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Prepared by D. M. Lancaster
Presented by C. W. Thomas.

Paper to be Presented at the Fifth Annual Joint Weed Control Conference -- February 2, 3, 4, 6, 1950

Flow Characteristics of Canals as Determined by Salt Cloud Investigations

The purpose of this paper is to describe the propagation of a chemical cloud as it progresses downstream in an irrigation canal. My remarks will be based on the movement of a cloud of common table salt. Since salt is a chemical it is reasonable to assume that the characteristics of a cloud of salt will be similar to those of a chemical injected into an open ditch for the purpose of killing weeds.

Experience with a salt cloud has resulted from the necessity of using it as a means of accurately determining the velocity of flow in a canal from which quantity is computed. Briefly, the salt-velocity method, as it is termed, consists of introducing salt into a stream and determining its passage at one or more points downstream by use of electrodes energized with direct or alternating current with an ammeter to indicate the flow of electricity, since the conductivity of the water is increased by the passage of the salt cloud. By measuring the time elapsed from the instant of salt injection to the passing of the cloud at an electrode station, a known distance downstream, the velocity is obtained. Volumetric measurements of the canal test section will then permit computation of the quantity of flow. Generally, the equipment used to detect the flow of the electricity is much more sensitive than an ammeter, however, the instrumentation involved in the procedure would constitute another subject.

It is apparent that this method does not require a knowledge of the concentration of the cloud of salt. It is possible, though, to evaluate the concentration by utilizing a calibrated conductivity meter.

This method of measuring water is not recommended for determining the quantity of flow to permit computation of the amount of weed killing chemical to be added, but is merely used as a means of analyzing the movement of a chemical cloud in an irrigation canal. Consider for a moment the methods to be utilized in measuring the quantity of flow in the canal to be treated. Extreme accuracy is not considered essential for this purpose and a procedure well known to operating personnel or ditch riders is preferable. One of the simplest and best known method is to use a current meter and if the canal section is average, an accuracy of plus or minus 10 percent may be expected with a single set of measurements. Should the only available section for current meter measurements be badly choked with weeds, the measurements will be less accurate and conceivably impossible to perform. In such an instance the weeds could be mechanically removed for a sufficient length of the canal to enable the current meter measurements to be made. Of course, in some cases, permanent measuring devices may exist in the canal, such as a weir, constant head orifice, Calco meter gate, etc., and if the instruments have been reasonably maintained the discharge from the ditch rider's record should suffice.

To grasp an idea of the method of formation of a chemical cloud, consider for a moment the movement of the particles of water in a canal before any chemicals are added. The type of flow is turbulent as opposed to laminar flow. Each particle of water is tossed about by many small eddy currents which characterize turbulent flow. If we were to take a particle of water and paint it red to enable us to observe the movement, we would see this particle moving in various directions and at an infinite number of velocities as it progressed downstream. The velocity, as we normally think of it, is an average of the infinite number of velocities and the direction may likewise be considered as an average. All of the water particles considered together represent an enormous mixing with each other. This is not to be confused with molecular motion which is so small as to be ignored in this discussion.

The mixing action of particles of weed killing chemicals introduced into the stream would be the same as the mixing of the water particles among themselves, so long as the density remained close to that of water. As the chemical cloud progresses downstream, its length increases due to the process of mixing. After traveling a certain distance all the chemical particles are thoroughly mixed with the water particles, and we can ascertain the cloud concentration with respect to its length. After traveling this distance the shape of the cloud is independent of and entirely different from the initial form at the point of injection. However, the size and shape of the cloud varies constantly as it moves in the canal.

Based on some experiments performed by Martin A. Mason at the University of Grenoble, the cloud distribution in a parabolic canal was uniform at a distance of approximately 33 feet from the point of injection with a velocity of flow of 1.3 feet per second. As the velocity of flow increased, the length required for attaining uniform distribution decreased. It was also shown that the distribution of the cloud took place in a shorter distance for increased boundary roughness. Hence, it is obvious that chemicals introduced into a canal for the purpose of killing weeds will form a uniformly distributed cloud in a short distance, particularly since the presence of weeds greatly increases the roughness factor.

Slide 1 LS-4948

This slide represents an oscillogram made in connection with the passing of a salt cloud in an open chute on the Yakima Project. The traces were made by galvanometers which produced straight lines until the salt cloud arrived resulting in an increase in the flow of electricity causing the galvanometers to deflect. The deflection at any instant is a function of the concentration at that particular section in the cloud. Note how the concentration increased rather sharply at the front of the cloud, (steepness of the trace) reached a maximum, then decreased at a slower rate. As this same salt cloud passes another set of electrodes farther downstream, it will be observed that the galvanometer trace is different, the slope of the trace which is a function of the degree of concentration is less and the maximum deflection or concentration is also less, but the length of the cloud is materially greater.

Slide 2 LS-4950

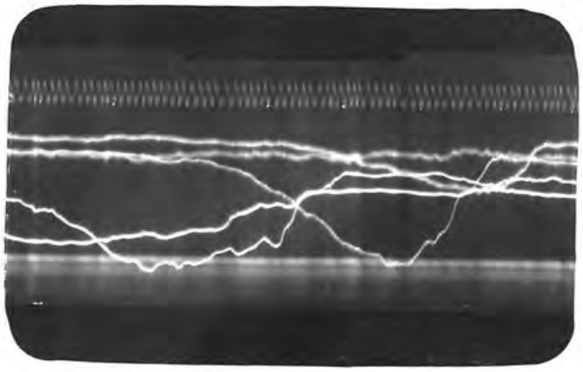
This slide represents a very similar condition which happens to be an oscillogram of the movement of a cloud down the spillway face of Grand Coulee Dam. This is an open canal with high velocity. Again note the steepness of the trace at the front of the cloud compared to that at the tail end, and that the total deflection, which is a measure of concentration of the salt cloud, decreased as we go downstream, and again, that the length of the cloud increases with the decreased concentration.

Slide 3 LS-4951

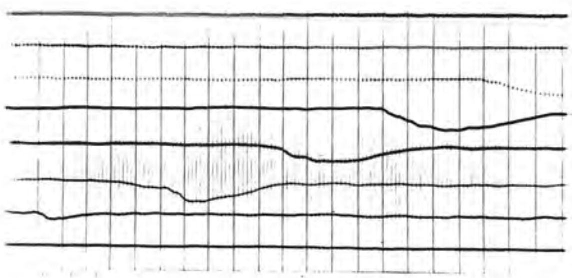
Based on these and similar measurements, together with a knowledge of velocity distribution within a canal, this graphic picture represents a cloud placed in a canal in the manner employed when weed killing chemicals are used. The chemical is considered to be introduced through a manifold arrangement to attain equal distribution across the canal at the earliest possible instant. The dots represent the cloud and the number of dots in any section represents the degree of concentration of the solution. Note the dispersing at the front of the cloud where some of the particles are carried near the center of the stream where the velocity is a maximum while those on the sides lag behind where the velocity is slowed by the friction of the boundaries. The front of the cloud is represented by the steep or rising part of the galvanometer traces shown on the two preceding slides and represented graphically here (lower part of slide) by the density curve. The density, or concentration, increases as we pass back into the cloud and soon reaches a maximum which is maintained until the rear of the cloud is approached when the density curve gradually drops to zero as result of the decreasing concentration. However, the rear of the cloud must have a shape somewhat similar to the front due to the higher velocity near the center of the stream. It will be noted that the density curve is maintained constant for a considerable distance in this case, whereas, in the preceding examples the density curve or galvanometer traces increased to a maximum and immediately started decreasing. This is due to the fact that the weed killing chemical is introduced for a relatively long period, whereas, in the case of the salt velocity, a very small quantity of chemical was added almost instantaneously. Had a large volume of salt been introduced, the galvanometer traces would have been more nearly like the density curve shown at the bottom of this slide.

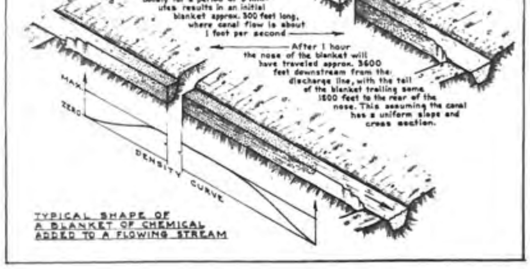
As is the usual case in theorizing, the ideal condition was chosen for this example. That is, one in which the canal is not choked with weeds, but weeds along the banks or bottom of the canal will merely retard the velocities in these regions resulting in a longer nose and tail. On the other hand, it is conceivable, particularly in the case of small ditches, that the ditches would be so choked with weeds that the velocity at any point would be practically the same as that at any other point causing a very flat front and tail. I believe the presence of weeds resulting in the retardation of flow with the increased period of contact between the weed and the chemical cloud would be advantageous to the weed killing problem. If I am wrong in this statement, someone may correct me. Another factor ignored in presenting the graphic picture of the chemical cloud is that of specific gravity. This problem does not arise in the salt velocity procedure since an extremely small quantity is used. For example, the traces shown as result of the Grand Coulee tests were obtained with a quantity of salt equivalent to an ordinary snow ball.

It is understood that the solution used for killing weeds has a specific gravity of approximately unity until the emulsion breaks causing the chemical cloud to obtain a specific gravity less than unity with the result that the chemical cloud rises to the surface.



Slide 1




Chemical discharged continuously for a period of 5 minutes results in an initial blanket approx. 300 feet long, where canal flow is about 1 foot per second
After 1 hour the nose of the blanket will have traveled approx. 3600 feet downstream from the discharge line, with the tail of the blanket trailing some 1500 feet to the rear of the nose. This assuming the canal has a uniform slope and cross section.
MAX.
ZERO
DENSITY CURVE
TYPICAL SHAPE OF A BLANKET OF CHEMICAL ADDED TO A FLOWING STREAM

Dale Lancaster
Hydraulics Lab

PROGRAM

FIFTH ANNUAL JOINT WEED CONTROL CONFERENCE

Bureau of Reclamation, Department of the Interior and
Bureau of Plant Industry, Department of Agriculture,
Denver, Colorado, February 2, 3, 4, 6, 1950.

February 2 (Thursday)

Morning

Tour Chief Engineer's Laboratories, Denver Federal Center. (Meet at Cosmopolitan Hotel 8:00 A.M. -- Transportation will be furnished to and from Denver Federal Center)

Noon

Lunch in D. F. C. Cafeteria.

Afternoon

Viewing of films and slides by all who have material to be shown. (16mm and slide projectors will be furnished)

Special Films

Microscopical and Microphotographical Studies on Effects of Aromatic Materials on Aquatic Plant Tissues. W. H. Mercer.

Laboratory Screening Methods for Testing Aquatic Weed Killers.

Treatment with aromatic Solvent of Canal near Torrington, Wyoming.

February 3 (Friday)

Research Program

Morning Session 4th Floor NCH

Dr. Karl S. Quisenberry, Chairman

Opening Remarks	Karl S. Quisenberry	15
Welcome to Denver	Avery A. Batson	15
Greetings to Conferees from C. W. Lineweaver	Robert B. Balcom	20-30
Importance of Weed Control in O & M Program on Irrigation Projects	John N. Spencer	20
Weed Control Research in Cooperation with the Bureau of Reclamation	Karl S. Quisenberry	
Remarks	Roy L. Lovvorn	20
Coordination of BPI Cooperative Weed Work in Northcentral States	L. M. Stahler	
Emulsifiers -- Theory and Application	A. L. Fowler	
Flow Characteristics of Canals as Determined by salt cloud Investigations	Dale M. Lancaster	
Importance of Certain Radicals in Weed Control Chemicals	John M. Shaw	
Soil Sterilization and Some Recent Applications	John M. Shaw	

Afternoon Session

BPI Research at Logan, Utah in 1949	F. L. Timmons
BPI Research at Prosser, Washington in 1949	Vic F. Bruns
BPI Research at Meridian, Idaho in 1949	Jesse M. Hodgson
BPI Research at Phoenix, Arizona in 1949	H. Fred Arle
BPI Research in Denver Laboratory in 1949 and plans for 1950	Eugene T. Oborn
Tentative Cooperative Weed Control Program for 1950	F. L. Timmons
Resume of Weed Control Research in Denver Laboratory by B. of R. in 1949	John M. Shaw
Tentative Weed Research Program in Denver Laboratory for 1950	W. T. Moran
Highlights of Weed Control in Region 1 in 1949	W. Dean Boyle
Highlights of Weed Control in Region 2 in 1949	Cecil J. Graham
Highlights of Weed Control in Region 3 in 1949	Curtis W. Bowser
Highlights of Weed Control in Region 4 in 1949	N. Harold Hirst
Highlights of Weed Control in Region 5 in 1949	John C. Koogler

February 3 (Friday)

Afternoon Session

Con't.

Highlights of Weed Control in Region 6 in 1949	Charles C. Butler
Highlights of Weed Control in Region 7 in 1949	John T. Maletic
Weed Problems Needing Further Research	John T. Maletic

February 4 (Saturday)

Morning Session

Objectives of a Good Weed Control Program and how the Objectives May be Achieved	John T. Meletic
Weed Control Equipment	Cecil J. Graham
Chemical Control of Herbaceous Landweeds	T. Dean Boyle
Control of Willows and other Woody Plants of the Northwest	Chas. G. Butler
Control of Salt Cedar and other Woody Plants of the Southwest	Curtis W. Bowser
Salt Cedar Control on McMillan Reservoir	Orlan J. Lowry
Control of Grasses on Ditchbanks	G. M. Finney
Control of Sugar Grass	M. G. Cakin
Prevention of Crop Injury with Herbicides	John G. Koogler
Weed Control by Burning	William H. Mercer

Afternoon Session

Control of Weeds through Construction	John G. Koogler
Seeding Ditchbanks	W. Harold Hirst
Specifications for Ditchbank Seedings	Dean M. Schacterle
Contracting for Ditchbank Seeding	Nat Tolman
Specifications for Equipment, Materials and Services	Curtis W. Bowser
Use of Nomograms for Solving Weed Control Mathematical Problems	John T. Meletic
Articles and Publications on Weed Control	Robert B. Balcom
Control of Emergent Waterweeds	Cecil J. Graham
Control of Submersed Waterweeds	W. Harold Hirst
Pros and Cons of Slug Method of Applying Aromatic Solvents	Laurel D. Firth

February 5 (Sunday)

Informal Conferences and Rest

February 6 (Monday)

Administrative Problems

Morning Session

Cooperation with other Agencies	D. T. Bolingbroke
Conservation of Water through Weed Control	Ralph S. Bristol
Weed Control on Public Lands	W. Dean Boyle
Weed Control as Part of Rehabilitation and Betterment Program	J. C. McGarrity
Funds for Weed Control	Chas. C. Butler

Afternoon Session

Weed Control Forms and Reports	Paul F. Beranek
Revision of Weed Control Material	Curtis W. Bowser
Report on Department of the Interior Weed Control Committee	Robert B. Balcom
Miscellaneous Administrative Matters	Robert B. Balcom