CONTROL OF AQUATIC WEEDS

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Summary

The problem of aquatic weeds in Canterbury is discussed with particular reference to control of submerged species.

Chemicals were applied by injection and using 2 ppm active ingredient, economical control of oxygen weed (*Elodea canadensis*) was gained with both diquat and paraquat and of water milfoil (*Myriophyllum elatinoides*) with paraquat. Stonewort (*Nitella hookeri*) was resistant to both herbicides and soon assumed dominance in some streams. The cost of chemical treatments used was much lower than for hand-cleaning but until a suitable treatment is found for stonewort a combination of chemical treatment and hand work will be required.

INTRODUCTION

TWO ASPECTS of land drainage are of particular concern to the farmers occupying the land and the local body responsible for it. These are, first, that all channels should be clear when the demand for drainage is likely to be greatest and, secondly, that the method should be efficient, low in cost, and without undesirable side effects.

This paper describes mainly work aimed at developing a technique of weed control which meets the above requirements. In addition, some reference is made to control of submerged aquatic weed in irrigation ditches.

THE PROBLEM

In addition to its creeks and rivers, the North Canterbury Catchment Board is responsible for about seventy miles of drains ranging in size from a flow of half to twelve cusecs. Some of the smaller drains are dry in summer but most have permanent flowing water. Without sterilization of sides and floor, drains cannot be kept constantly free of weeds. The aim must therefore be to achieve maximum clearance at the time of greatest need.

Hand-cleaning has been costing 5s. to 7s. 6d. per chain for an operation which might be performed three or four times per year. This is expensive and, because of its slowness, the aim of having all channels clear at any given time could not be achieved. Drain cleaning by dragline, when necessary, is also expensive and can cause instability of channel floors and sides.

There is, of course, a relationship between the rate of siltation in drains and the effect of weeds on rate of flow. This is of particular concern in the extensive irrigation channels of mid-Canterbury

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where the water constantly carries a substantial load of glacial "flour". The siltation of races is markedly influenced by the presence of weed growth, with the result that the capacity of races can be reduced in only a few years to no more than half their original volume.

CHEMICAL CONTROL

EMERGENT WEEDS

Following work reported by Banfield in 1959, spraying with a 2,2-DPA/amitrole/2,4-D mixture was adopted for control of emergent weeds. This treatment was later supplemented by a paraquat/2,4-D mixture. By using one of the two treatments as circumstances dictate and spraying twice-yearly, emergent weeds are being kept under satisfactory control. One advantage of paraquat is that foliage is quickly killed, even after late autumn spraying, and drains can soon operate at full capacity.

Emergent weeds initially of importance were cocksfoot (*Dactylis glomerata*), prairie grass (*Bromus unioloides*), water twitch (*Glyceria fluitans*), monkey musk (*Mimulus guttatus*) and watercress (*Nasturtium officinale*). After one or two treatments, however, the problem changed from a predominantly grass one to one involving mainly broadleaved weeds such as docks (*Rumex* spp.), redshank (*Polygonum persicaria*), buttercup (*Ranunculus* spp.), and plantains (*Plantago* spp.).

SUBMERGED WEEDS

Even in small drains, submerged weeds were a problem. The most common species was oxygen weed (*Elodea canadensis*), with watercress present in most drains. Water milfoil (*Myriophyllum elatinoides*) was a problem in many waterways with some submerged *Glyceria fluitans* in most. Starwort (*Callitriche stagnalis*) was of some importance, while duckweed (*Lemna* sp.) and waterfern (*Azolla rubra*) were often present but were not a problem in flowing water. Stonewort (*Nitella hookeri*) existed in quantity in some streams of more than 30 cusecs but prior to chemical treatment was not of importance in smaller channels.

Other species, such as horse's mane (*Ruppia spiralis*) and the pond-weeds *Potamogeton cheesmanii*, *P. ochreatus* and *P. pectinatus*, inhabit streams and lakes in the district but were not present in significant amount in the drains treated.

EXPERIMENTS

All submerged weeds dealt with were growing in flowing water. This raised the question of how best to apply the herbicide. Trials with moving water present the problem that direct comparison of treatments is not possible. One stream constitutes no more than one plot and replication can be gained only by repetition in streams as nearly similar as possible. For this reason few treatments can be employed.

Access for mobile spraying equipment is also difficult, so injection was chosen as the means of introducing the herbicide.

APPLICATION

Injection consists of metering into the stream a predetermined quantity of chemical over a period of time. Work described here

was done largely on drains maintained by the North Canterbury Catchment Board which to some extent determined the rate of injection and its period of time.

Flow measurement by current meter was found to be difficult in shallow or weed-choked drains. Consequently in such drains flows were estimated by approximate methods. The measurements required are the depth and width of the water and its surface velocity. Tables have been prepared by which the chemical required for a given treatment can be obtained from those measurements. This allows unskilled people to carry out the work with little fear of error. Where injections have been made in rivers with flows of 30 to 50 cusecs, a current meter was used to measure the flow.

Dilution of the chemical helps to preserve accuracy of injection, the equipment necessary being something that will allow a steady controlled flow of the diluted chemical over the required period. The writers used an open 45 gal oil drum fitted with a gate valve connected to a short length of perforated pipe by plastic hose. The boom (perforated pipe) was supported horizontally just below the surface of the water and the herbicide fed to it by gravity, a constant flow being maintained by adjusting the valve.

The rate of flow was checked by having a gauge stick calibrated in gallons. For a 30 minute injection, the chemical was diluted to 30 gal and released at the rate of one gallon per minute, and so on. For narrow drains a suitably perforated 5 gal drum is quite suitable.

TREATMENTS

The materials used were diquat and paraquat. The rates of application were 1 and 2 parts per million (5 and 10 ppm formulation) over periods ranging from 30 to 80 minutes (all treatments are in terms of active ingredient).

Where any treatment was used for the first time, a cage of brown fingerling trout was submerged in the stream a short distance below the injection point by an officer of the North Canterbury Acclimatisation Society.

Most applications were made in November and December but, in all, treatments were made in 7 different months. Paraquat at 2 ppm was injected into irrigation races near Ashburton for periods of 40 to 60 minutes, while the same material was oversprayed into a drained race (pools remaining) at 1.5 lb per acre. The only weed of significance was water milfoil.

Water temperature in most cases was within the range of 52 to 62°F.

RESULTS

Diquat at 2 ppm was effective against oxygen weed over distances up to a mile but gave poor control of the other major weed, water milfoil. Similarly, it failed to control the semi-submerged species watercress and water twitch. Paraquat was at least as effective against oxygen weeds as diquat. However, as already stated, direct comparisons are not possible and, if anything, paraquat was superior to diquat against this weed. On water milfoil, paraquat was clearly better than diquat and at 2 ppm for 30 minutes gave control over up to 80 chains. Paraquat injection damaged the submerged stems of watercress, making them more brittle. Water twitch floating on the surface was only slightly damaged but fully submerged plants turned brown and were sometimes swept away by the current.

Stonewort was unaffected by either diquat or paraquat. As a result, the removal of other submerged weeds opened the way for a remarkable increase in the amount of stonewort present. Drains which had been completely dominated by oxygen weed, within two years became choked with stoneworth.

The period of injection was not found to be very critical. For the length of drain being treated, 30 minutes gave control over similar distance to 40 or 60 minutes. On irrigation races, however, injection over 60 minutes did give control over a greater distance than the 40 minute injection.

Treatment of irrigation races in October, whether by injection and over-spraying, was a failure, whereas injection in February was fairly successful. The failure in October could have been because the water had been flowing for only about three weeks and the milfoil had grown to only 3 to 4 in. long.

Where diquat or paraquat was used successfully, visible symptoms were often 7 to 10 days in becoming obvious. However, within the first week after treatment, water levels fell by as much as 12 in.

None of the test fish was lost as a result of submersion in the treated streams.

LARGE-SCALE TREATMENT

The North Canterbury Catchment Board adopted paraquat at 2 ppm over 30 minutes as its treatment for submerged aquatic weeds.

As drains frequently have springs or small drains adding to the flow along their length, measurements are taken at the downstream end. In long drains, injections have been made at one mile intervals, calculations being based on the flow one mile below the injection point. This means that initially the rate of injection can be considerably more than 2 ppm but care is taken to see that it does not approach the level toxic to fish.

Except for the ingress of stonewort, results in the drain have been satisfactory, the effects in some cases extending up to two miles below the last injection point. Where stonewort has assumed dominance, the Board has resorted to hand-clearing. It appears that, once the stonewort is cleared by hand, it in turn is replaced by other (susceptible) species such as oxygen weed.

Water in the mid-Canterbury irrigation scheme carries in suspension considerable glacial "flour", which probably interferes with the action of diquat and paraquat. Results with paraquat on milfoil were reasonably satisfactory, but trials are planned with residual chemicals applied when the races are dry.

The South Canterbury Catchment Board and other Canterbury local bodies are in the course of testing injection and overspraying with herbicides for control of aquatic weeds.

DISCUSSION AND CONCLUSION

For emergent aquatic weeds, chemical treatment by over-spraying is now an accepted practice. The availability of alternative treatments reduces the likelihood of a predominance of one or more resistant species. (*Paspalum* does not occur in Canterbury drains.)

Of the submerged species encountered, oxygen weed is readily controlled by diquat or paraquat. There have nevertheless been failures reported but in at least one case a heavy silt deposit on the foliage was probably the reason.

Water milfoil is not easily controlled and is best treated with paraquat. Semi-submerged weeds such as watercress and water twitch are partially controlled by injection but are better treated by overspraying.

Until a chemical control is available for stonewort, one or two hand-cleanings will have to be interspersed from time to time.

No special precautions have been taken concerning safety of livestock and no cases of poisoning have been reported.

On a cost basis, chemical control offers considerable advantages. For control of submerged weeds by injection, a series of drains totalling 28 miles and varying from one to twenty cusecs cost an average of 1s. 10d. per chain. Two applications were needed for one year's control, giving a total cost of 3s. 8d. per chain. The cost per chain per application was made up of 3d. for labour, 1d. for plant and 1s. 6d. for chemical. In contrast, hand-work on drains carrying 2 to 4 cusecs has cost between 15s. and 30s. per chain for year-round clearance.

With the introduction of chemical control of submerged aquatic weeds, the problem of resistant species very soon arose. This is likely to occur where only one treatment can be employed. We should consider, however, what we really expect from chemicals in water-weed control. Sterilization of channel sides destroys stability, while permanent clearance of channel floors could promote serious erosion. Unless waterways are sterilized or completely roofed-over, some vegetation will grow. Our aim, therefore, should probably be to encourage vegetation which will cause the minimum impediment to flow and where necessary to use chemicals to give clearance cheaply and efficiently, even if only for a short time.

ACKNOWLEDGEMENTS

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REFERENCE

Banfield, G. L., 1959: *Proc. 12th N.Z. Weed Control Conf.*: 73.

Appendix*

DRAIN WEED CONTROL WITH PARAQUAT

A concentration of 10 ppm of paraquat† for 30 minutes has given efficient and economical control of submerged weeds for a distance of 40 chains from the point of injection in drains at a cost which shows substantial savings over hand or mechanical cleaning. The following tables give the amount of paraquat required to maintain the required concentration of chemical in drains of various widths and flow rates for periods of 30, 45 and 60 minutes.

Instructions for Use

1. Calculate mean depth of drain by adding depths of the two sides, dividing by two and adding to this the depth of the centre and halving the result.
2. From Table A, calculate the cross-sectional area in square feet by plotting the mean water depth of the drain against the width of the water surface.
3. Calculate the discharge of the drain in cusecs by measuring the time in seconds it takes for a wooden float to travel 100 ft and plotting this in Table B against the cross-sectional area of drain obtained from Table A.
4. Read the amount of paraquat required from Table C by plotting the discharge in cusecs obtained from Table B against the exposure time required.

Example: For a 12 ft wide drain with depths at the sides of 7 in. and 5 in. and a centre depth of 10 in. and a flow rate of 100 ft in 75 sec the amount of paraquat required would be:

Sides: 7 in. + 5 in. = 12 in.

Mean side depth: 12 in. ÷ 2 in. = 6 in.

Centre depth = 10 in.

Mean depth: 6 in. + 10 in. ÷ 2 in. = 8 in.

FROM TABLE A

For 12 ft surface width plus a mean depth of 8 in. the cross-sectional area is 8 sq. ft.

FROM TABLE B

For a flow rate of 100 ft in 75 sec and a cross-sectional area of 8 sq. ft the discharge = 8.5 cusecs.

FROM TABLE C

For 8.5 cusecs flow for a period of 30 min. would require 7 pt 13 oz of paraquat.

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† The paraquat referred to in this appendix is the formulation containing 2.0 lb active ingredient per gallon,

TABLE A: CROSS-SECTIONAL AREA IN SQUARE FEET
Width of Water Surface

	2'0"	2'6"	3'0"	3'6"	4'0"	4'6"	5'0"	5'6"	6'0"	6'6"	7'0"	7'6"	8'0"	8'6"	9'0"	9'6"	10'0"	10'6"	11'0"	11'6"	12'0"	12'6"	13'0"	13'6"	14'0"	14'6"	15'0"	15'6"
3'	0.5	0.6	0.8	0.9	1.0	1.1	1.3	1.4	1.5	1.6	1.8	1.9	2.0	2.1	2.2	2.3	2.5	2.6	2.8	2.9	3.0	3.2	3.3	3.4	3.5	3.6	3.8	3.9
4'	0.7	0.8	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.2	2.3	2.5	2.7	2.8	3.0	3.2	3.4	3.5	3.7	3.8	4.0	4.2	4.3	4.5	4.7	4.8	5.0	5.2
5'	0.9	1.0	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.3	6.5
6'	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.3	4.5	4.8	5.0	5.3	5.5	5.8	6.0	6.3	6.5	6.7	7.0	7.2	7.5	7.8
7'	1.2	1.5	1.8	2.1	2.3	2.7	2.9	3.2	3.5	3.8	4.1	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.5	6.7	7.0	7.3	7.6	7.9	8.2	8.4	8.8	9.1
8'	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.4	6.7	7.1	7.4	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0	10.3
9'	1.5	1.9	2.3	2.7	3.0	3.4	3.8	4.2	4.5	4.9	5.3	5.7	6.0	6.4	6.8	7.2	7.5	7.9	8.3	8.6	9.0	9.4	9.7	10.2	10.5	10.9	11.3	11.6
10'	1.7	2.1	2.5	2.9	3.3	3.8	4.2	4.6	5.0	5.4	5.8	6.3	6.7	7.2	7.5	8.0	8.4	8.8	9.2	9.6	10.0	10.4	10.8	11.3	11.7	12.1	12.5	12.8
11'	1.8	2.3	2.8	3.2	3.7	4.2	4.6	5.1	5.5	6.0	6.4	6.8	7.3	7.7	8.3	8.8	9.2	9.6	10.1	10.5	11.0	11.4	11.9	12.4	12.9	13.3	13.8	14.2
12'	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5
13'	2.2	2.7	3.3	3.8	4.3	4.9	5.4	6.0	6.5	7.1	7.6	8.1	8.6	9.2	9.8	10.2	10.7	11.4	11.9	12.5	13.0	13.5	14.1	14.6	15.2	15.7	16.3	16.8
14'	2.3	2.9	3.5	4.1	4.7	5.3	5.8	6.5	7.0	7.7	8.2	8.7	9.3	9.9	10.5	11.4	11.5	12.3	12.9	13.4	14.0	14.5	15.2	15.8	16.3	16.9	17.5	18.2
15'	2.5	3.1	3.8	4.4	5.0	5.7	6.3	6.9	7.5	8.2	8.8	9.4	10.0	10.7	11.3	11.8	12.5	13.2	13.8	14.4	15.0	15.6	16.3	16.9	17.5	18.1	18.8	19.4
16'	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0	8.7	9.3	10.0	10.6	11.4	12.0	12.7	13.3	14.0	14.7	15.4	16.0	16.7	17.3	18.0	18.7	19.3	20.0	20.7
17'	2.8	3.5	4.3	5.0	5.7	6.4	7.1	7.8	8.5	9.2	9.9	10.7	11.3	12.0	12.8	13.5	14.3	15.0	15.8	16.5	17.3	18.0	18.8	19.5	20.2	21.0	21.7	22.5
18'	3.0	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0	9.8	10.5	11.3	12.0	12.8	13.5	14.3	15.2	15.8	16.7	17.4	18.3	19.0	19.8	20.6	21.4	22.2	22.9	23.8
19'	3.2	4.0	4.8	5.5	6.3	7.2	7.9	8.8	9.5	10.3	11.1	11.9	12.6	13.3	14.2	15.0	15.8	16.7	17.5	18.4	19.2	20.0	20.8	21.7	22.5	23.3	24.1	25.0
20'	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0	10.8	11.7	12.6	13.4	14.4	15.3	16.3	17.3	18.2	19.2	20.1	21.1	22.0	22.9	23.8	24.8	25.6	26.5	27.4
21'	3.5	4.4	5.3	6.1	7.0	7.9	8.8	9.6	10.5	11.4	12.3	13.2	14.0	14.9	15.8	16.7	17.5	18.4	19.2	20.1	21.1	22.0	22.9	23.8	24.8	25.6	26.6	27.5
22'	3.7	4.6	5.5	6.4	7.3	8.3	9.2	10.0	11.0	11.9	12.8	13.8	14.6	15.6	16.5	17.4	18.3	19.2	20.1	21.0	22.1	23.0	24.0	24.9	25.9	26.8	27.8	28.8
23'	3.8	4.8	5.8	6.7	7.7	8.7	9.6	10.5	11.5	12.4	13.4	14.4	15.3	16.3	17.3	18.3	19.2	20.1	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0
24'	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0	31.0
25'	4.2	5.2	6.3	7.3	8.3	9.4	10.4	11.5	12.5	13.6	14.6	15.6	16.6	17.7	18.8	19.8	20.8	21.9	22.9	24.0	25.0	26.0	27.1	28.1	29.2	30.2	31.3	32.3
26'	4.3	5.4	6.5	7.6	8.7	9.8	10.8	12.0	13.0	14.2	15.2	16.2	17.3	18.4	19.5	20.6	21.7	22.8	23.8	25.0	26.0	27.1	28.2	29.2	30.3	31.4	32.5	33.6
27'	4.5	5.6	6.8	7.9	9.0	10.2	11.3	12.4	13.5	14.7	15.7	16.9	18.0	19.2	20.3	21.4	22.5	23.6	24.7	25.9	27.0	28.1	29.3	30.4	31.5	32.6	33.8	35.0
28'	4.7	5.8	7.0	8.2	9.3	10.5	11.7	12.8	14.0	15.3	16.3	17.5	18.6	19.9	21.0	22.2	23.4	24.5	25.6	26.9	28.0	29.1	30.4	31.5	32.6	33.8	35.0	36.2
29'	4.8	6.0	7.3	8.5	9.7	10.9	12.1	13.3	14.5	15.8	16.9	18.1	19.3	20.6	21.8	23.0	24.2	25.4	26.6	27.8	29.0	30.2	31.4	32.6	33.8	35.0	36.3	37.4
30'	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0	16.3	17.5	18.8	20.0	21.3	22.5	23.8	25.0	26.2	27.5	28.8	30.0	31.2	32.5	33.7	35.0	36.2	37.5	38.8
31'	5.2	6.5	7.8	9.0	10.3	11.7	12.9	14.2	15.5	16.8	18.1	19.5	20.6	22.0	23.3	24.6	25.8	27.1	28.4	29.7	31.0	32.2	33.6	34.8	36.1	37.4	38.8	40.0
32'	5.3	6.7	8.0	9.3	10.7	12.0	13.3	14.7	16.0	17.4	18.7	20.1	21.3	22.7	24.0	25.4	26.6	28.0	29.3	30.7	32.0	33.3	34.7	36.0	37.3	38.6	40.0	41.3
33'	5.5	6.9	8.3	9.6	11.0	12.4	13.8	15.2	16.5	17.9	19.3	20.7	22.0	23.4	24.8	26.2	27.5	28.9	30.2	31.6	33.0	34.3	35.7	37.1	38.4	39.8	41.3	42.6
34'	5.7	7.1	8.5	9.9	11.3	12.8	14.2	15.6	17.0	18.5	19.9	21.4	22.5	24.1	25.5	27.0	28.3	29.7	31.1	32.6	34.0	35.4	36.8	38.2	39.6	41.0	42.5	44.0
35'	5.8	7.3	8.8	10.2	11.7	13.2	14.6	16.1	17.5	19.0	20.5	22.0	23.3	24.9	26.3	27.8	29.2	30.6	32.0	33.5	35.0	36.5	37.9	39.3	40.8	42.2	43.8	45.3
36'	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27.0	28.5	30.0	31.5	33.0	34.5	36.0	37.5	39.0	40.5	42.0	43.5	45.0	46.5

TABLE B: DISCHARGE IN CUSECS
Cross-sectional area from Table A

25	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	9.9	10.3	10.7
30	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0	26.6	27.2	28.8	30.4	32.0	33.6	35.2
35	1.2	2.3	3.4	4.6	5.7	6.9	8.0	9.3	10.7	12.0	13.3	14.6	16.0	17.3	18.6	20.0	21.4	22.7	24.0	25.4	26.7	28.0
40	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0
45	0.9	1.8	2.7	3.6	4.5	5.3	6.2	7.1	8.0	8.9	9.8	10.7	11.6	12.5	13.4	14.3	15.1	16.0	16.9	17.8	18.7	19.6
50	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0	12.8	13.6	14.4	15.2	16.0	16.8	17.6
55	0.7	1.5	2.2	2.9	3.6	4.4	5.1	5.8	6.6	7.3	8.0	8.8	9.5	10.2	10.9	11.7	12.4	13.1	13.8	14.6	15.3	16.0
60	0.7	1.3	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0	8.7	9.4	10.0	10.7	11.4	12.0	12.7	13.4	14.0	14.7
65	0.6	1.2	1.9	2.5	3.1	3.7	4.3	4.9	5.6	6.2	6.8	7.4	8.0	8.6	9.2	9.9	10.5	11.2	11.7	12.3	12.9	13.6
70	0.6	1.1	1.7	2.3	2.9	3.4	4.0	4.6	5.2	5.7	6.3	6.9	7.4	8.0	8.6	9.2	9.7	10.3	10.9	11.5	12.0	12.6
75	0.5	1.1	1.6	2.1	2.7	3.2	3.7	4.3	4.8	5.3	5.9	6.4	6.9	7.4	8.0	8.5	9.1	9.6	10.2	10.7	11.3	11.8
80	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0
85	0.5	1.0	1.4	1.9	2.3	2.8	3.3	3.8	4.2	4.7	5.2	5.7	6.1	6.6	7.1	7.5	8.0	8.5	8.9	9.4	9.9	10.4
90	0.4	0.9	1.3	1.8	2.2	2.7	3.1	3.6	4.0	4.5	4.9	5.3	5.8	6.2	6.7	7.1	7.6	8.0	8.4	8.9	9.3	9.8
95	0.4	0.8	1.3	1.7	2.1	2.5	3.0	3.4	3.8	4.2	4.6	5.1	5.5	5.9	6.3	6.7	7.2	7.6	8.0	8.4	8.8	9.3
100	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.8
105	0.4	0.8	1.1	1.5	1.9	2.3	2.7	3.1	3.4	3.8	4.2	4.6	5.0	5.3	5.7	6.1	6.5	6.9	7.2	7.6	8.0	8.4
110	0.4	0.7	1.1	1.5	1.8	2.2	2.5	2.9	3.3	3.6	4.0	4.4	4.7	5.1	5.5	5.8	6.2	6.5	6.9	7.3	7.6	8.0
115	0.4	0.7	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.5	3.8	4.2	4.5	4.9	5.2	5.6	5.9	6.3	6.6	7.0	7.3	7.6
120	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0	5.3	5.7	6.0	6.3	6.7	7.0	7.3
125	0.3	0.6	1.0	1.3	1.6	1.9	2.2	2.6	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.1	5.4	5.8	6.1	6.4	6.7	7.1
130	0.3	0.6	0.9	1.2	1.5	1.9	2.2	2.5	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8	6.2	6.5	6.8
135	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.5
140	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.3	2.6	2.9	3.1	3.4	3.7	4.0	4.3	4.6	4.9	5.1	5.4	5.7	6.0	6.3
145	0.3	0.6	0.8	1.1	1.4	1.7	1.9	2.2	2.5	2.8	3.0	3.3	3.6	3.9	4.1	4.4	4.7	5.0	5.2	5.5	5.8	6.1
150	0.3	0.5	0.8	1.1	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.5	3.7	4.0	4.3	4.5	4.8	5.1	5.3	5.6	5.9
155	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.3	2.6	2.8	3.1	3.4	3.6	3.9	4.1	4.4	4.7	4.9	5.2	5.4	5.7
160	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.5	2.8	3.0	3.2	3.5	3.8	4.0	4.3	4.5	4.8	5.0	5.3	5.5
165	0.2	0.5	0.8	1.0	1.2	1.5	1.7	1.9	2.2	2.4	2.6	2.9	3.2	3.4	3.7	3.9	4.1	4.4	4.6	4.9	5.1	5.3
170	0.2	0.5	0.7	0.9	1.2	1.4	1.6	1.9	2.1	2.3	2.6	2.8	3.1	3.3	3.5	3.8	4.0	4.2	4.5	4.7	4.9	5.2
175	0.2	0.5	0.7	0.9	1.1	1.4	1.6	1.8	2.0	2.3	2.5	2.7	3.0	3.2	3.4	3.7	3.9	4.1	4.3	4.6	4.8	5.0
180	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2	2.4	2.7	2.9	3.1	3.3	3.6	3.8	4.0	4.2	4.4	4.7	4.9
185	0.2	0.4	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.2	2.4	2.6	2.8	3.0	3.2	3.5	3.7	3.9	4.1	4.3	4.5	4.8
190	0.2	0.4	0.6	0.8	1.1	1.2	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6
195	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.9	2.0	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.7	3.9	4.1	4.3	4.5
200	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4

TIME IN SECONDS

	11.1	11.5	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	
	25	36.8	38.4	40.0	41.6	43.2	44.8	46.4	48.0	49.6	51.2	53.8	54.3	56.0	57.6	59.2	60.7	62.4	64.0	65.5	67.2
	30	30.7	32.0	33.4	34.7	36.0	37.4	38.7	40.0	41.4	42.7	44.0	45.4	46.7	48.0	49.3	50.6	52.0	53.4	54.6	56.0
	35	26.3	27.4	28.6	29.7	30.8	32.0	33.2	34.3	35.4	36.6	37.7	38.8	40.0	41.2	42.3	43.4	44.6	45.6	46.8	48.0
	40	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0	41.0	42.0
	45	20.5	21.4	22.3	23.2	24.0	24.9	25.8	26.6	27.4	28.4	29.3	30.2	31.1	32.0	32.9	33.8	34.7	35.6	36.5	37.4
	50	18.4	19.2	20.0	20.8	21.6	22.4	23.2	24.0	24.8	25.6	26.4	27.2	28.0	28.8	29.6	30.4	31.2	32.0	32.8	33.6
	55	16.8	17.5	18.2	18.9	19.7	20.4	21.2	21.8	22.6	23.3	24.0	24.7	25.5	26.2	26.9	27.6	28.4	29.1	29.8	30.5
	60	15.4	16.0	16.7	17.4	18.2	18.7	19.4	20.0	20.7	21.4	22.0	22.7	23.4	24.0	24.7	25.3	26.0	26.7	27.3	28.0
	65	14.2	14.8	15.4	16.0	16.7	17.4	17.9	18.5	19.1	19.7	20.3	20.9	21.5	22.2	22.8	23.4	24.0	24.6	25.2	25.8
	70	13.2	13.7	14.3	14.9	15.5	16.0	16.6	17.1	17.7	18.3	18.9	19.4	20.0	20.6	21.1	21.7	22.3	22.8	23.4	24.0
	75	12.3	12.8	13.4	13.9	14.4	15.0	15.6	16.0	16.6	17.1	17.6	18.2	18.7	19.2	19.8	20.3	20.8	21.4	21.9	22.4
	80	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0
	85	10.9	11.3	11.8	12.3	12.7	13.2	13.7	14.1	14.6	15.1	15.6	16.0	16.5	16.9	17.4	17.9	18.4	18.8	19.3	19.8
	90	10.3	10.7	11.2	11.6	12.0	12.5	12.9	13.4	13.8	14.2	14.7	15.1	15.6	16.0	16.5	16.9	17.4	17.8	18.2	18.7
	95	9.7	10.1	10.6	11.0	11.4	11.8	12.2	12.7	13.1	13.5	13.9	14.3	14.8	15.3	15.6	16.0	16.5	16.9	17.3	17.7
	100	9.2	9.6	10.0	10.4	10.8	11.2	11.6	12.0	12.4	12.8	13.2	13.6	14.0	14.4	14.8	15.2	15.6	16.0	16.4	16.8
	105	8.8	9.1	9.5	9.9	10.3	10.7	11.1	11.5	11.8	12.2	12.6	13.0	13.4	13.7	14.1	14.5	14.9	15.4	15.7	16.0
	110	8.3	8.7	9.1	9.5	9.8	10.2	10.6	10.9	11.3	11.7	12.0	12.4	12.8	13.1	13.5	13.9	14.3	14.6	14.9	15.3
	115	8.0	8.3	8.7	9.1	9.4	9.7	10.1	10.5	10.8	11.1	11.5	11.8	12.2	12.5	12.9	13.2	13.6	13.9	16.3	16.6
	120	7.7	8.0	8.3	8.7	9.0	9.3	9.7	10.0	10.4	10.7	11.0	11.4	11.7	12.0	12.4	12.7	13.0	13.4	13.7	14.0
	125	7.4	7.7	8.0	8.3	8.7	9.0	9.3	9.6	9.9	10.3	10.6	10.9	11.3	11.6	11.9	12.2	12.5	12.8	13.2	13.5
	130	7.1	7.4	7.7	8.0	8.3	8.6	8.9	9.2	9.5	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	13.0
	135	6.8	7.1	7.4	7.7	8.0	8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5
	140	6.6	6.9	7.1	7.4	7.7	8.0	8.3	8.6	8.9	9.2	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.4	11.7	12.0
	145	6.3	6.6	6.8	7.2	7.4	7.7	8.0	8.3	8.6	8.8	9.1	9.4	9.7	9.9	10.2	10.5	10.8	11.0	11.3	11.6
	150	6.2	6.4	6.7	6.9	7.2	7.5	7.7	8.0	8.3	8.5	8.8	9.1	9.3	9.6	9.9	10.1	10.4	10.7	10.9	11.2
	155	5.9	6.2	6.5	6.7	7.0	7.2	7.5	7.7	8.0	8.3	8.5	8.8	9.0	9.3	9.5	9.8	10.1	10.3	10.6	10.8
	160	5.8	6.0	6.3	6.5	6.8	7.0	7.3	7.5	7.8	8.0	8.3	8.5	8.8	9.0	9.2	9.5	9.7	10.0	10.2	10.5
	165	5.6	5.8	6.1	6.3	6.6	6.8	7.0	7.3	7.5	7.8	8.0	8.3	8.5	8.7	9.0	9.2	9.5	9.7	10.0	10.2
	170	5.4	5.7	5.9	6.1	6.4	6.6	6.8	7.0	7.3	7.5	7.8	8.0	8.2	8.5	8.7	8.9	9.2	9.4	9.6	9.9
	175	5.2	5.5	5.7	6.0	6.2	6.4	6.6	6.9	7.1	7.3	7.5	7.7	8.0	8.2	8.5	8.7	8.9	9.2	9.4	9.6
	180	5.1	5.3	5.5	5.8	6.0	6.2	6.5	6.7	6.9	7.1	7.3	7.6	7.8	8.0	8.2	8.4	8.7	8.9	9.1	9.3
	185	5.0	5.2	5.4	5.6	5.8	6.0	6.3	6.5	6.7	6.9	7.1	7.3	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.1
	190	4.8	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8
	195	4.7	4.9	5.1	5.3	5.5	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4
	200	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4

TIME IN SECONDS

QUANTITY OF PARAQUAT
(Rate 10 ppm)

PERIOD OF INJECTION												
30 mins.			45 mins.			60 mins.						
Gals	Pts	Oz	Gals	Pts	Oz	Gals	Pts	Oz				
9	14	18	1	1	16	1	1	16				
10	18		1	1	10	1	1	10				
11			1	1	5	1	1	5				
12			1	1	1	1	1	1				
13			1	1	1	1	1	1				
14			1	1	1	1	1	1				
15			1	1	1	1	1	1				
16			1	1	1	1	1	1				
17			1	1	1	1	1	1				
18			1	1	1	1	1	1				
19			1	1	1	1	1	1				
20			1	1	1	1	1	1				
21			1	1	1	1	1	1				
22			1	1	1	1	1	1				
23			1	1	1	1	1	1				
24			1	1	1	1	1	1				
25			1	1	1	1	1	1				
26			1	1	1	1	1	1				
27			1	1	1	1	1	1				
28			1	1	1	1	1	1				
29			1	1	1	1	1	1				
30			1	1	1	1	1	1				
31			1	1	1	1	1	1				
32			1	1	1	1	1	1				
33			1	1	1	1	1	1				
34			1	1	1	1	1	1				
35			1	1	1	1	1	1				
36			1	1	1	1	1	1				
37			1	1	1	1	1	1				
38			1	1	1	1	1	1				
39			1	1	1	1	1	1				
40			1	1	1	1	1	1				
41			1	1	1	1	1	1				
42			1	1	1	1	1	1				
43			1	1	1	1	1	1				
44			1	1	1	1	1	1				
45			1	1	1	1	1	1				
46			1	1	1	1	1	1				
47			1	1	1	1	1	1				
48			1	1	1	1	1	1				
49			1	1	1	1	1	1				
50			1	1	1	1	1	1				
51			1	1	1	1	1	1				
52			1	1	1	1	1	1				
53			1	1	1	1	1	1				
54			1	1	1	1	1	1				
55			1	1	1	1	1	1				
56			1	1	1	1	1	1				
57			1	1	1	1	1	1				
58			1	1	1	1	1	1				
59			1	1	1	1	1	1				
60			1	1	1	1	1	1				
61			1	1	1	1	1	1				
62			1	1	1	1	1	1				
63			1	1	1	1	1	1				
64			1	1	1	1	1	1				
65			1	1	1	1	1	1				
66			1	1	1	1	1	1				
67			1	1	1	1	1	1				
68			1	1	1	1	1	1				
69			1	1	1	1	1	1				
70			1	1	1	1	1	1				
71			1	1	1	1	1	1				
72			1	1	1	1	1	1				
73			1	1	1	1	1	1				
74			1	1	1	1	1	1				
75			1	1	1	1	1	1				
76			1	1	1	1	1	1				
77			1	1	1	1	1	1				
78			1	1	1	1	1	1				
79			1	1	1	1	1	1				
80			1	1	1	1	1	1				
81			1	1	1	1	1	1				
82			1	1	1	1	1	1				
83			1	1	1	1	1	1				
84			1	1	1	1	1	1				
85			1	1	1	1	1	1				
86			1	1	1	1	1	1				
87			1	1	1	1	1	1				
88			1	1	1	1	1	1				
89			1	1	1	1	1	1				
90			1	1	1	1	1	1				

PERIOD OF INJECTION												
30 mins.			45 mins.			60 mins.						
Gals	Pts	Oz	Gals	Pts	Oz	Gals	Pts	Oz				
9	14	18	1	1	16	1	1	16				
10	18		1	1	10	1	1	10				
11			1	1	5	1	1	5				
12			1	1	1	1	1	1				
13			1	1	1	1	1	1				
14			1	1	1	1	1	1				
15			1	1	1	1	1	1				
16			1	1	1	1	1	1				
17			1	1	1	1	1	1				
18			1	1	1	1	1	1				
19			1	1	1	1	1	1				
20			1	1	1	1	1	1				
21			1	1	1	1	1	1				
22			1	1	1	1	1	1				
23			1	1	1	1	1	1				
24			1	1	1	1	1	1				
25			1	1	1	1	1	1				
26			1	1	1	1	1	1				
27			1	1	1	1	1	1				
28			1	1	1	1	1	1				
29			1	1	1	1	1	1				
30			1	1	1	1	1	1				
31			1	1	1	1	1	1				
32			1	1	1	1	1	1				
33			1	1	1	1	1	1				
34			1	1	1	1	1	1				
35			1	1	1	1	1	1				
36			1	1	1	1	1	1				
37			1	1	1	1	1	1				
38			1	1	1	1	1	1				
39			1	1	1	1	1	1				
40			1	1	1	1	1	1				
41			1	1	1	1	1	1				
42			1	1	1	1	1	1				
43			1	1	1	1	1	1				
44			1	1	1	1	1	1				
45			1	1	1	1	1	1				
46			1	1	1	1	1	1				
47			1	1	1	1	1	1				
48			1	1	1	1	1	1				
49			1	1	1	1	1	1				
50			1	1	1	1	1	1				
51			1	1	1	1	1	1				
52			1	1	1	1	1	1				
53			1	1	1	1	1	1				
54			1	1	1	1	1	1				
55			1	1	1	1	1	1				
56			1	1	1	1	1	1				
57			1	1	1	1	1	1				
58			1	1	1	1	1	1				
59			1	1	1	1	1	1				
60			1	1	1	1	1	1				
61			1	1	1	1	1	1				
62			1	1	1	1	1	1				
63			1	1	1	1	1	1				
64			1	1	1	1	1	1				
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66			1	1	1	1	1	1				
67			1	1	1	1	1	1				
68			1	1	1	1	1	1				
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71			1	1	1	1	1	1				
72			1	1	1	1	1	1				
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75			1	1	1	1	1	1				
76			1	1	1	1	1	1				
77			1	1	1	1	1	1				
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79			1	1	1	1	1	1				
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81			1	1	1	1	1	1				
82			1	1	1	1	1	1				
83			1	1	1	1	1	1				
84			1	1	1	1	1	1				
85			1	1	1	1	1	1				
86			1	1	1	1	1	1				
87			1	1	1	1	1	1				
88			1	1	1	1	1	1				
89			1	1	1	1	1	1				
90			1	1	1	1	1	1				

PERIOD OF INJECTION												
30 mins.			45 mins.			60 mins.						
Gals	Pts	Oz	Gals	Pts	Oz	Gals	Pts	Oz				
9	14	18	1	1	16	1	1	16				
10	18		1	1	10	1	1	10				
11			1	1	5	1	1	5				
12			1	1	1	1	1	1				
13			1	1	1	1	1	1				
14			1	1	1	1	1	1				
15			1	1	1	1	1	1				
16			1	1	1	1	1	1				
17			1	1	1	1	1	1				
18			1	1	1	1	1	1				
19			1	1	1	1	1	1				
20			1	1	1	1	1	1				
21			1	1	1	1	1	1				
22			1	1	1	1	1	1				
23			1	1	1	1	1	1				
24			1	1	1	1	1	1				
25			1	1	1	1	1	1				
26			1	1	1	1	1	1				
27			1	1	1	1	1	1				
28			1	1	1	1	1	1				
29			1	1	1	1	1	1				
30			1	1	1	1	1	1				
31			1	1	1	1	1	1				
32			1	1	1	1	1	1				
33			1	1	1	1	1	1				
34			1	1	1	1	1	1				
35			1	1	1	1	1	1				
36			1	1	1	1	1	1				
37			1	1	1	1	1	1				
38			1	1	1	1	1	1				
39			1	1	1	1	1	1				
40			1	1	1	1	1	1				
41			1	1	1	1	1	1				
42			1	1	1	1	1	1				
43			1	1	1	1	1	1				
44			1	1	1	1	1	1				
45			1	1	1	1	1	1				
46			1	1	1	1	1	1				
47			1	1	1	1	1	1				
48			1	1	1	1	1	1				
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54			1	1	1	1	1	1				
55			1	1	1	1	1	1				
56			1	1	1	1	1	1				
57			1	1	1	1	1	1				
58			1	1	1	1	1	1				
59			1	1	1	1	1	1				
60			1	1	1	1	1	1				
61			1	1	1	1	1	1				
62			1	1	1	1	1	1				
63												