| Access Road. | 2,000.0.0. |
| Supervision, transport, and contingencies. | 3,000.0.0. |
| | £21,000.0.0. |

The access road would be an extension of that provided for the race construction. It is assumed that, if this work is embarked on, it will be done at the same time as the race and that the accommodation provided for the latter work will serve.

The cost of the supply of 1270 acre feet is £16.10.0. per acre foot.

As this is less than the cost of the race supply it is evident that the construction of the dam would be justified.

The quantities are based on a concrete arch of minimum thickness of 2 ft. 6 ins. and upstream radius of 120 ft., the working stress being 25 tons per square foot. The construction of the dam can be justified even if the cost is £25,000.

(6) DAM AT STONE HUT FLAT:

This scheme (No.5 in the 1949 report) entailed the construction of a dam of either 90 feet or 100 feet in height at the lower end of Stone Hut Flat, and the driving of a tunnel of either 8,650 feet or 8,000 feet between the Hope's Creek basin and the Manorburn.

It was proposed to utilise only the top 25 feet in this dam, and thus keep the tunnel at such a level that it would be possible to divert water from it into the lower reaches of the Upper Bonanza Race. The original estimates for the two dams show respective concrete yardages of 9,500 c.yds. and 12,000 c.yds. These were based on an arch radius of 330 feet, and comparatively short gravity sections. From further examination of the site plan, I now consider that the gravity sections should be lengthened so that they attain a maximum height of 30 feet in the case of the higher dam and 20 feet in the low. The yardages of concrete now are:-

| | 90 ft. high dam. | 100 ft. high dam. |
|---|---|---|
| Gravity sections. | 1,250 | 2,950 |
| Arch section. | 9,250 | 12,050 |
| | 10,500 c.yds. | 15,000 c.yds. |

As there are other possible combinations of dam height. usable storage and tunnel length, I have made trial estimates of various possibilities to determine which is the most economic. There is a certain expenditure on race and pipe line construction common to all and the variables are the costs of dam, tunnel and cut at Halliday's Flat and the usable storage.

To permit of water from this scheme being diverted into the lower section of the Bonanza Race it is necessary to make a deep cut at a saddle where the present race drops some 30 feet down a small gully.

The minimum allowable invert level at the tunnel outlet is 1974'. In the following analysis, I have taken the cases of dams of 90 feet, 95 feet and 100 feet height, the respective crest levels being 2010', 2015' and 2020'. The minimum draw down level adopted is 1985 feet. The details are:-.

| Crest of dam. | Draw down level. | Yardage of concrete. | Tunnel length. | Cutting Halliday's Flat. | Usable Storage. | Cost. | Cost per acre foot. |
|---|---|---|---|---|---|---|---|
| ft. | ft. | c.yds. | ft. | c.yds. | ac.ft. | £ | £ |
| (a) 2010 | 1985 | 10,500 | 8650 | 14200 | 4700 | 367200 | 78 |
| (b) 2015 | 1985 | 12,500 | 8650 | 14200 | 6070 | 411200 | 67.7 |
| (c) 2015 | 1990 | 12,500 | 8300 | 8800 | 5270 | 399800 | 75.9 |
| (d) 2020 | 1985 | 15,000 | 8650 | 14200 | 7600 | 461200 | 60.7 |
| (e) 2020 | 1990 | 15,000 | 8300 | 8800 | 7000 | 449800 | 64.3 |
| (f) 2020 | 1995 | 15,000 | 8000 | 4000 | 6200 | 440000 | 71 |

It should be noted that the costs shown are not the total costs but simply those of the three items listed above. They are based on the following unit prices:-

Concrete in dam - £20 per c.yd.
Tunnel excavation - £17 per lin.ft.
Rock excavation in cutting - £1 per c.yd.

On the score of capital cost per acre foot of usable storage the order of preference is (d) (e) and (b)

As a crest height of 2020 feet is a limiting one for this particular dam site, I propose adopting, in any further discussions, a dam with crest height 2018 feet and draw down level of 1985 feet. This will have a usable storage of 7000 acre feet, and the yardage of concrete will be reduced to approximately 14,000 c.yds. The surface area at 1985 feet is 100 acres.

AVAILABLE WATER SUPPLY:

If the conditions existing between the years 1945 and 1955 are again taken as a standard, the position is:-

| | |
|---|---|
| Stored in Stone Hut Dam as at 1.10.45. - | 7000 acre feet. |
| Discharge of Hope's Creek 1.10.45-30.4.55.- | 95700 acre feet. |
| Total. | 102700 acre feet. |

If this dam were capable of giving full regulation the average amount available per irrigation season would be 10270 acre feet. Even though this dam would be operated in conjunction with the Manorburn Dam and discharges varied to suit the conditions in both, inspection shows that it would not be large enough to prevent some loss of water. It is not safe to count, therefore, on an average annual diversion greater than 9400 acre feet.

In the original proposal it was intended to pipe the water across the Manorburn opposite peg 1M 70 CHS on the Bonanza Race, and then relocate that race by tunnels and new channel as far as the cut at Halliday's Flat. It is now proposed to cross the Manorburn lower down to a point opposite 2M 30 CHS on the Bonanza Race, and avoid the expensive tunnels by the construction of siphons and open race, plus a deep cut at a saddle between 2M 30 CHS and 2M 50 CHS.

The tunnel from the dam will have a maximum capacity in the unlined section (7ft.6ins. x 6ft.) of 70 cusecs. This is more than is required, and the proposed capacity of the race from the tunnel to the Manorburn and the siphon across that stream is 60 cusecs.

From the outlet end of the siphon (opposite 2M 30 CHS Bonanza Race) to Halliday's Flat a capacity of 100 cusecs has been allowed for. Water sent down from the Manorburn Dam will be dropped from the Bonanza Race into the new race at some point beyond 2M 30 CHS. This race should be lined except in the deep cuts. I am allowing for a 1" coating of reinforced gunite on the sides and 2½" of lightly reinforced concrete on the bottom. A thin gunite coat on the floor is likely to be affected by frost action and subject to greater damage by gravel and stone fragments carried along the race. The estimated cost is:-

Dam in Hope's Creek:

| | |
|---|---|
| Excavating foundations. | 5,000.0.0. |
| Concrete in place 14,000 c.yds. @ £20. | 280,000.0.0. |

Tunnel (7ft. 6 ins. x 6 ft.):

| | |
|---|---|
| Driving - 8,650 ft. @ £17. | 147,050.0.0. |
| Lining (9") 1,600 ft. @ £16. | 25,600.0.0. |
| Race excavation - 60 cusecs - 100 chs. @ £50 | 5,000.0.0. |
| Siphon across Manorburn - 36" dia. - reinforced concrete - 1800 ft. @ £6. | 10,800.0.0. |

Bonanza Race Relocation:

| | |
|---|---|
| Cut between 2M 30CHS. & 2M 50CHS. | |
| Earth - 2,500 c.yds. @ 6/- | 750.0.0. |
| Rock - 7,500 c.yds. @ £1. | 7,500.0.0. |
| Cut at Halliday's Flat - rock, 14,200 c.yds @ £1 | 14,200.0.0. |
| Race excavation - 100 cusecs - 70 chs. @ £65 | 4,550.0.0. |
| Race lining 70 chs. @ £100 | 7,000.0.0. |
| Pipe lines - 48" dia. - 750 feet at £10 | 7,500.0.0. |
| Accommodation. | 6,000.0.0. |
| Access Roads. | 3,000.0.0. |
| Supervision and contingencies. | 26,100.0.0. |
| | £550,000.0.0. |

Details of the race dimensions on which the prices are based are as follows:-

| Capacity. | Bottom Width. | Depth of Water. | Excavation Quantities. Earth. | Rock. | Batters | N. |
|---|---|---|---|---|---|---|
| 60 | 6 ft. | 3 ft. | 12 | 38 | 1 to 1 | .035. |
| 100 | 6 ft. | 2ft. 9 ins. | 14 | 50 | ½ to 1 | .016. |

Lining is not required on the 60 cusec race which is on flat ground. The average slope on the line of the 100 cusec race is 12°.

Earth has been priced at 7/- and rock at 24/- per cubic yard.

The capital cost per acre foot of the additional water diverted in the Upper Bonanza Race is £58.10.0. as against £48.0.0. for the Upper Tunnel Scheme.

BONANZA RACE IMPROVEMENTS:

Excluding a length of pipe line, and some 25 chains already gunited, there are still two miles of the Bonanza Race which would remain in commission if the above scheme is constructed. This length, plus a further two miles, is the section responsible for the bulk of the present heavy race losses.

The total length of the Upper Bonanza Race, to the point where the Lower Bonanza Race leaves it at Halliday's Flat, is approximately seven miles. The last 2¾ miles lie in comparatively flat and safe country where race losses are moderate.

I have given consideration to various schemes for lining the first two miles of the Upper Bonanza Race. On account of the shortness of the working season, (rarely more than two months after irrigation ends and severe winter conditions begin) and general difficulties of access, I can see no feasible method other than guniting the face of the outside wall and the cutting of a chase 1 ft. or more deep near its toe. This chase would be filled with concrete and the gunite reinforcing carried down into it.

In general, the first four miles of the race lie on a bench excavated mostly in solid rock, the outer wall consisting of rubble masonry faced with from 2 ins. to 3 ins. of plain concrete. On some sections portion of the bottom is also covered with a skin of concrete. While some of the leakage originates near the inner wall and is difficult to trace, the bulk of the loss is either under or through the outer wall. The work proposed should be capable of reducing by more than half, the losses in any particular section. As the use of explosives could not be permitted in cutting the chase, the work would be expedited if a small channelling machine could be adapted to the job. For estimate purposes, I am allowing for the work being done by line drilling and pneumatic picks.

The estimated cost is £75 per chain or £6,000 per mile. To scheme (3) above must be added a further £12,000 to tie in with it all the possible improvements of the Upper Bonanza Race. If either the tunnel proposal or the race proposal (Schemes A and B of this report) is embarked upon and the whole course of the Upper Bonanza Race retained, the work proposed is guniting and channelling of four miles at a cost of £24,000.

In the past 10 irrigation seasons the average ~~percentage~~ race losses in the Upper Bonanza Race have been 11.4% of the water diverted into it. The four miles of guniting should reduce this loss to 6%, and two miles of guniting, plus the relocation in Scheme C, should bring it down to approximately 4%. On an average annual diversion of 16,800 acre feet this would have represented, in the one case, a saving of 900 acre feet, and in the other, a saving of 1,240 acre feet. Race losses over the whole scheme would have been 23¼% and 21¾% respectively.

GENERAL WATER SUPPLY POSITION:

It seems obvious that, if the present Ida Valley water allowance of 18 inches is retained, there can be no justification for the heavy expenditure on either Schemes A or C. I propose working on the assumption that the allowance will be fixed at 15 inches, and that there will be no increase in the present rates. This entails sacrificing £2,000 of future revenue in exchange for 3,000 acre feet of water, but is, nevertheless, a worthwhile proposition. The revenue per acre from new areas can be set, with justice, at a considerably higher figure than the present revenue.

The various proposals can now be summarised:-

| Scheme | Yield (acre feet). Hope's Creek | Manorburn and Poolburn Dams and weirs. | Total | Race Losses. | Nett Yield. | Nett requirements present areas. | Surplus (acre feet) |
|---|---|---|---|---|---|---|---|
| A | 8000 | 22,800 | 30,800 | 7160 | 23,640 | 18,240 | 5400 |
| $B_1$ | 2600 | 22,800 | 25,400 | 5900 | 19,500 | 18,240 | 1260 |
| $B_2$ | 3600 | 22,800 | 26,400 | 6140 | 20,260 | 18,240 | 2020 |
| C | 9400 | 22,800 | 32,200 | 7000 | 25,200 | 18,240 | 6980 |

$B_1$ = Race only.

$B_2$ = Race and storage dam.

Ignoring in the meantime the costs of any new distributary races and further race losses in new extensions, the position is as follows:-

| Scheme | New Expenditure. £ | Surplus Water. | Cost per acre foot. £ | Interest charge at $\frac{7}{8}$ % acre feet. | Interest charge per acre. |
|---|---|---|---|---|---|
| A | 409,000 | 5400 | 76 | 13/3 | 16/7 |
| $B_1$ | 80,600 | 1260 | 64 | 11/3 | 14/- |
| $B_2$ | 101,600 | 2020 | 51 | 9/- | 11/3 |
| C | 562,000 | 6980 | 81 | 14/3 | 17/10 |

The above costs include expenditure on Upper Bonanza Race improvements.

Maintenance charges in Ida Valley have averaged 13/4d. per acre over the past three years. Further consideration will be given to Schemes A and $B_2$, the better of the minor and of the major ones.

Scheme A. -

There are, within the bounds of the existing Ida Valley Race system, at least 1000 acres of additional land, suitable for irrigation. This area absorbing a nett supply of 1250 acre feet could be supplied with little additional construction cost or race losses. The balance of 4,150 acre feet could supply 3,200 acres above the German Hill Race, between Dovedale Creek (Run 261N) and the Idaburn Scheme. The pumping lift would be approximately 80 feet and the pump capacity from 18 to 20 cusecs. Losses from the 10 miles of race (on easy slopes) would be more than counterbalanced by the return flow into the German Hill Race. In the absence of any detailed surveys, the estimated costs of this extension can be rough ones only.

The final position is:-

| | |
|---|---|
| Expenditure as above. | £409,000.0.0. |
| Race extensions within present scheme | 2,000.0.0. |
| New race on German Hill - 10 miles @ £800 | 8,000.0.0. |
| Gauge boxes, bridges and race crossings. | 3,000.0.0. |
| Pumping plant (275 H.P.) and transmission lines. | 10,000.0.0. |
| Pumping main - 24 in. dia. - 750 feet @ £4 | 3,000.0.0. |
| Enlarging German Hill Race. | 2,000.0.0. |
| | £437,000.0.0. |

Annual Charges to be borne by irrigators:

| | |
|---|---|
| Interest: $\frac{7}{8}$% of £437,000.0.0. | £3,825.0.0. |
| Depreciation on plant: 5% of £10,000.0.0. | 500.0.0. |
| Depreciation on pipe lines: 1% of £3,000.0.0. | 30.0.0. |
| Power charges: 275 H.P. at (say) £9 | 2,475.0.0. |
| Additional maintenance costs. | 1,000.0.0. |
| Total. | £7,830.0.0. |

Annual charge per acre for 15" supply = 37/3d.

In my allowance of £1,000 for extra maintenance costs, I have assumed that the improvements to be carried out on the Upper Bonanza Race will reduce present costs by £200.

This overall picture is the most optimistic one that can be take of this scheme.

If the Ida Valley allowance is fixed at 16" per annum, the amount of water available for extensions is 4,400 acre feet, capable of supplying 3,300 acres.

Capital charges would be decreased by approximately £5,000 and annual costs by £850. The required rate is then 42/3d. per acre.

The rate for power is only 2/3 of the normal rate charged by the local Power Board, but I have adopted the low figure on the assumption that some special rate may be obtainable.

Scheme B2.-

In this case the water available for extensions above the German Hill Race is 770 acre feet, capable of supplying 615 acres on a 15" basis. No enlargement of the German Hill Race would be required and a small pumping plant of four cusecs capacity and 50 foot lift could be located in or near Run 261H. This location is suggested, as the adjacent properties have little or no water. The supply race could be reduced to 2½ miles or less in length. As in Scheme A, 1,000 acres would be supplied within the present race system.

The final position is:-

| | |
|---|---|
| Expenditure as before. | £101,600.0.0. |
| Race extensions within present scheme. | 2,000.0.0. |
| New race on German Hill; 2½ miles @ £400. | 1,000.0.0. |
| Pumping plant (40 h.p.) & transmission line. | 2,000.0.0. |
| Pumping main - 15" dia. - 500 feet @ £2.10.0. | 1,250.0.0. |
| Culverts, crossings and gauge boxes. | 650.0.0. |
| | £108,500.0.0. |

Annual charges to be borne by irrigators:

| | |
|---|---|
| Interest at 7/8% on £108,500.0.0. | £950.0.0. |
| Depreciation on plant: 5% on £2,000.0.0. | 100.0.0. |
| Depreciation on pipe lines: 1% on £14,000.0.0. | 140.0.0. |
| Power charges: 40 H.P. at (say) £9 | 360.0.0. |
| Additional maintenance: Hope's Creek Race. | 350.0.0. |
| Additional maintenance: Ida Valley. | 650.0.0. |
| | £2550.0.0. |

Allowance has been made, as before, for a saving of £200 on Upper Bonanza Race maintenance.

Annual charge for a 15" supply = 31/6d.

Scheme C. -

This would show charges of approximately 40/- for a 15" supply and 42/- for a 16" supply, and has no advantage over A or $B_2$.

If power charges were at the full Power Board rate of approximately £13.10.0. per H.P., the above acreage charges would be increased by amounts ranging between 2/3d. per acre in the case of Scheme $B_2$ and 7/- per acre in the case of Scheme C.

ALTERNATIVE ARRANGEMENT OF SCHEME A.

In the foregoing I have provided for pumping of supplies to any new areas above the German Hill Race. From the point of view of layout this is the neatest arrangement and reduces the length of the new race required to supply the lands most in need of water. It is the farms and small grazing runs at the bottom end of Ida Valley which have little or no water at present. These lands can also be served by a high level race out of the Poolburn, a race which would travers broken country in its upper section and which necessitates lengthy siphons at Maori and Dovedale Creeks. Its length would be 20 miles.

The pumping scheme has high annual charges, chiefly due to high power costs. Some reduction in annual charges could be effected by facing a further capital expenditure of some £80,000 and constructing the high level race from the Poolburn. The new capital expenditure would then be £517,000.

On the basis of a 15" supply to existing and new areas, the annual charges would be approximately as follows:-

| | |
|---|---|
| Interest: 7/8% of £517,000 | 4525 |
| Depreciation on pipe lines 1% of £30,000 | 300 |
| Additional maintenance costs | 1750 |
| | £6575 |

The rate per acre, for a 15" supply, would thus be reduced to 31/4, but the total capital cost per acre of new land served would be increased from £104 to £123. Neither arrangement shows any promise.

It should be noted that, where there is water for only a limited area above the German Hill Race (as in Scheme B2) the high level race is out of the question and pumping should be resorted to.

SUMMARY.

Where pumping is proposed, the new areas and charges for the various schemes are as follows:-

| Scheme. | Water Allowance. | New Area acres. | Total Cost £ | Capital Cost per acre. £ | Rate per acre Power £9 per H.P. | Rate per acre Power £13/10/- per H.P. |
|---|---|---|---|---|---|---|
| A | 15" | 4200 | 437,000 | 104 | 37/3 | 43/3 |
| | 16" | 3300 | 432,000 | 131 | 42/3 | 48/9 |
| B2 | 15" | 1615 | 108,500 | 67 | 31/6 | 33/9 |
| | 16" | 765 | 103,500 | 135 | 37/6 | 37/6 |
| C | 15" | 5580 | 600,000 | 107 | 40/- | 46/9 |
| | 16" | 4380 | 590,000 | 135 | 42/- | 48/- |
| | | SCHEMES WITH NO PUMPING | | | Rate per acre | |
| A (Alternative) | 15" | 4200 | 517,000 | 123 | 31/4 | |
| | 16" | 3300 | 510,000 | 154 | 36/6 | |
| B1 | 15" | 1000 | 82,600 | 83 | 28/- | |
| | 16" | 200 | 80,600 | 403 | 120/- | |

It is obvious that none of the major schemes can be recommended, even if the water allowance can be reduced to 15". They are uneconomic both with respect to total cost and capital cost per acre. With a 15" allowance, only B1 and B2 are worthy of consideration. I am very doubtful if any of the settlers will be prepared to pay more than or even as much as 30/- per acre for this amount of water.

It could be argued that the expenditure of £24,000 for

guniting 4 miles of the Bonanza Race should be met irrespective of what other steps are taken, and should not be a charge against any new areas. This would mean a reduction in the acreage charge for Scheme B1 (15") of 4/3 and for Scheme B2 (15") of 2/6. For B2 (16") the reduction would be 5/6.

With the uncertainty as to the future quota of water it is difficult to make a firm recommendation. However, unless the new quota can be reduced to 15", it is difficult to justify any expenditure other than that on improving the Bonanza Race i.e. £24,000. If the work is so limited, all that can then be hoped for is that the supply position will improve sufficiently to give the No. 2 agreement irrigators their full quota and thus justify the imposing of the additional charge of 3/3 per acre.

If a 15" quota is established the choice of new works is limited to schemes B1 or B2.

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