AN INVESTIGATION INTO THE INCIDENCE OF SPURTING FROM WEEPING WALL SLURRY STORES

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LIST OF FIGURES

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1.1 Introduction and Background Information.

Weeping wall slurry stores are generally built above ground level on a concrete base. Excess liquid drains out through narrow gaps in the walls and is collected in effluent channels around the store. It is then emptied into and stored in reception tanks below ground. These tanks are divided into three in order to provide primary, secondary, and tertiary settlement of the effluent before it is spray irrigated or vacuum tankered away. The liquid that weeps out of the store is a very hazardous substance as regards the pollution of water. It has a high and varying Biochemical Oxygen Demand of between 1,000 and 12,000 mg/litre (where Biochemical Oxygen Demand [BOD] is a measure of the amount of oxygen required by micro organisms to break down organic matter).

The store contents gradually dry out and become similar in consistency to farmyard manure. When the farmer wishes to empty the store he gains access by removing certain panels from one of the walls of the store.

There is no typical design for a weeping wall slurry store, but the walls are all on average between 1.5 and 3 metres high. They can be built with either concrete panels or wooden sleepers in order to form vertical or horizontal slatting. The width and shape of the slats again vary from store to store, but the widths are on average between 25 and 40 millimetres. A typical store is shown in figure one.

GENERAL DESIGN OF A WEEPING WALL SLURRY STORE

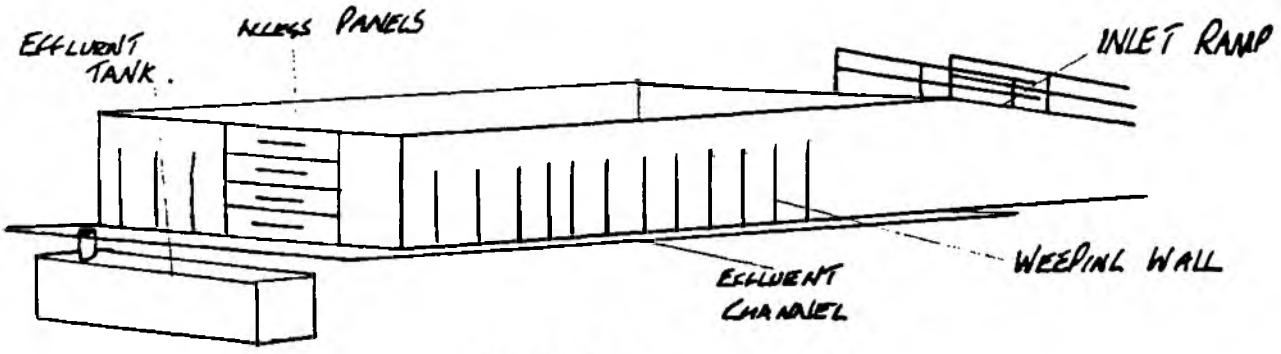


Figure.One

Weeping wall stores are suitable for cattle slurry which contains a lot of straw bedding material. The straw (or any other similar bedding material) helps to bond the solid fraction of the slurry together whilst still allowing the liquid fraction to weep out.

The contents of the store cannot be removed until they have dried out thoroughly, and therefore stores are not typically emptied until the late spring or early summer.

The size of the store is calculated from the length of the winter housing period, taking into account the amount the volume of dung, and bedding, but not rainfall as this will drain out of the store.

Under the control of Pollution (silage, slurry, and agricultural fuel oil) Regulations 1991 the store must have a minimum storage capacity of four months and a space of 300 millimetres (freeboard) must be left between the uppermost level of the slurry and the top of the walls, this must also be considered when designing a store.

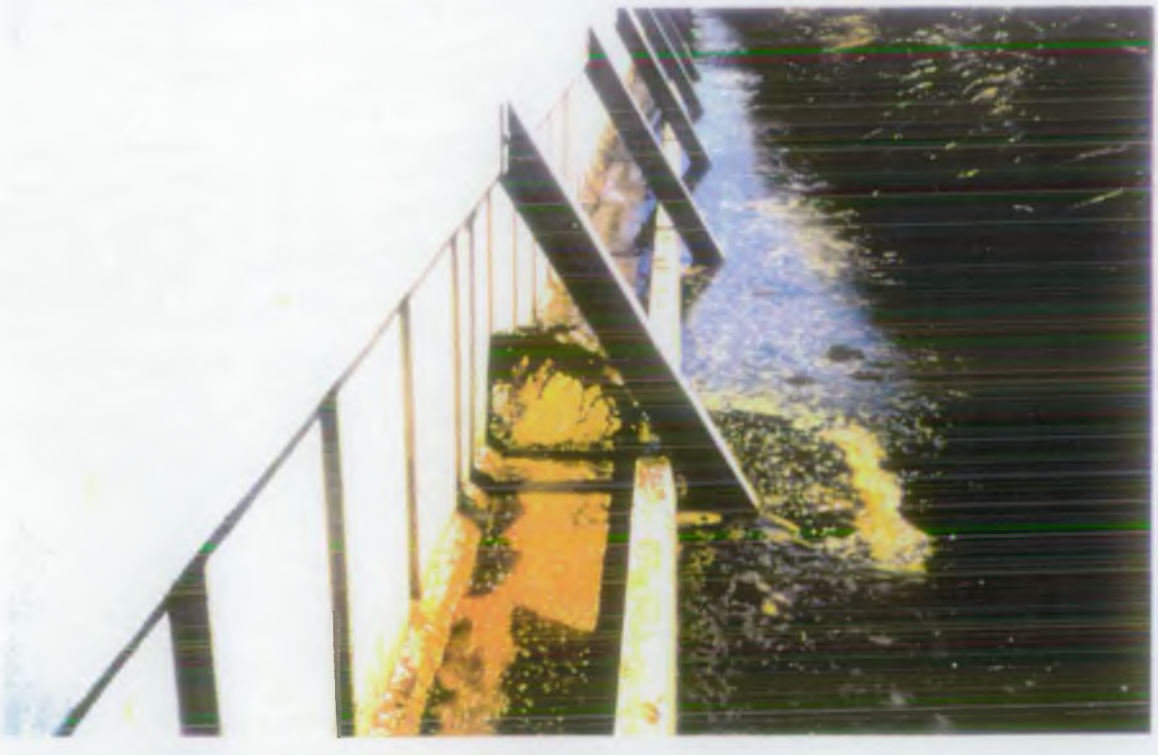
The principal of a weeping wall slurry store is to prolong the amount of storage available by removing as much of the liquid fraction of the slurry as possible. In some cases the stores function extremely well whilst in others there has been severe problems in the form of "spurts".

This is where, for some unknown reason, a pocket of liquid has built up inside the store and has been forced to one of the weeping walls where it has then spurted out under considerable pressure. The amounts of liquid which are discharged in such cases are extremely variable, and can be anything from 20 litres to 50,000 litres. Nobody knows why these spurts occur, and it is impossible to predict exactly when they are going to happen.

1.2 The Effects of Spurting.

When spurting occurs the very large volumes of escaping liquid may cause pollution problems in one or two ways. Either the spurting liquid runs away in an uncontrolled manner and goes into a watercourse, or it is retained within the effluent channel by earth banks or shuttering, but is of such an intensity that the irrigation system cannot cope resulting in the tanks flooding and overflowing, or, due to over-irrigation, substantial run-off of effluent.

Please refer to figure two which shows a spurt in progress.



2.1 Aims and Objectives.

The aim of this research project is to investigate the incidence of spurting from weeping wall slurry stores as per the following guidelines:

1) Try to establish the reasons why spurting occurs.

2) Look at ways/methods of reducing the occurrence of spurting or reducing/eliminating the effects if it does occur.

In order to achieve these aims and objectives the project has been structured into five separate stages.

2.2 Stage One.

The first part of the project is to select a series of farms with weeping wall stores in order to study the general design and use of such stores. This study will include looking at the type of slatting, the spacing, the dimensions, the capacity, size of the effluent channel, and the height at which the slats start. It will also include looking at the history of the store and making any other relevant notes. All such information will then be tabulated and cross referenced in order to attempt to identify any similarities between incidents. This information will then be used in order to compile further questions as necessary.

2.3 Stage Two.

The second stage of the project is to use the information gathered in stage one and carry out some physical investigations into the problem. This will involve devising and performing experiments in order to test out the theories and conclusions made in stage one.

2.4 Stage Three.

The third stage of the project is to interpret the information and data gained from stage two and assess the need for further practical investigations. Then to make any possible conclusions and/or carry out further studies into the problem.

2.5 Stage Four.

Part four of the project shall be used to devise possible methods of preventing or reducing the risk of spurting and then testing them out and assessing their feasibility.

2.6 Stage Five.

Part five of the project will be used to draw final conclusions as to the reasons why weeping walls spurt, and whether there are any steps which can be taken in order to prevent them spurting or to reducing the risk of them spurting.

STAGE ONE

3.1 Farm Selection

In the first instance a series of farms were located by referring to records of Ministry of Agriculture grant approval letters. Each letter outlined what the grant was for, and hence it was possible to locate farms which had applied for grant aid to help with the improvement of existing weeping wall stores, or the erection of new ones. A list of farms was drawn up from the letters sent out over the last three years.

3.2 Visit One

The aim of the first visit was to primarily establish whether the farm had a working weeping wall store, and if it did, were there any objections to allowing the store becoming part of the research project, (please refer to figure three, on page five, for a map of the farm locations). Once co-operation had been achieved some basic details of the store were recorded. These included: the type of slatting, the material used to build it, the spaces left between the slats, the dimensions and approximate capacity of the store, where the slats start from, and the width of the channel. A rough diagram was drawn depicting the inlets, access points, and the location of the weeping wall(s). Some photographs were taken and any other relevant notes were made. All of these results were entered onto individual farm reports and also onto a large table so that they could be cross referenced.

The individual farm reports may be found at the rear of this report in appendix A, and the results table (table 1) may be found on page 6.

3.3 Visit Two

All of these results were then analyzed both as a whole and on an individual basis in order to locate areas which required further investigation on subsequent visits. A set of questions were then drawn up for the repeat visits. These were generally the same for each farm and they aimed to establish the physical factors which affect each location. The results of these questions were then entered onto the cross referencing table, table 1, along with the previous information.

3.4 Stage One Conclusions

By referring to table one it would appear that not many of the factors listed actually match up in any way. However, at this point of the investigation it is possible to generalize and say that of the stores which have had problems with spurting they have mostly been large capacity stores, with three or more sides weeping. Therefore it is necessary to investigate these conclusions further to test their validity. It is also necessary to establish which of the physical factors, if any, have any bearing on the incidence of spurting.

Table One

KEEPING WALL FARM DATA

FARM NAME.	SLATTING.	SHAPE.	WIDTH.	W R/TR.	MATERIAL.	HGSS.
HIGHER HAWKERLAND	VERTICAL	| |	45mm	REG	WOOD	FLOOR
RILL FARM	VERTICAL	\	30mm	IREG	CONCRETE	FLOOR
PARSONAGE FARM	VERTICAL	/\	25mm	REG	CONCRETE	0.2m
BRIDGE FARM	VERTICAL	/\	25mm	REG	CONCRETE	0.3m
MISDON FARM	VERTICAL	) (	25mm	IREG	CONCRETE	FLOOR
HIGHER GORMISH	HORIZ'AL	=	30mm	IREG	WOOD	0.3m
HIGHER BRADLEY	VERTICAL 1/2	/\	30mm	REG	CONCRETE	FLOOR
ASHBURY COURT	VERTICAL	/\	25mm	REG	CONCRETE	0.1m
CROSS FARM	VERTICAL	/\	25mm	REG	CONCRETE	FLOOR
EAST VILLAVIN	VERTICAL	/\	30mm	REG	CONCRETE	0.1m
PUTSHOLE FARM	VERTICAL	/\	35mm	REG	CONCRETE	FLOOR
GREAT CLISTON	VERTICAL	/\	25mm	REG	CONCRETE	0.1m
TOWN BARTON	VERTICAL 1/2	/\	30mm	REG	CONCRETE	FLOOR

CAPACITY.	PREVIOUS?	WHERE?	ROD?	HASL.	No.S.WG.
190m3	YES (24/3/92)		NO	137m	1 (3mSEC)
503m3	YES (31/3/91)		YES	120m	4
187m3	NO	-	YES	120m	1
648m3	YES (20/1/92)	CORNER	NO	30m	3
389m3	NO	-	NO	210m	1.5
120m3	NO	-	NO	180m	1
389m3	NO	-	YES	80m	2
393m3				210m	1.5
200m3	YES (20/4/90)	CORNER	YES	153m	3
500m3	NO	-	NO	183m	1 (4mSEC)
66.5m3	NO	-	NO	153m	1
243m3	YES (3/91)	CORNER	NO	130m	3
480m3	YES (15/3/92)	CORNER	NO	100m	3

+ 8X PRV

***** FARM DATA KEY *****

W.R.I.R. WIDTHS REGULAR OR IRREGULAR

HASS HEIGHT AT WHICH SEATS START

HASL HEIGHT ABOVE SEA LEVEL

No.S.WG. NUMBER OF SECTIONS WEEPING

I.E.E. IS FACE OF WEEPING WALL EXPOSED?

STAGE TWO

4.1 Objectives

The aim of stage two of the project was to use the information gathered from stage one in order to devise some physical investigations. The primary observation which needed further research was the conclusion that, of the stores studied to this point, those which had spurted had all done so from the corners of the stores.

4.2 Methodology

At present some farmers with weeping wall slurry stores employ the method of "rodding" their stores. This involves inserting a length of rod (or any other such implement) into the store which pierces any pockets of liquid which then discharge from the store along the fracture caused by the rod. Therefore the principal of the experiment would be to insert a series of pipes into the store. The purpose of this would be to establish if and where there are any pockets of liquid building up within the store and also to ascertain the effectiveness of the method of "rodding".

The full details of the experiment may be found on page 8.

BARNSTAPLE
EAST AREA
KEY
MAIN TOWNS
PARTICIPATING FARMS
AREA BOUNDARIES
SEA BOUNDARIES

4.3 Weeping Wall Experiment

AIM

To establish the effect of rodding on a weeping wall slurry store.

PROCEDURE

1: Take a number of 3m rods and place cork bungs in either end of each rod.*

2: Insert the set of rods into the store at regular intervals to a depth of 2.8m at about 30 cm above ground level.

3: Once in place, individually take each rod and remove the bung from the innermost end by pushing it out with a long rod.

4: Record if any liquid emerges, approximately how much and where from.

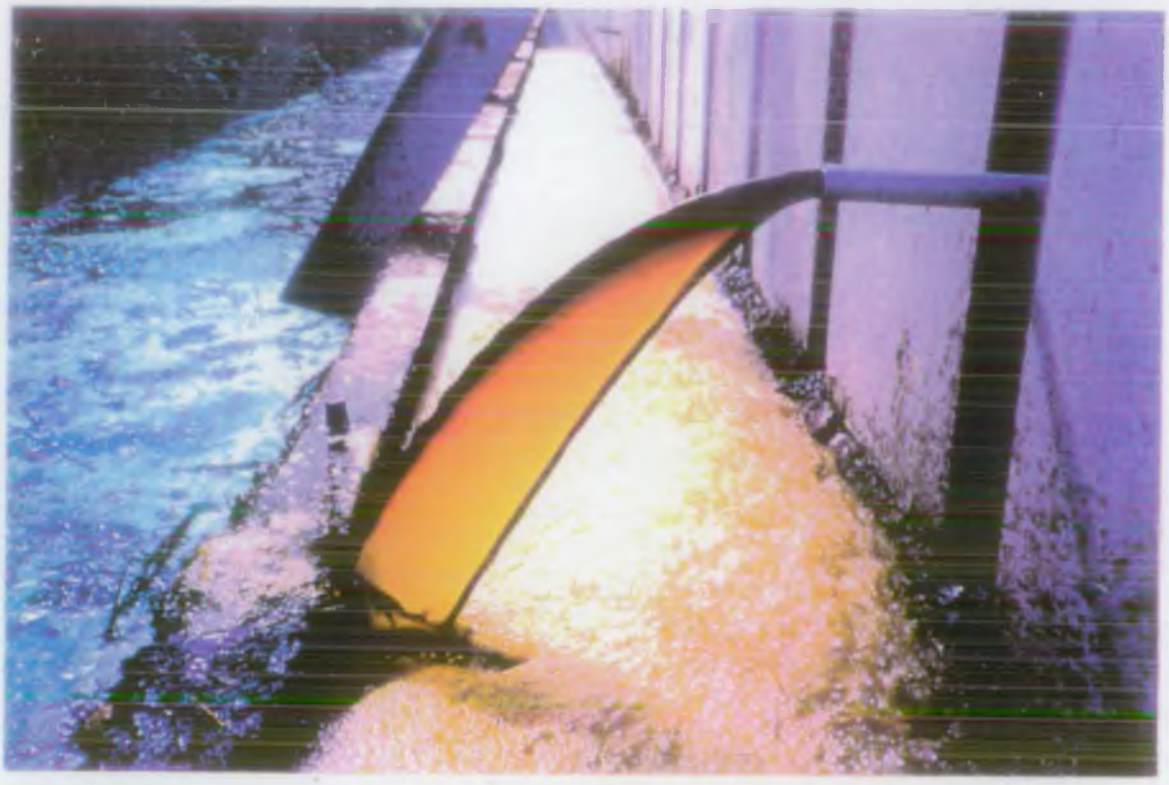
5: Re-stopper the outside end of the rod and repeat for each individual rod.

6: Repeat steps 4 and 5 for as long as necessary.

7: Re-position the rods if required.

* The number of rods will vary from store to store, but generally a gap of 3m should be left between each rod.

DIAGRAM



4.4 Results

Rod No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Week 1:	2	-	-	2	-	-	-	-	-	-	2	2	-
Week 2:	2	2	-	2	-	-	-	-	-	-	2	2	2
Week 3:	1	-	-	2	-	-	-	-	-	-	2	1	1
Week 4:	1	-	2	-	1	1	1	-	-	-	2	1	1
Week 5:	1	-	-	-	1	1	-	-	-	-	2	2	1
Week 6:	1	-	-	2	1	1	-	-	-	-	2	2	1

KEY
2= Large Discharge (15 mins - 120 mins)
1= Small Discharge (less than 15 mins)
-= No Discharge

4.5 Result Commentary

Rod number one had a couple of good discharges in the first two weeks of the experiment, but then the level of discharge dropped from about a one hour average to about ten minutes. It is important to note that the discharge in week one was in the form of a full blown spurt rather than a discharge from the pipe. Due to the duration and magnitude of this spurt it is possible to say that a very large quantity of liquid was drawn off the store and therefore the decline in discharge levels was inevitable. The continuing low flow discharges from this pipe could be attributed to the liquid moving from the inlet point to the pipe by capillary action along the solid back wall of the store.

Rods two and three remained dormant for the duration of the experiment except for two isolated incidents where the rods were moved slightly which resulted in the slats beginning to spurt. Each spurt lasted for approximately three-quarters of an hour and were both relatively low pressure discharges. However in the latter weeks of the experiment the rods were again moved but no further discharges were brought about.

Rod number four was one of the most reliable dischargers with an average discharge lasting about one and a half hours at a good constant rate. The no flow results in weeks four and five were due to the fact that the cork had been removed from the rod after the week three visit and had not been replaced, hence the rod became blocked. However, the cork was replaced in week five and the rod started discharging again in week six.

Rod numbers five, six, and seven all remained dormant for the first three weeks during which the weather was predominantly dry. However, a week of heavy rain between the weeks three and four visits led to very slight discharges which were very low pressure and lasted for no more than one minute.

Rods eight, nine, and ten all remained dormant even through the very wet weather of weeks four and five. In order to confirm this inactivity these rods were all moved and agitated but no discharges of any sort came about, thus it is possible to conclude that there were no substantial pockets of liquid in that area of the store.

Rods eleven, twelve, and thirteen, however, did all discharge on a regular basis. The average discharge from rod eleven was about two hours, rod twelve was about one and a quarter hours, and rod thirteen was about half an hour.

4.6 Conclusions

Before any conclusions are drawn it is first necessary to report that since the rodding experiment was started, the incidence of "natural" spurts (ie. spurts not artificially created) has been considerably reduced. Therefore to this point it is possible to conclude the following:

1) Pockets of liquid are building up within the store and are generally in the corners.

2) By carrying out the rodding experiment (as described in the text above) it appears that the hydraulic pressure and the amount of dirty water within the store has been greatly reduced, thus resulting in a vast reduction of the incidence of naturally occurring "spurts".

3) Due to the results from rods five, six, and seven in weeks four to six it is possible to conclude that heavy rainfall does affect the build up of liquid within the store.

4) Due to the results from rod four it is possible to conclude that even if a rod does become blocked with solid during a discharge, by simply replacing the cork, the rod will become unblocked of its own accord due to the build up of gases within that rod.

STAGE THREE

5.1 Objectives

Stage three of the project was to be used to interpret all of the information collated to this point and assess which areas required further investigation.

Firstly it was decided that the layering within the slurry required further studies in order to determine whether there was a uniform pattern of layers throughout the store. Secondly there appeared to be a need to gather more information about other farms (with weeping wall stores) outside the South West region in order to assess the magnitude of the problem on a more nationwide basis.

5.2 Core Sampling

The best way to study the layering within the slurry was to take core samples. However conventional core sampling rods (augers) were not suitable for sampling slurry due to its solid/liquid consistency. Therefore an alternative method was sought. It was suggested that the same pipes as were used in the weeping wall experiment could be used to sample the slurry. The principal behind this method would be to insert the rods vertically into the slurry to floor level, and then to stopper the exposed end of the rod in order to create a vacuum. It was then hoped that the sample could be lifted out without the rod losing any of its contents.

Unfortunately the results were not as expected. Only a small amount of solid entered the rod on insertion and this then prevented any further quantities of slurry from entering. Therefore various other methods of inserting the pipes were tried but all of which proved to be unsuccessful. In a final attempt a series of larger diameter rods were used, but an accurate sample was still unobtainable.

However, during the course of the experiment it was important to note that a full blown developed. It is believed that this was brought about by the vibrations caused by the action of walking on the barge boards which were laid on the surface of the slurry. "Shock waves" were clearly visible emanating over the area of the whole store. The spurt occurred opposite and at the furthest point from where the experiment was being conducted. This coincided with the point at which the "waves" would be at their most intense. It therefore became obvious that vibrations may have a relationship with the incidence of spurting.

5.3 Further Information

The next aim of stage three was to obtain more information about the experiences of other farmers with weeping wall stores. It was decided that the best way to achieve this would be to write to a number of farming publications with the hope of either getting some information from the staff or actually getting the letter requesting further information published in that particular magazine or paper.

The letter (a copy of which may be found in appendix B) was printed in Farmers Weekly, Farming News, South West Farmer, and various other National Farmers Union publications over the country. The response was very good with enquiries coming from as far apart as Newcastle Upon Tyne, Dyfed, and East Anglia.

In all twenty-three enquiries were received either by telephone or letter. Each individual related some basic information about their stores, ie. size, shape, amount of water entering the store etc. They then gave their general opinions as to the effectiveness of weeping wall stores and any problems that they had had were discussed.

5.4 Stage Three Conclusions

After the stage three investigations two new conclusions came to light. Firstly, it appeared that vibrations may effect the incidence of spurting. Secondly, from the further information gathered from the enquiries, a link emerged between the amount of water going into the store and the incidence of spurting.

STAGE FOUR

6.1 Objectives

Stage four of the project was to be used to devise methods which may be used to prevent or reduce the risk of spurting.

It was decided that two ideas should be investigated at this stage. Firstly, the conclusion that vidrations may induce spurting. Secondly, to establish whether it was possible to devise a computer programme which would assess the drainage patterns within a weeping wall slurry store.

6.2 The Effects of Vibrations

The reason for investigating the effects of vibrations was to establish whether they do induce spurting. If they did, it may be possible to use them as a method of draining liquid off the store and therefore reducing the risk of "uncontrolled" spurting.

In order to test out the vibration theory an industrial "vibrating poker" was hired. This piece of equipment is normally used to remove air bubbles from concrete. It consists of an air compressor, an air hose, and a metal shaft. This shaft vibrates at a very high speed and sends out small, high frequency waves.

The first store selected for experimentation was the store on which the rodding experiment had been conducted. This store was used because it was known exactly where the pockets of liquid were building up.

In order to gain access to the surface of the store a series of barge boards were placed on the crust in the areas where the poker was being inserted. The poker was then placed at the various points (as shown in figure 4) and left in place for varying amounts of time.

Unfortunately the vibrations did'nt appear to have any effect on the slurry during the experiment. However, approximately twenty minutes after the experiment had finished a spurt did occur. It was of medium pressure and lasted about thirty minutes. The estimated volume of the discharge was between 1500 and 2000 litres.

As this result was relatively inconclusive it was decided to try the experiment on another store. This store was smaller and had only a 3m section of weeping wall. The poker was inseted around the weeping section and around the access sleepers. The duration of each insertion was again varied.

Again the experiment did'nt appear to have any effect on the store. In order to assess the liquid content of the store the weeping section was rodded. After a while a spurt was induced with the rod thus proving that there were pockets within the store.

6.3 Vibration Conclusions

From the results of the experiment and from other experiences it is possible to conclude the following: Firstly that the vibrating poker does'nt appear to induce spurting. Secondly it is believed that larger vibrations (ie. those created by walking on the barge boards) are more likely to induce a spurt.

6.4 Computer Modelling

One possible way to reduce the risk of spurting would be to find out where the store is most likely to spurt so that remedial action could be taken. Therefore a computer programme was required. Such a programme should assess the drainage potential of each individual metre square of the store.

In order to make the programme as simple as possible several assumptions had to be made. Firstly it was necessary to assume that liquid within the store only moved towards the weeping walls. Secondly, that any such movements would be in straight lines only with no diagonal moves. Lastly that the store is one with three or four sides weeping.

Once these assumptions had been decided a computer programme was designed which assessed the probability of liquid moving to each weeping wall. The probabilities were then combined in order to produce an overall drainage figure for each metre square.

A copy of the programme may be found in appendix C.

These figures were then entered into a graphics programme and displayed in the form of a 3-D bar chart. Please refer to figure 5 for an example chart.

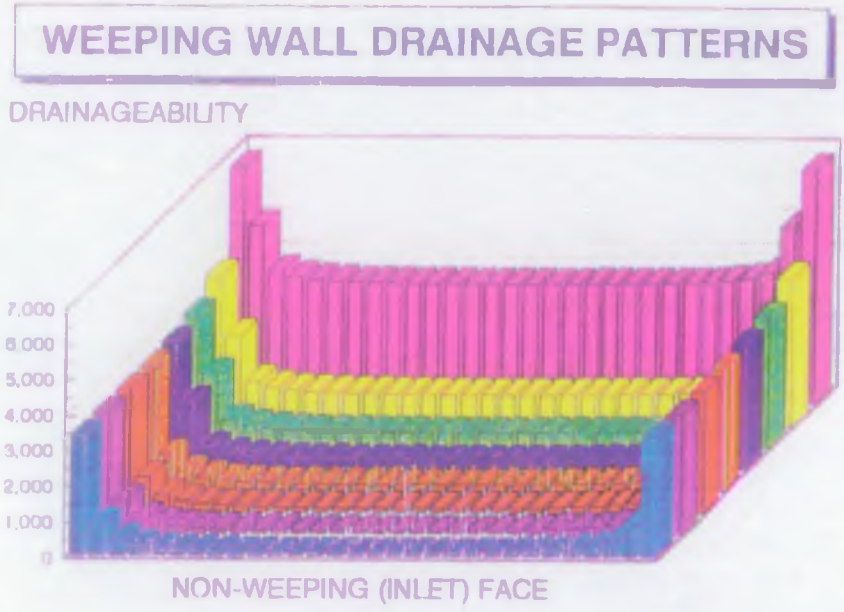


Figure.Five

The highest peaks on the chart correspond to the points where most drainage occurs. However from the information gathered to this point it also appears that these highest peaks also correspond with the areas that are most likely to spurt. Therefore it would be possible to use this method to predict where spurts are most likely to happen so that remedial action may be taken.

The remedial action would include several actions. Either by rodding that area of the store on a regular basis. Or by placing shuttering on the outside of the store to deflect any potential spurts.

STAGE FIVE

7.1 Possible Causes of Spurting

1) Heavy rainfall.

2) Excess amounts of liquid going into the store.

3) Not enough straw bedding in the slurry.

4) Disturbance of store by vibrations.

5) Slots in weeping walls becoming blocked.

6) A thaw following prolonged periods of freezing.

7.2 Recommendations

1) All weeping wall stores should be bunded with either retaining walls or earth banks around their perimeter in order to provide total containment in the case of emergency. However, if this method is employed it is then necessary to put a cut out device on the pump in order to eliminate the possibility of run-off from over irrigation.

2) It is advised that existing weeping wall stores should be rodded or have rods inserted into them as in the weeping wall experiment. Such action relieves the build up of hydraulic pressure within the store. The insertion of rods into the store is preferable to normal rodding as the release of liquid is more controlled.

3) It is also necessary to advise farmers/consultants that they should keep as much water out of the store as possible. ie. All yard/parlour water should be diverted straight to the three stage settlement tank or irrigation system. As a result the dirty water system would have to be designed to cope with larger amounts of liquid.

4) It is possible to stop a spurt by ramming a scaffolding plank down between the weeping wall and the slurry. Therefore it is advised that the necessary apparatus be kept on site at all times.

5) It is advised that farmers should be made aware of the dangers of removing the access sleepers in order to empty the store. The problem is that substantial amounts of liquid often build up behind the solid crust at the access point. When the sleepers are removed and the slurry is disturbed a wave of dirty water may emerge causing a serious pollution risk. It is advised that the store should be emptied with a side arm shovel or by removing one sleeper at a time. It would also be necessary to empty the effluent tanks before the sleepers are removed so that any spillage could be contained.

6) Finally it will be necessary to make this advice available to farmers, agricultural consultants, and any other related bodies.

APPENDIX A

Individual Farm Reports

WEEPING WALL - FARM REPORTS

1:-HIGHER HAWKERLAND FARM ;Aylesbeare - Mr.Wyatt

*SLATTING -Vertical wooden slatting in weeping wall.
-Horizontal wooden sleepers in access point.

*SPACING -Regular spacing of 45mm.

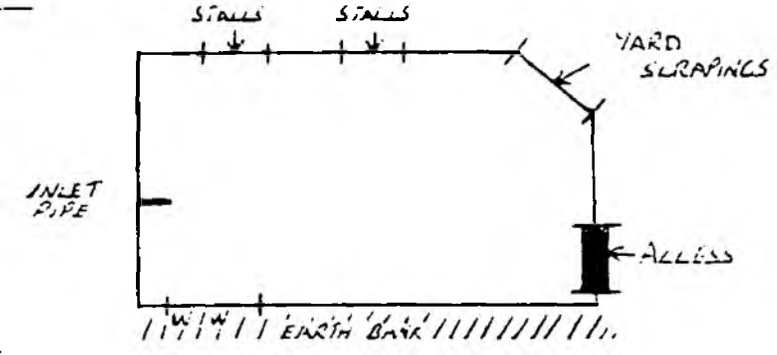
*DIMENSIONS -Approximately 14m x 14m (NB.one corner is slightly filed off,see diagram) x 1m high (to pipe).

*CHANNEL WIDTH -Approximately 0.5m.

*HEIGHT S.START -Start from floor.

*APPROXIMATE CAPACITY -190m3.

*DIAGRAM



*NOTES

Weeping wall is relatively small (width approx.3m),however it is faced with a steep earth bank along the entirety of the wall which would deflect and contain any spurts.The weeping wall seems to be working quite well.The sleepers in the store appear to be weeping as well.It is important to note that due to the position of the pipe in the wall,the slurry store may only be filled to a depth of one metre (approximately).

(Date of visit ;16/01/92)

WEEPING WALL - FARM REPORTS

2:-RILL FARM :Ottery St.Mary - Mr.Burrow

*SLATTING. -Verticle concrete slatting all 4 faces
-Horizontal concrete sleepers in access point

*SPACING. -Irregular spacing,sample space was 36mm at narrow point of 'v' notch which is on the outside face of the store

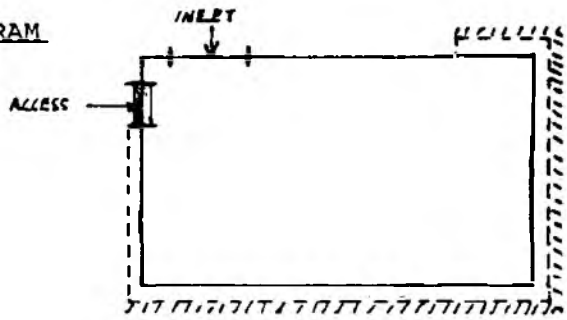
*DIMENSIONS -Approximately 16m x 21m x 1.5m.Walls lean outwards at top

*CHANNEL WIDTH -Varies between 0.5m-0.8m

*HEIGHT S.START -Start from floor

*APPROXIMATE CAPACITY -504m3

*DIAGRAM



*NOTES

On inspection of the store there was evidence of a small spurt from the bottom left hand corner.Individual slats were of a 'v' notch nature,with the notch narrowing towards the outside of the store.Individual concrete sections lean outwards from the inside of the store into a retaining metal rail.

Mr.Burrow suggested contacting Mr.Broom of Logshayne Farm,Colyton,who has the same sort of store with the 'v' notch the other way around in comparison to Rill Farm.

Due to previous incidents of spurting the owners have erected low retaining earth banks around two sides of the store.

(Date of visit;16/01/92)

WEEPING WALL - FARM REPORTS

3:- PARSONAGE FARM :Nymet Rowland - Mr.shapland

*SLATTING -Verticle concrete slatting along one side
-Horizontal concrete sleepers in access point

*SPACING -'V' notches opening from approx. 25mm on inside to 50mm on outside.Spaces are all regular.

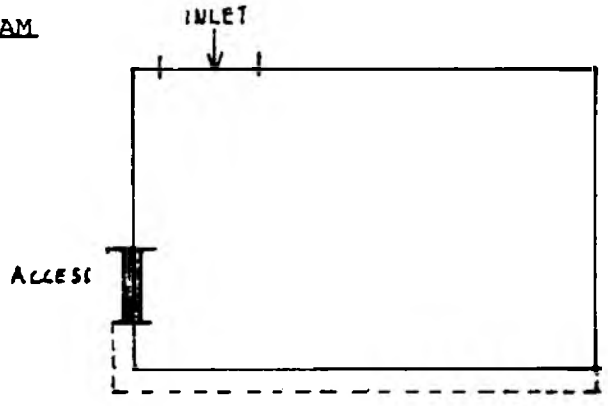
*DIMENSIONS -Approximately 13m x 8m x 1.8m

*CHANNEL WIDTH -Approximately between 0.5m - 0.6m

*HEIGHT S.START -Start 0.2m above floor level

*APPROXIMATE CAPACITY -187m3

*DIAGRAM



*NOTES

No yard water goes into store.Only water to enter store is rain water. Important to note the size of the store which is relatively small.There is a 0.5m high retaining wall on the other side of the effluent channel.

(Date of visit ;16/01/92)

WEEPING WALL - FARM REPORTS

4:-BRIDGE FARM : Stoke Canon - Mr.Horrel

*SLATTING -Pre-cast concrete panels with verticle slats of a 'v' notch nature
-Horizontal concrete sleepers in access point

*SPACING -'V' notches opening from approx.25mm on the inside of the store to 50mm on the outside.

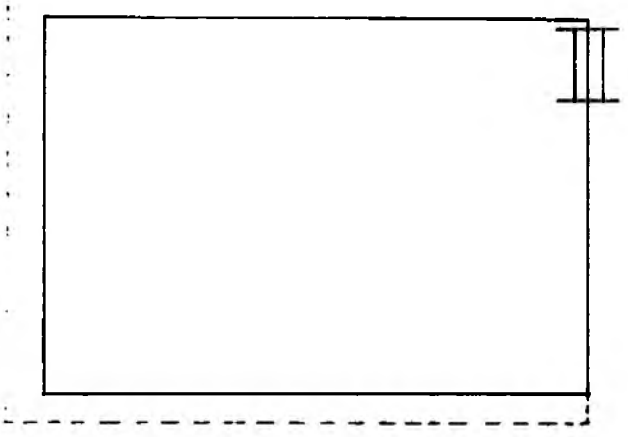
*DIMENSIONS -20m x 18m x 1.8m

*CHANNEL WIDTH -Approximately 0.5m

*HEIGHT S.START -30mm from floor level

*APPROXIMATE CAPACITY -648m3

*DIAGRAM



*NOTES

Only one inlet point into storage area.Farmer witnessed a small spurt approximately one week before my visit from the bottom left hand corner as in photographs.

(Date of visit ;21/01/92)

WEEPING WALL - FARM REPORTS

5:-MISDON FARM :Folly Gate,nr.Okehampton - Mr.Cleave

*SLATTING -Concrete panels with spaces left betw-en them giving verticle slatting
-Horizontal wooden sleepers in access point

*SPACING -Irregular spacing of approximately 25mm

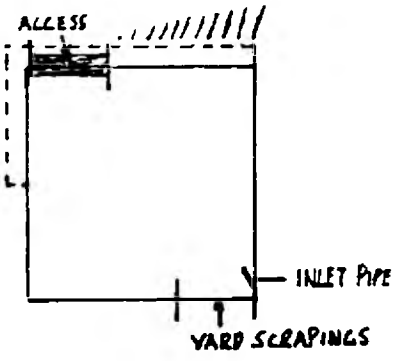
*DIMENSIONS -18m x 12m x 1.8m (approx.)

*CHANNEL WIDTH -Approximately 0.7m

*HEIGHT S.START -Start from floor level

*APPROXIMATE CAPACITY -389m3

*DIAGRAM



*NOTES

Concrete panels used to form walls are the same as those used to build silage stores,therefore the ends of each panel are of a toungue and groove nature.This would probably make it impossible to rod the store,but may also serve to deflect any possible spurts(see below).

(Date of visit ;21/01/92)

WEEPING WALL - FARM REPORTS

6:-HIGHER GORHUISH ;Northlew,nr.Okehampton - Mr.Rundle

*SLATTING -Wooden horizontal sleepers in weeping wall
-Wooden sleepers in access point

*SPACING -Spacing between sleepers irregular,but approximately 30mm on average.

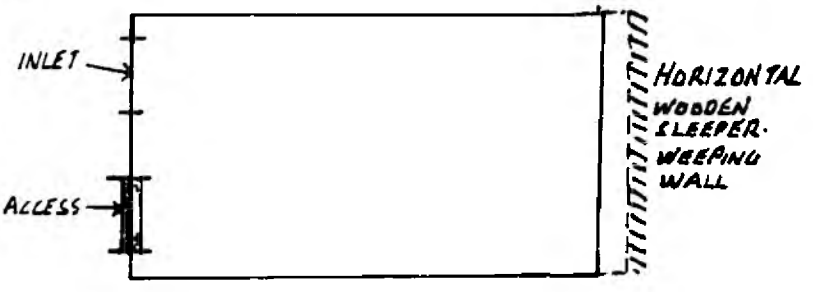
*DIMENSIONS -Approx.10m x 8m x 1.5m

*CHANNEL WIDTH -Approx.0.5m

*HEIGHT S.START -Start above first sleeper at approx. 30cm above floor level

*APPROXIMATE CAPACITY -120m3

*DIAGRAM



*NOTES

Store slopes down hill towards weeping wall end.Weeping wall appears to be functioning quite well,and Mr.Rundle reports to have had no problems with spurting.

WEEPING WALL - FARM REPORTS

7:-HIGHER BRADLEY FARM :Petrockstowe,nr.Hatherleigh - Mr.Martin

*SLATTING -Pre-cast concrete sections (Pages Engineering) with verticle half slatting
-Horizontal concrete sleepers in access point

*SPACING -Regular 'v' notches opening outwards from approx. 30mm

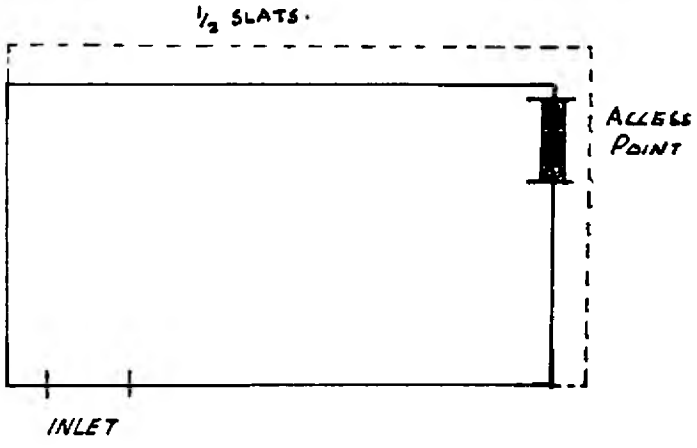
*DIMENSIONS -18m x 12m x 1.8m

*CHANNEL WIDTH -Approx. 0.5m

*HEIGHT S.START -Slats start from floor level

*APPROXIMATE CAPACITY -389m3

*DIAGRAM



*NOTES

Pages Engineering store with half slats.Only one inlet point into store. Mr.Martin reports to have had no problems with the store and spurting,but was however advised by Pages to rod the store on a regular basis.

WEEPING WALL - FARM REPORTS

A:-ASHBURY COURT ;Ashbury,nr.Okehampton - Mr.Williamson

*SLATTING -Concrete panels with verticle slatting
-Horizontal concrete sleepers in access point

*SPACING -'V' notch slatting opening outwards from 25mm on the inside to 75mm on the outside.All spacing regular

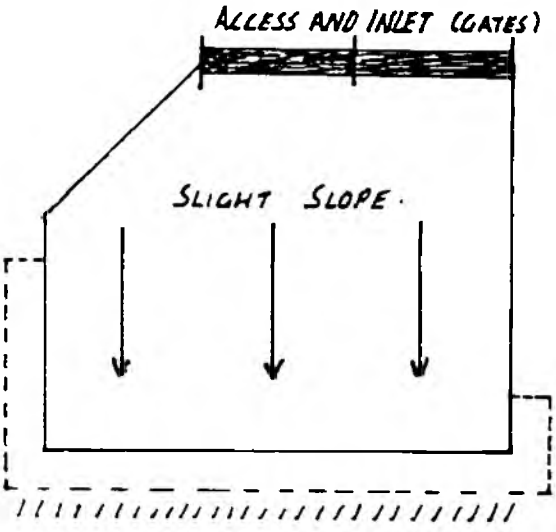
*DIMENSIONS -17.5m x 15m x 1.5m

*CHANNEL WIDTH -Approx. 0.3m

*HEIGHT S.START -Slats start from 10cm above floor level

*APPROXIMATE CAPACITY -393m3

*DIAGRAM



*NOTES

Store is on a slight slope towards weeping wall.Store was quite empty on visit,but appears to be functioning relatively well.Only one inlet into store.

WEEPING WALL - FARM REPORTS

9:-CROSS FARM :Dolton,nr.Winkleigh - Mr.Holland

*SLATTING -Concrete panels with verticle slatting

*SPACING -'v' notch spaces,regularly distributed opening out from approx.25mm to approx.75mm

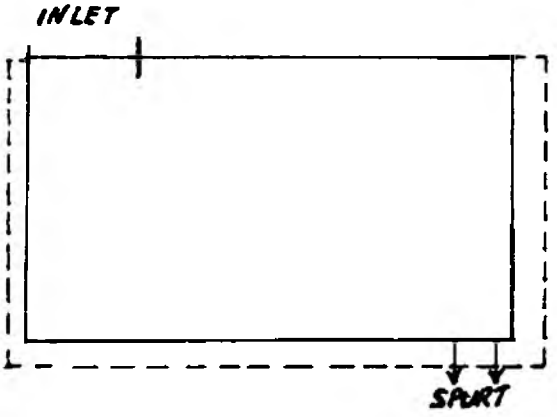
*DIMENSIONS -10m x 8m x 2.5m

*CHANNEL WIDTH -Approx.0.4m

*HEIGHT S.START -Start from floor level

*APPROXIMATE CAPACITY -200m3

*DIAGRAM



*NOTES

Had a large spurt which caused a pollution on the 20th April 1990. Spurt occured at furthest point from inlet.Since this incident Mr.Holland has put corragated sheets along the bottom parts of the weeping walls. Mr.Holland now also rods the store on a regular basis.

(Date of visit ;23/01/92)

WEEPING WALL - FARM REPORTS

10:-EAST VILLAVIN FARM :Roborough - Mr.Hookway

*SLATTING -Concrete panels with verticle slatting

*SPACING -Regular 'v' notch slatting opening outwards from 30mm on the inside to75mm on the outside

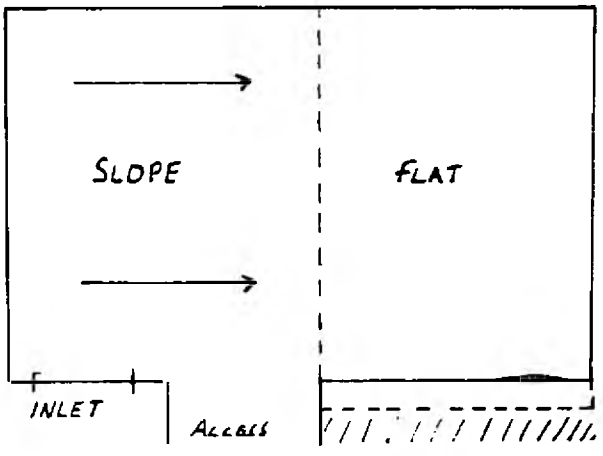
*DIMENSIONS -22m x 13m x 2/1.5m

*CHANNEL WIDTH -Approx.0.8m

*HEIGHT S.START -Slats start from 10cm above floor level

*APPROXIMATE CAPACITY -500m3

*DIAGRAM



*NOTES

Unusual designed store with inlet part of store sloping downwards towards weeping wall area.No trouble with spurting in the past but Mr.Hookway has not allowed the store to fill above 2 feet deep.

WEEPING WALL - FARM REPORTS

11:-PUTSHOLE FARM ;Langtree,nr.Torrington - Mr.Larkworthy

*SLATTING -Concrete panels with verticle slatting

*SPACING -Regular spacing,'v' notch slats opening from 35mm on the inside to 75mm on the outside

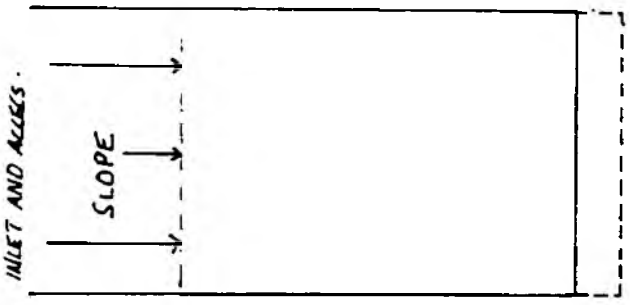
*DIMENSIONS -9.5m x 7m x 1m

*CHANNEL WIDTH -1m wide with a 0.5m retaining wall opposite

*HEIGHT S.START -Slats start from floor level

*APPROXIMATE CAPACITY -66.5m3

*DIAGRAM



*NOTES

Quite a small store,appears to be functioning quite well.Very wide channel with retaining wall which may restrict any low pressure spurts.

WEEPING WALL - FARM REPORTS

12:-GREAT CLISTON FARM :Exbourne,nr.Okehampton - Mr.Hanks

*SLATTING -Concrete panels with verticle slatting
-Horizontal concrete sleepers in access point

*SPACING -'v' notch slats with regular spacing opening outwards from 25mm on the inside to 75mm on the outside

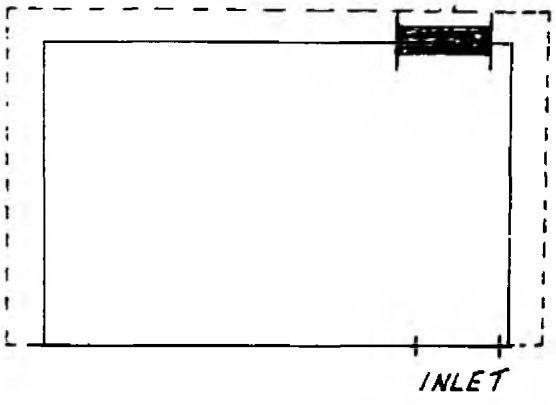
*DIMENSIONS -Approx.15m x 9m x 1.8m

*CHANNEL WIDTH -Approx.0.5m

*HEIGHT S.START -Slats start from 10cm above floor level

*APPROXIMATE CAPACITY -243m3

*DIAGRAM



*NOTES
Has previously spurted in March 1991 from bottom left hand corner(furthest point from inlet).No problems since.

APPENDIX B

Letter To Farming Press

Student wants information on spurting slurry stores

Sir, I am a student at Seale-Hayne College, Newton Abbot, Devon. Part of my course requires me to spend nine months working in industry, and for my industrial placement I am working for the National Rivers Authority, South West Region, where I am conducting a research project into weeping wall slurry stores.

My primary interest is in the incidents of "spurting" from such stores. That is where, for some unknown reason, a pocket of liquid has built up within the store and has then been forced to one of the weeping slats where it has then been discharged under great pressure in the form of a "spurt".

Through my research it has beco apparent that this is a serious problem. I would, therefore, be delighted to learn of any experie that you or your readers may ha had with spurting from weeping slurry stores; please telephone m Exeter (0392) 444000 ext 2007, o write to the address below.

Piers O'Neill
NRA, Manley House, Kestrel Wa Exeter, Devon.

FARMERS WEEKLY 15.5.92

APPENDIX C

Computer Programme

COMPUTER PROGRAMME

```
10   INPUT A
30   B=AxA
40   C=1/B
45   C=Cx0.33333
50   R=C
60   PRINT R
70   INPUT D
90   E=DxD
100  F=1/E
105  F=Fx0.33333
110  R=R+F
120  PRINT R
130  INPUT I
150  J=IxI
160  K=1/J
170  R=R+0.33333xK
180  PRINT R
190  PRINT "R          [35 spaces]          "
200  GO TO 10
```

APPENDIX D

Farm Case Study

SPURTING INCIDENT LOG SHEET

PJWO/WWRP/SILS 1

CATCHMENT: 05 J

NAME OF FARM: TOWN BARTON FARM

NAME OF FARMER: Mr. DAVID HANDAY

LOCATION: SANDFORD, Nr. CREDITON

TELEPHONE No: (0363) 772626 / 774884

DATE OF INCIDENT: 15 / 3 / 92

TIME OF INCIDENT: EARLY HOURS OF SUNDAY MORNING.

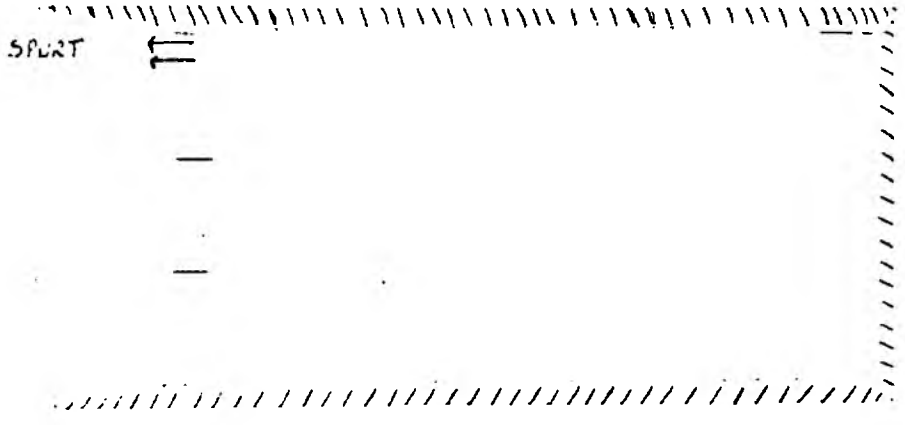
LOCATION OF SPURT: LEFT HAND CORNER, ON ACCESS POINT WALL.

DURATION OF SPURT: UNKNOWN.

ESTIMATED VOLUME OF DISCHARGE: APPROXIMATELY 10,000 GALLONS

WEATHER CONDITIONS: RAIN AND WIND READING UP TO SPURT, VERY WINDY OVER NIGHT DIRECTLY BEFORE THE SPURT.

DIAGRAM:



PJWO/WWRP/SILS /

NOTES: THE STORE IS A PAGES ENGINEERING STORE WHICH FEATURES VERTICAL RACK SLOTS OF A 'V' NOTCH FASHION, WITH THE 'V' OPENING EXTENDING ON THE OUTSIDE EDGE OF THE STORE. SINCE ITS ERECTION IN JULY 1991 THE STORE HAS SUFFERED 3 FIRES, (NOT INCLUDING THIS INCIDENT). PAGES ADVISE THAT THE FARMERS ROD THEIR STORE ON A REGULAR BASIS, BUT MR. MUNDAY FOUND THAT THE ~~(EFFLUENT)~~ EFFLUENT WHICH EMERGED WAS TOO THICK AND TENDED TO CHOKE UP THE PUMP. MR. MUNDAY SAYS THAT EACH SPILL HAS FOLLOWED WET WEATHER. AFTER ONE OF THE EARLIER SPILLS MR. MUNDAY CONTACTED AMS WHO ADVISED HIM TO USE MORE STRAW BEDDING, BUT THIS SEEMS TO HAVE HAD LITTLE OR NO EFFECT ON THE SUBSEQUENT INCIDENTS.

SPURTING INCIDENT LOG SHEET

PJWO/WWRP/SILS 2

CATCHMENT: 065

NAME OF FARM: TOWN BARTON FARM.

NAME OF FARMER: DAVID MUNDY

LOCATION: SANDFORD, NR. CREDITON.

TELEPHONE No: (0363) 772676 / 774584

DATE OF INCIDENT: 23/3/92.

TIME OF INCIDENT: EARLY HOURS OF MONDAY MORNING.

LOCATION OF SPURT: C.V ACCESS POINT NO 2, TO THE LEFT OF THE ACCESS POINT.

DURATION OF SPURT: UNKNOWN.

ESTIMATED VOLUME OF DISCHARGE: 5,000 - 10,000 GALLONS.

WEATHER CONDITIONS: VERY WINDY AND WET.

DIAGRAM:

PJWO/WWRP/SILS 2.

NOTES: THE SPILL OCCURRED UNDER MUCH THE SAME CONDITIONS AS THAT OF THE 15/3/92. MR. MUNDAY FAILED IN A CONTRACTOR CALL AGAIN TO EMPTY HIS TANKS, THE CONTRACTOR ALSO DOSED THE STORE TO A LESSER EXTENT IN ORDER TO TAKE OUT AS MUCH DIRTY WATER AS POSSIBLE.

WEEPING WALL RODDING EXPERIMENTS

WEEK ONE

WEEPING WALL EXPEIMENT

WEEK ONE RESULTS

ACCESS FACE

Strong wind blowing rain and hail into the access face of the store. The surface of the slurry appeared to be weeping very heavily, especially in the corner with the back inlet wall. When rod number one was inserted into the store it appeared that a pocket of liquid was pierced, and a large spurt then followed. However, this spurt could not be channelled through the pipe. This discharge lasted for about twenty minutes. No further pockets of liquid were found with rods two and three.

LONG FACE

The only rods to discharge any liquid along this face were rods four and eleven. Rod number four allowed a small volume of high solid content liquid to be discharged. This rod did however become choked with solid material on a regular basisand had to be rodded itself. This discharge lasted about five minutes. Rod number eleven on the other hand did allow a relatively large amount of liquid to be discharged from it. The liquid that emerged was very thin and watery with low suspended solids. This rod also became choked but on a lot less frequent basis than rod number four. Rod numbers 5-10 did'nt produce any liquid at all, even after each individual pipe was rodded through with a smaller diameter tube.

END FACE

Rod number twelve displayed the same characteristics as rod number eleven and allowed a relatively large amount of liquid to be discharged for approximately one hour. It was concluded that this rod was tapped into the same pocket of liquid as rod number eleven. Rod number thirteen did'nt discharge any effluent at all, not even after it was rodded through.

CONCLUSIONS

After these week one resultsit appears that the pockets of liquid are mainly building up in the corners of the store rather than along the long South face.

1. Large build up of liquid apparent, both corks removed, effluent was discharged all around the pipe rather than through it.

2. Both corks removed, no effluent emerged even after the pipe was rodded through.

3. Both corks removed, no effluent emerged even after the pipe was rodded through.

4. Both corks removed, small amount of effluent emerged. Pipe had to be rodded through as it kept choking up with solids.

5. Both corks removed, no effluent emerged even after the pipe was rodded through.

6. Both corks removed, no effluent emerged even after the pipe was rodded through.

7. Both corks removed, no effluent emerged even after the pipe was rodded through.

8. Both corks removed, no effluent emerged even after the pipe was rodded through.

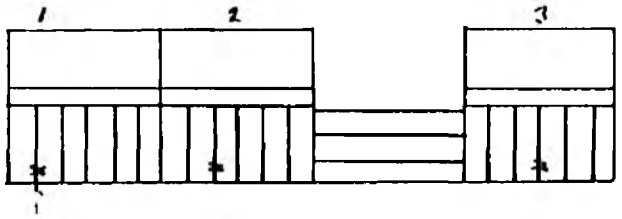
9. Both corks removed, no effluent emerged even after the pipe was rodded through.

10. Both corks removed, no effluent emerged even after the pipe was rodded through.

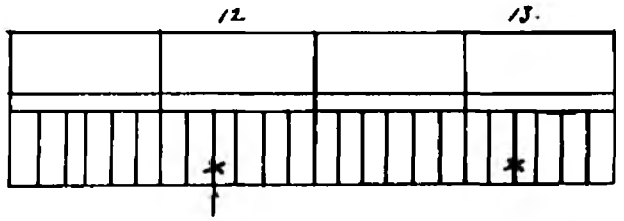
11. Both corks removed, effluent emerged with low s.s. under considerable pressure.

12. Both corks removed, effluent emerged with low s.s. under considerable pressure.

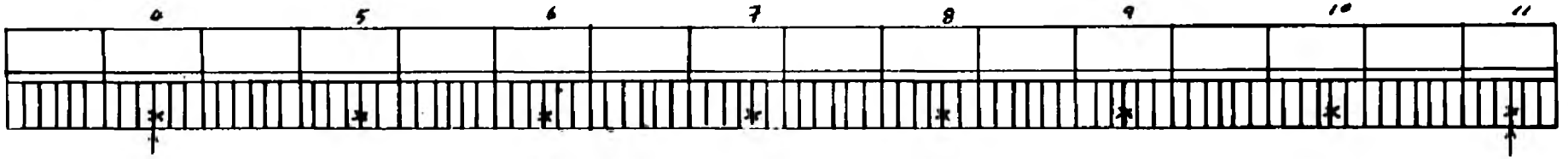
WEST ELEVATION



EAST ELEVATION



SOUTH ELEVATION.



WEEK ONE RESULTS.

WEEPING WALL RODDING EXPERIMENTS

WEEK TWO

WEEPING WALL EXPERIMENT - Week Two

GENERAL NOTES AND OBSERVATIONS

Access Face:

There was a moderate wind blowing directly into the access face of the store which appeared to drying out the surface of the slurry being exposed in the slats of the weeping wall. Once this surface crust was broken or disturbed by moving the rods slightly (especially rods one and two) liquid did start squirting out under considerable pressure.

Long Face:

The conclusions drawn from week one seem to hold as there were no apparent signs of any substantial pockets of liquid being formed along the majority of the face away from the corners, ie. rods 5-10. The previous weeks conclusions also appear to hold as to the theory that the pockets of liquid were forming more towards the corners of the store. Rod number 4 which had discharged slightly in week one was working exceptionally well. When it was opened a small amount of high solid content liquid emerged, but was rapidly followed by a substantial gush of very low solid content effluent. Due to the fullness of the three stage settlement tank the rod had to be resealed very quickly, and hence no duration/volume of discharge could be measured. However it is possible to say that there must be a large amount of liquid in the store due to the pressure and the thickness of the effluent.

End Face:

Both rods in the end face displayed the same characteristics as rods 4 and 11, and so they were left unopened. This face had several slats which were weeping very heavily and appeared that they may spurt at any time. The level of slurry at this end was also slightly higher than at the access face end, thus suggesting that there may be a large pocket of liquid at this end.

1. Large build up of liquid apparent - cork not opened.

2. Large build up of liquid apparent - cork not opened.

3. No build up of liquid apparent - cork removed no effluent emerged, pipe not rodded through.

4. Very large amount of liquid apparent - cork removed, rapidly followed by a heavy gush of watery effluent. Cork replaced immediately to stop flow.

5. No apparent build up of liquid - cork opened no effluent emerged, pipe not rodded through.

6. No apparent build up of liquid - cork removed no effluent emerged, pipe was not rodded through.

7. No apparent build up of liquid - cork removed no effluent emerged, pipe was not rodded through.

8. No apparent build up of liquid - cork removed no effluent emerged, pipe was not rodded through.

9. No apparent build up of liquid - cork removed no effluent emerged, pipe was not rodded through.

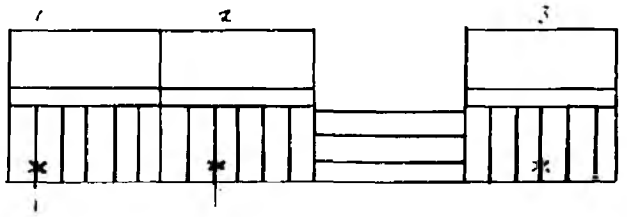
10. No apparent build up of liquid - cork removed no effluent emerged, pipe was not rodded through.

11. Very large build up of liquid apparent - cork was not removed.

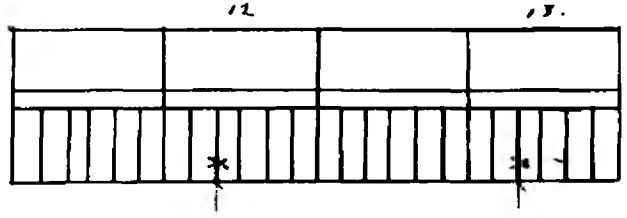
12. Very large build up of liquid apparent - cork was not removed.

13. Very large build up of liquid apparent - cork was not removed.

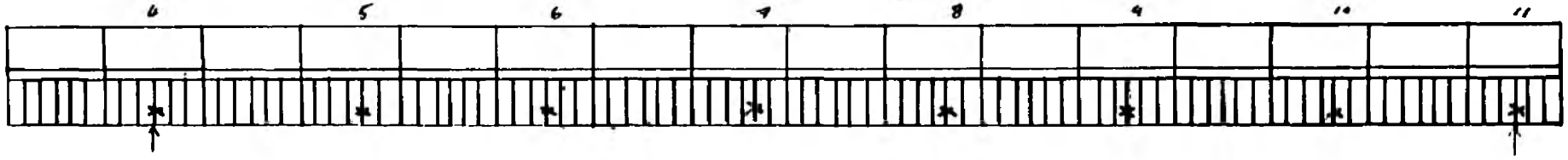
WEST ELEVATION



EAST ELEVATION



SOUTH ELEVATION.



WEEK TWO RESULTS.

WEEPING WALL RODDING EXPERIMENTS

WEEK THREE

WEEPING WALL EXPERIMENT - Week Three

GENERAL NOTES AND OBSERVATIONS

Access Face:

The day was bright and sunny with a light wind blowing into the access face. Once again the wind appeared to be drying out the surface of the slurry which was being exposed between the slats. Even though the rods in this face did'nt discharge, (or discharged very little), it was still apparent that there was a significant amount of liquid building up behind the surface crust of the slurry. Mr. Munday walked on the slurry along the access wall and pushed a pipe through the surface crust. This revealed that this crust was between 10 cm and 20 cm thick, and that beneath this solid layer there was a large amount of liquid.

Long Face:

The results for the long face remain the same as on previous occasions with no discharges from rods 5 - 10, but rods 4 and 11 both discharged for approximately 2 hours at a good constant rate. The effluent which emerged was very watery with a low solid content.

End Face:

Rod number 12 did discharge some effluent for a short time but quickly became blocked. Rod number 13 also discharged a small amount of effluent which stopped quite quickly. This face of the store was'nt weeping so heavily as on previous occasions. However on moving rod number 13 slightly, liquid did start squirting out around the outside of the pipe, thus suggesting that a pocket of liquid was present.

1. Cork opened - very small amount of effluent emerged

2. Cork opened - no effluent emerged

3. Cork opened - no effluent emerged

4. Cork opened - very large amount of effluent emerged. Discharge lasted for approximately 2 hours.

5. Cork opened - no effluent emerged

6. Cork opened - no effluent emerged

7. Cork opened - no effluent emerged

8. Cork opened - no effluent emerged

9. Cork opened - no effluent emerged

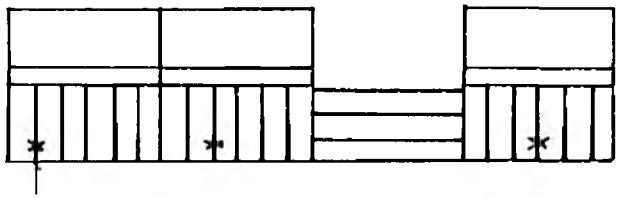
10. Cork opened - no effluent emerged

11. Cork opened - very large amount of effluent emerged. Discharge lasted for approximately 2 hours.

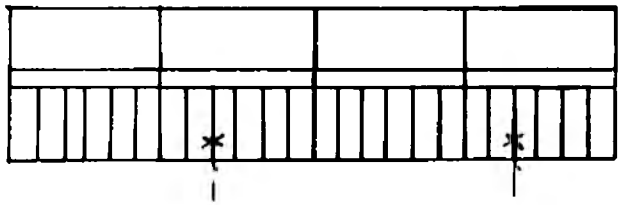
12. Cork opened - very small amount of effluent emerged.

13. Cork opened - very small amount of effluent emerged.

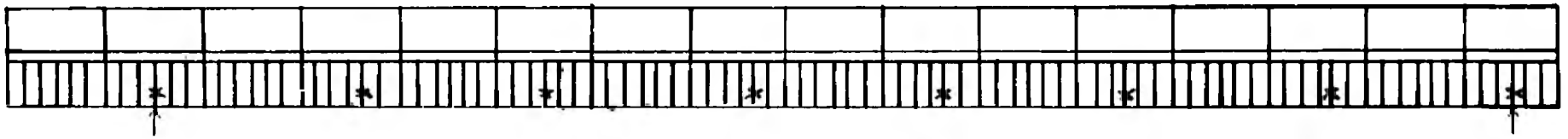
WEST ELEVATION



EAST ELEVATION



SOUTH ELEVATION.



WEEK THREE RESULTS

WEEPING WALL RODDING EXPERIMENT

WEEK FOUR

WEEPING WALL EXPERIMENT - Week Four

GENERAL NOTES AND OBSERVATIONS

ACCESS FACE

The weather leading up to the week four visit had been predominantly very wet and windy, however the day of the visit was fine but still windy. The store appeared to be quite sodden in comparison to the previous week. The wind was once again blowing directly into the access face and the slurry exposed between the slats was relatively dry, but they were weeping very heavily. Rods one and three discharged along this face, with the discharge from rod three turning into a full blown spurt when it was re-stoppered. The spurt lasted for 1 hour 5 minutes. Rod two did not discharge at all.

LONG FACE

This face was also weeping very heavily especially towards the corners. Rod number four had been opened by Mr. Munday and left open to discharge. However, as it had been left unsealed it had become blocked with solid material. This blockage appears to have increased the build up of liquid, as the slats around the rod were weeping very heavily, and the slightest movement of the rod resulted in small amounts of liquid squirting out under considerable pressure. Rods 5, 6, 7, discharged small amounts of high solid content liquid, whilst rods 8, 9, 10, did not discharge any liquid at all. Rod number 11 discharged a large volume of liquid of the same magnitude as in previous weeks, but was sealed up quickly due to the fullness of the three stage settlement tank and the inactivity of the fixed irrigator.

END FACE

Both of the rods in the end face discharged small amounts of high solid content liquid. The slats around rod number 13 were all weeping very heavily. The level at this end of the store still appears to be higher than the rest of the store thus suggesting a higher water content along this face.

CONCLUSIONS

It appears that the heavy rainfall of the week leading up to the visit did have quite a significant effect on the build up of liquid within the store. From the week four results it is apparent that some of the rain water is percolating down through the surface crust of the slurry and is then forming subsurface pockets of liquid. This is indicated by rods 5, 6, 7, which have, up until present, remained dry, but which did on this occasion discharge some high S.S. effluent.

ROD RESULTS –Week Four

Rod No.

1: Cork was removed and a small amount of high S.S. effluent emerged.

2: Cork was removed and no effluent emerged.

3: Cork was removed and a large amount of effluent emerged, cork replaced. Slurry around the pipe then fractured and a spurt then followed, the duration of which was 1 hour 5 minutes.

4: Pipe was left uncorked for several days and had become blocked with solids.

5: Cork was removed and a small amount of high S.S. effluent emerged.

6: Cork was removed and a small amount of high S.S. effluent emerged.

7: Cork was removed and a small amount of high S.S. effluent emerged.

8: Cork was removed, no effluent emerged.

9: Cork was removed, no effluent emerged.

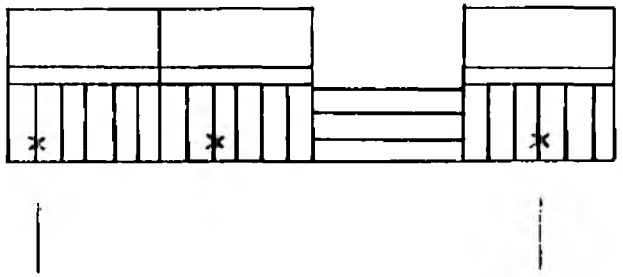
10: Cork was removed, no effluent emerged.

11: Cork was removed and a large amount of effluent emerged of the same magnitude as in previous weeks.

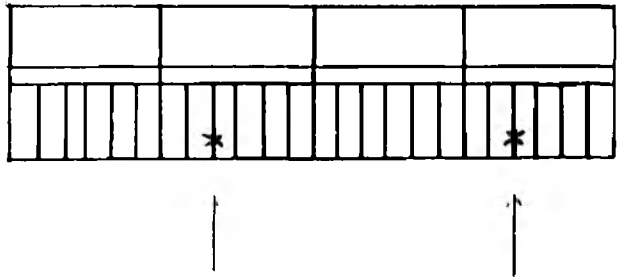
12: Cork was removed and a small amount of high S.S. effluent emerged.

13: Cork was removed and a small amount of high S.S. effluent emerged.

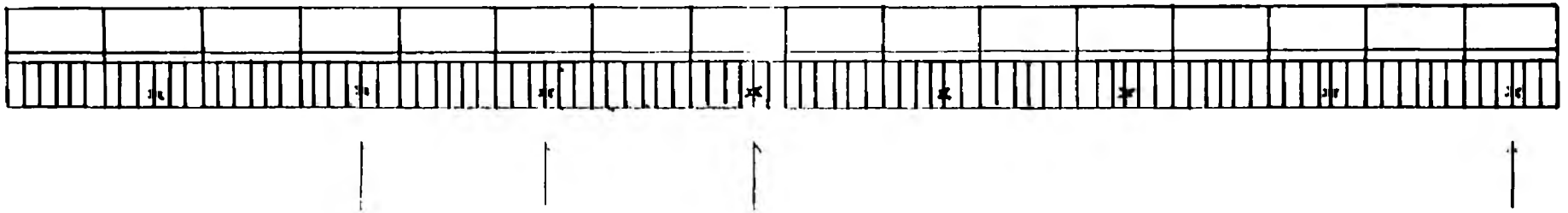
WEST ELEVATION



EAST ELEVATION



SOUTH ELEVATION.



WEEK FOUR RESULTS.

ROD No.	1	2	3	4	5	6	7	8	9	10	11	12	13
WEEK 1:	**	0	0	**	0	0	0	0	0	0	**	**	0
WEEK 2:	**	**	0	**	0	0	0	0	0	0	**	**	**
WEEK 3:	*	0	0	**	0	0	0	0	0	0	**	*	*
WEEK 4:	*	0	**	0	*	*	*	0	0	0	**	*	*
WEEK 5:	*	0	0	0	*	*	0	0	0	0	**	**	*
WEEK 6:	*	0	0	**	*	*	0	0	0	0	**	**	*

KEY:

** = HIGH FLOW

* = LOW FLOW

0 = NO FLOW