A Novel System for Designing Lay-Flat Irrigation Pipe Systems for Flood & Furrow Irrigation

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University of Arkansas

Presented at the IA show 2019, Las Vegas, NV, Tuesday December 3

The Lay-Flat Pipe System for Irrigation


DANGER

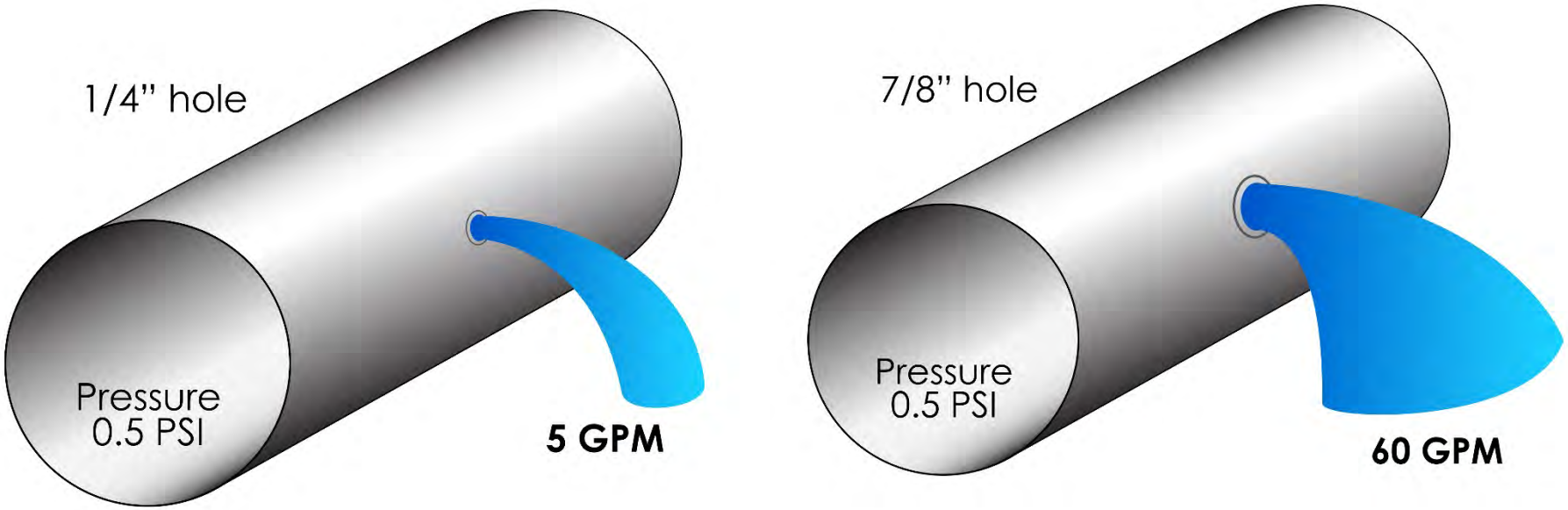
Commercial hole puncher – 10 different diameters
7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, 15/16, 1”

Various size Plastic Hole Punchers

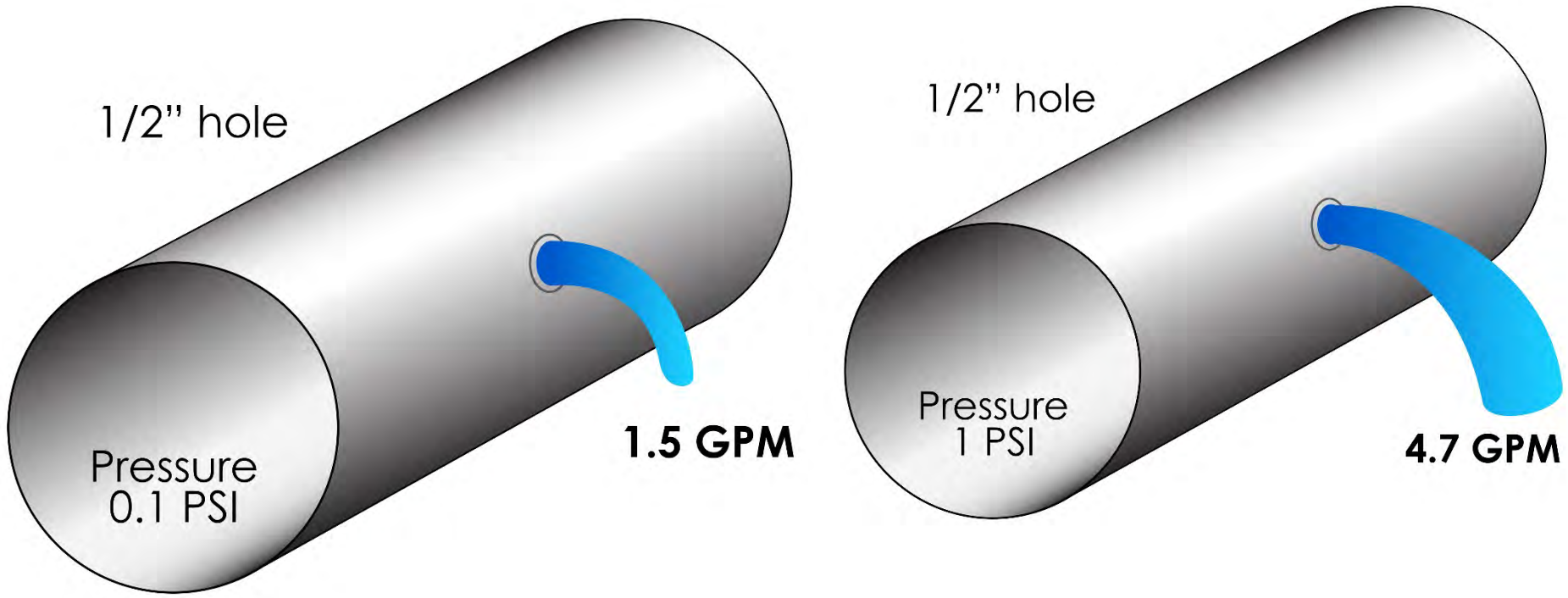
Lay flat pipe

- Labor savings are significant over gated pipe for surface irrigation. Two workers can install several of miles of pipe per day. Up to 6 MPH.
- Cost is about $200/roll, typical lengths are 1320 feet (400 meters).
- Pipe is rolled back up after season and recycled.
- Holes are punched at exact row spacing allowing for complex placement, diagonal alignments and angles between the crown pipe and rows.
- Thickness 7-10 mils, sizes 10” to 22” Diameter. Polyethylene with a UV inhibitor.
- Challenge with lay flat pipe is that it operates on a 1 meter or 3 ft burst pressure, thus is hydraulically challenging to match hole sizes with ratio of flow needed per furrow and pressure.

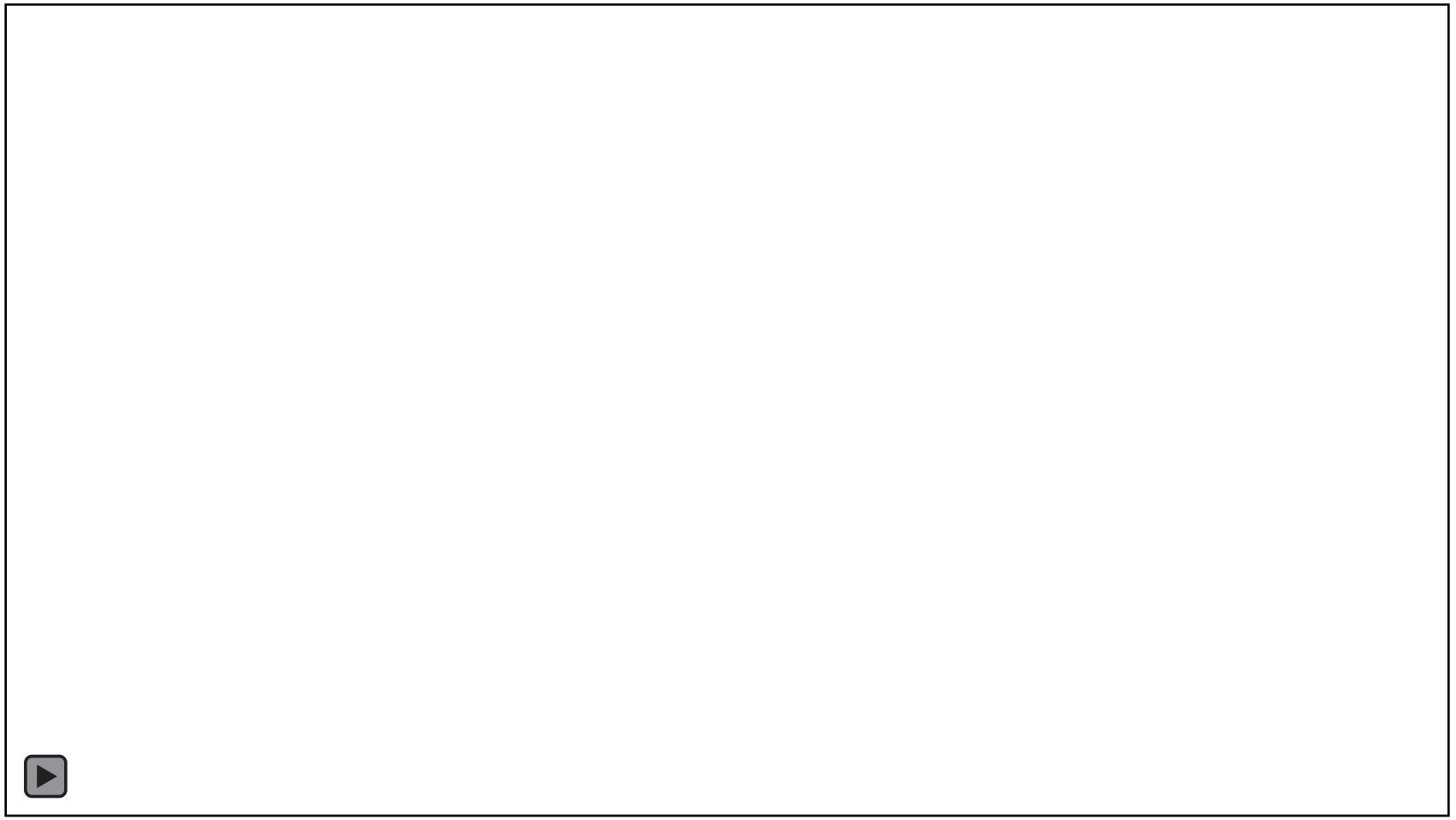
How hole size effects flow in layflat pipe

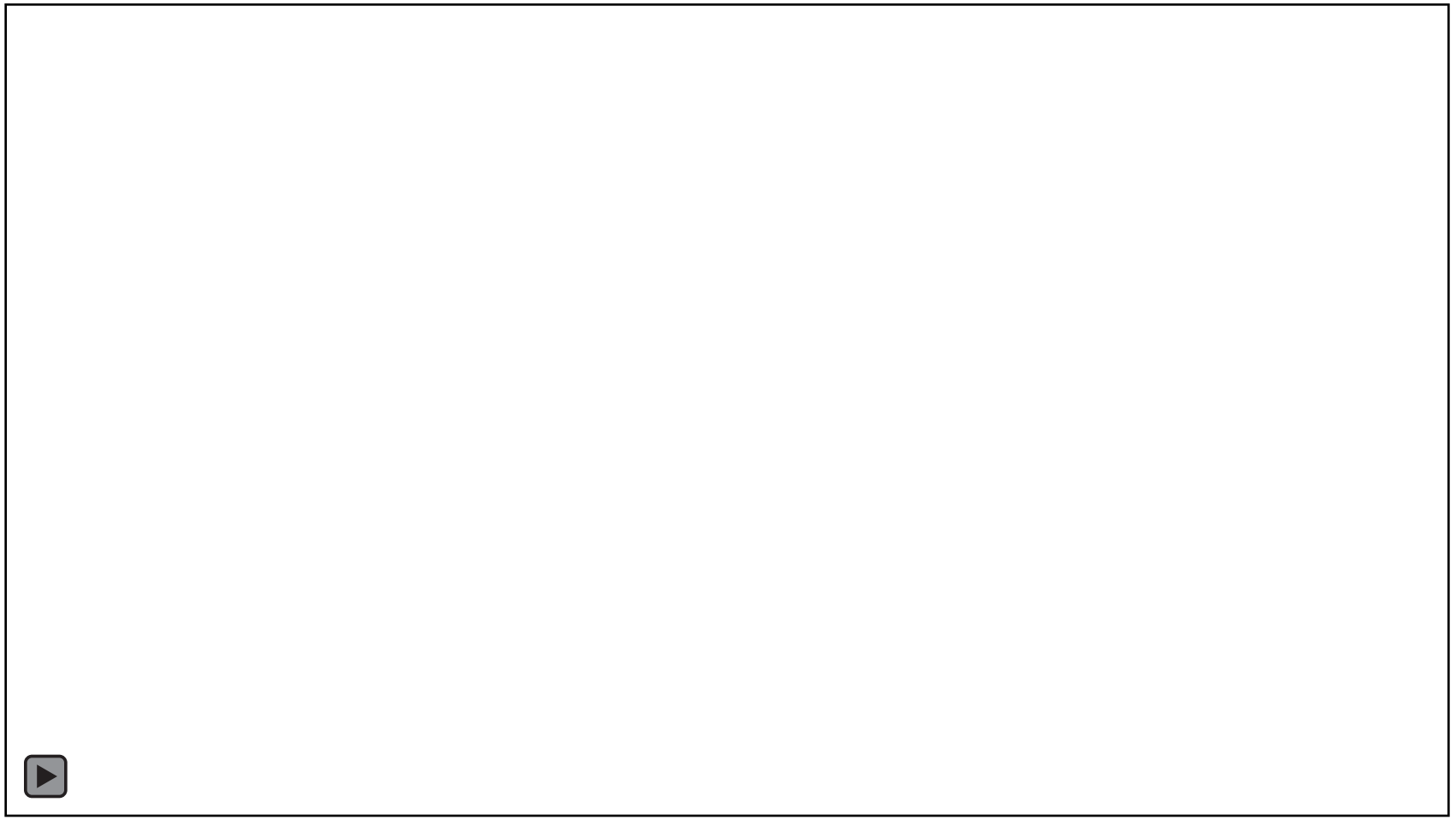


How pressure effects flow in lay flat pipe



Computerized Hole Selection





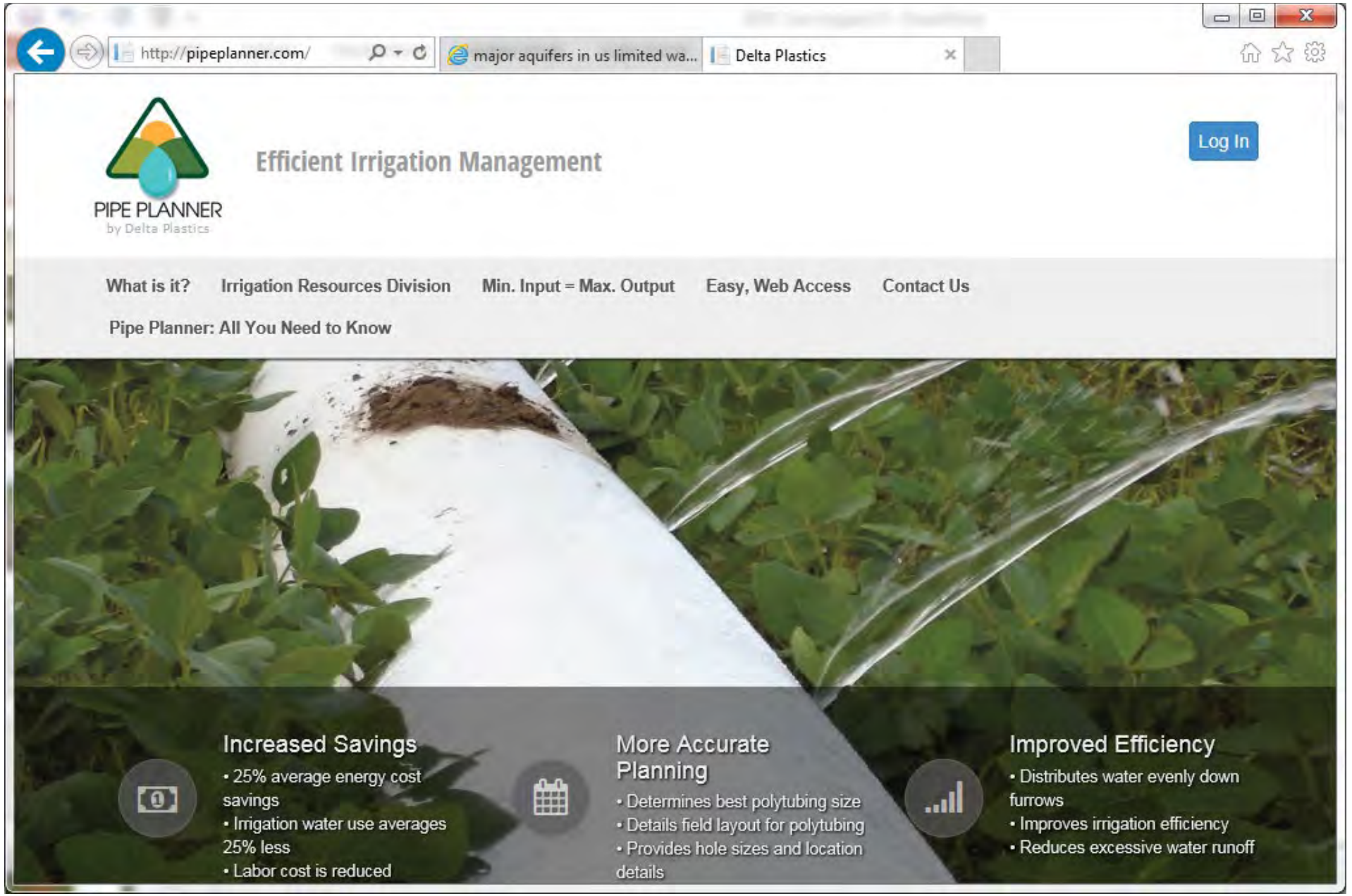
Computerized Hole Selection

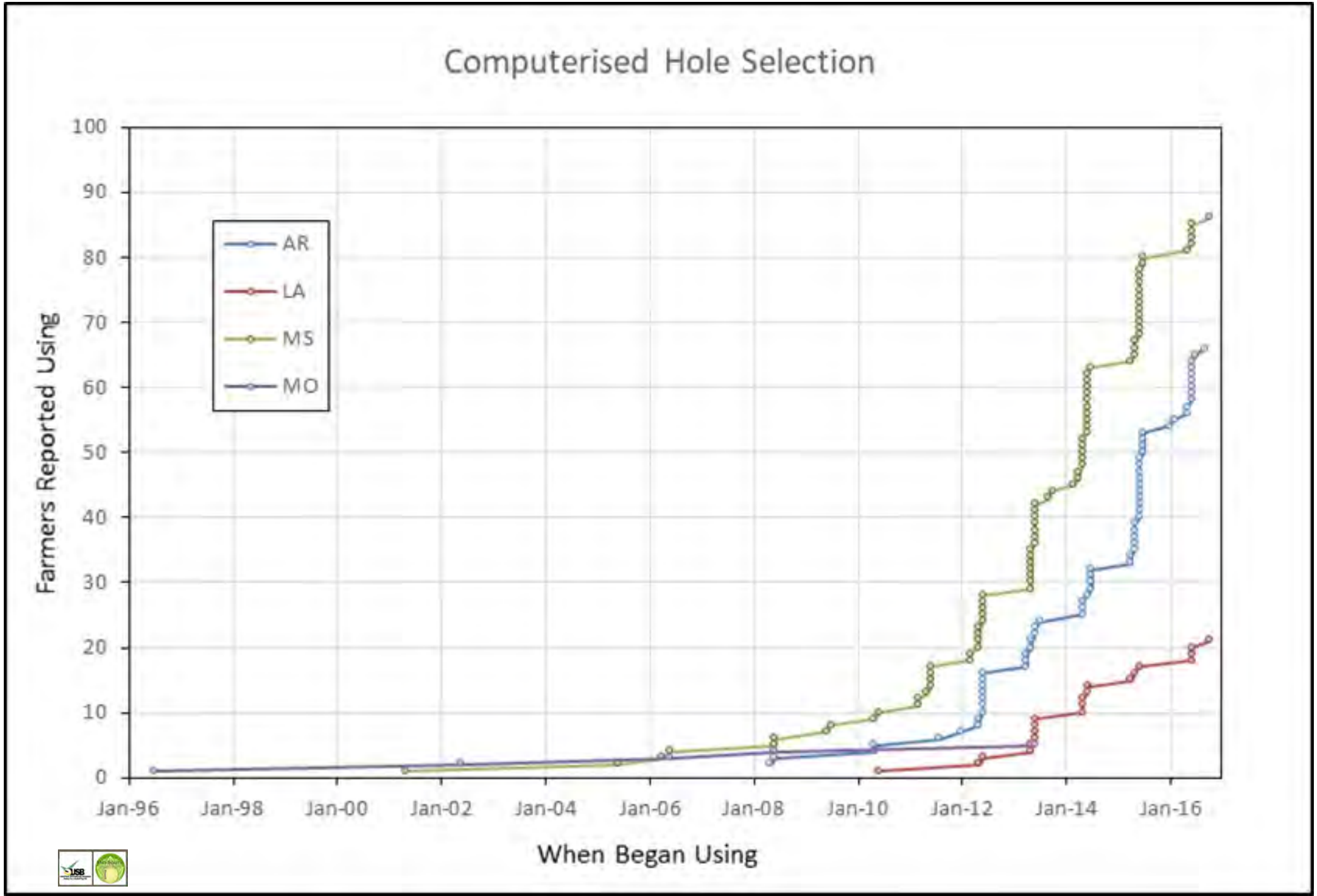
- CHS is the process of proportioning flow based on row length, row spacing, while accounting for friction loss from elevation and hydraulic losses. The goal is for the proper quantity of water to be delivered to each furrow uniformly.
- Uses computer to determine hole punch plan for layflat irrigation pipe. Balances pressure, pipe size, elevation and flow rate to deliver uniform furrow flow based on row length.
- Water and fuel reduced by 20% on regularly shaped fields
  - Savings likely higher on irregularly shaped fields
  - Landscape water savings potential 226,430 ac-ft/yr
- Given current or increasing fuel costs, CHS increases profitability by 70 dollars $acre^{-1}$ on regularly shaped fields.
  - Profit margin likely higher on irregularly shaped fields
- Delta Plastics Inc released free to public, web-based tool in August 2014 with goal of reducing water use by 20% by 2040. www.pipeplanner.com

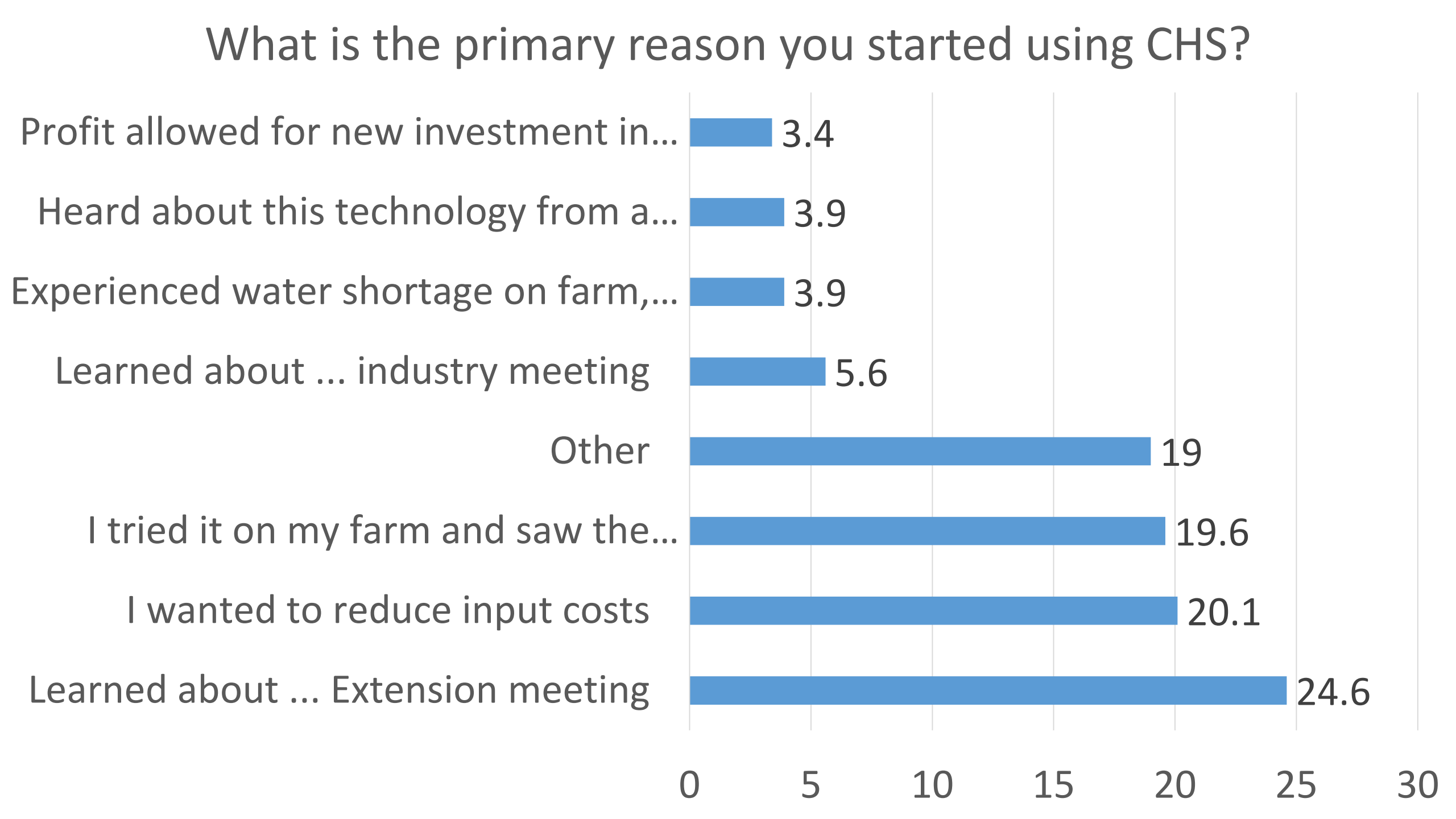
Adapted from slide courtesy of Jason Krutz, MSU

PIPE PLANNER
by Delta Plastics

Efficient Irrigation Management


http://pipeplanner.com/
major aquifers in us limited wa...
Delta Plastics
PIPE PLANNER
by Delta Plastics
Efficient Irrigation Management
Log In
What is it?
Irrigation Resources Division
Min. Input = Max. Output
Easy, Web Access
Contact Us
Pipe Planner: All You Need to Know
Increased Savings
• 25% average energy cost savings
• Irrigation water use averages 25% less
• Labor cost is reduced
More Accurate Planning
• Determines best polytubing size
• Details field layout for polytubing
• Provides hole sizes and location details
Improved Efficiency
• Distributes water evenly down furrows
• Improves irrigation efficiency
• Reduces excessive water runoff


Computerised Hole Selection
Farmers Reported Using
When Began Using
AR
LA
MS
MO
0
10
20
30
40
50
60
70
80
90
100
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04
Jan-06
Jan-08
Jan-10
Jan-12
Jan-14
Jan-16


What is the primary reason you started using CHS?
Profit allowed for new investment in...
3.4
Heard about this technology from a...
3.9
Experienced water shortage on farm,...
3.9
Learned about ... industry meeting
5.6
Other
19
I tried it on my farm and saw the...
19.6
I wanted to reduce input costs
20.1
Learned about ... Extension meeting
24.6
0
5
10
15
20
25
30

PIPE PLANNER

Pipe Planner Irrigation Design Results

Farm Name: Kris Keller
Field Name: west of lake
Set: Set 1 (22 hrs)
Hole Spacing: Every Furrow
Flow Per Outlet 1.59
Minimum Pressure : 0.00 ft
Maximum Pressure : 0.00 ft
Hole Size: 1/4,5/16,3/8,7/16,1/2,9/16,5/8,11/16,3/4,13/16,7/8,15/16,1,Enable Gates

Uniformity: 90 %
Min. Head Pressure: 0.68 ft
Max Head Pressure:: 1.75 ft
Set Area: 28 ac
Flow In: 1800 gpm

Pipe Size (in)	Pipe Function	Pipe Length (ft)	Hole Size (in)	Furrow Count	Build Up Height (ft)
15x10	Supply	0 - 68 ft			
15x10	Irrigation	68 - 294 ft	L: 5/16 R: 5/16	90	
15x10	Irrigation	294 - 513 ft	L: 3/8 R: 5/16	87	
15x10	Irrigation	513 - 664 ft	L: 7/16 R: 5/16	60	
15x10	Irrigation	664 - 827 ft	L: 1/2 R: 5/16	65	
15x10	Irrigation	827 - 974 ft	L: 9/16 R: 5/16	58	
15x10	Irrigation	974 - 1037 ft	L: 1/2 R: 5/16	25	
15x10	Irrigation	1037 - 1098 ft	L: 7/16 R: 5/16	24	
15x10	Irrigation	1098 - 1204 ft	L: 3/8 R: 5/16	42	
15x10	Irrigation	1204 - 1513 ft	L: 5/16 R: 5/16	123	
	Build Up	1513 ft			0.93

Use a round tool 1/8 inch in diameter to relieve air that forms at the top of the polytubing. Do not use a tool that could slice the polytubing. If faster furrow flow is detected in wheel-track furrows, punch a 1/8 inch smaller hole in these furrows to achieve more even water distribution. All other tips can be found at 'http://www.deltapl.com/irrigation-resources/'. DO NOT USE A TOOL THAT COULD SLICE THE POLYTUBING!

Computerized Hole Selection

- Proper implementation of CHS reduces water use by 25-50% by proportioning flow based on crown elevation, row length, pipeline pressure, and flow.
- Delta Plastics Pipe Planner and public licensed PHAUCET (Pipe Hole And Uniform Crown Evaluation Tool) can be used to develop a CHS plan.
- Current adoption of CHS is 40% in the mid-south region.
- Implementation of CHS can be a challenge, plans that show multiple hole changes are difficult to implement, yet these are the plans that with the highest potential to improve efficiency and profitability.

Computerized Hole Selection (CHS)

- Uses punch tool sized between ¼ inch to 7/8” to punch hole in every furrow or every other furrow. On one side or both sides of pipe.
- Mobile app “Poly Pipe Printer” is used to upload an already designed CHS plan and control printer.
- CHS is used for furrow irrigated row crops.

Multiple Inlet Rice Irrigation

- Uses blue gates and blue gate hole insertion tool to proportion flow to each levee based on size.
- Each Levee has a combination of holes and gate settings that provides for efficient distribution of water in the rice field.
- Mobile app “Rice Irrigation” is used to design MIRI plan and control printer.

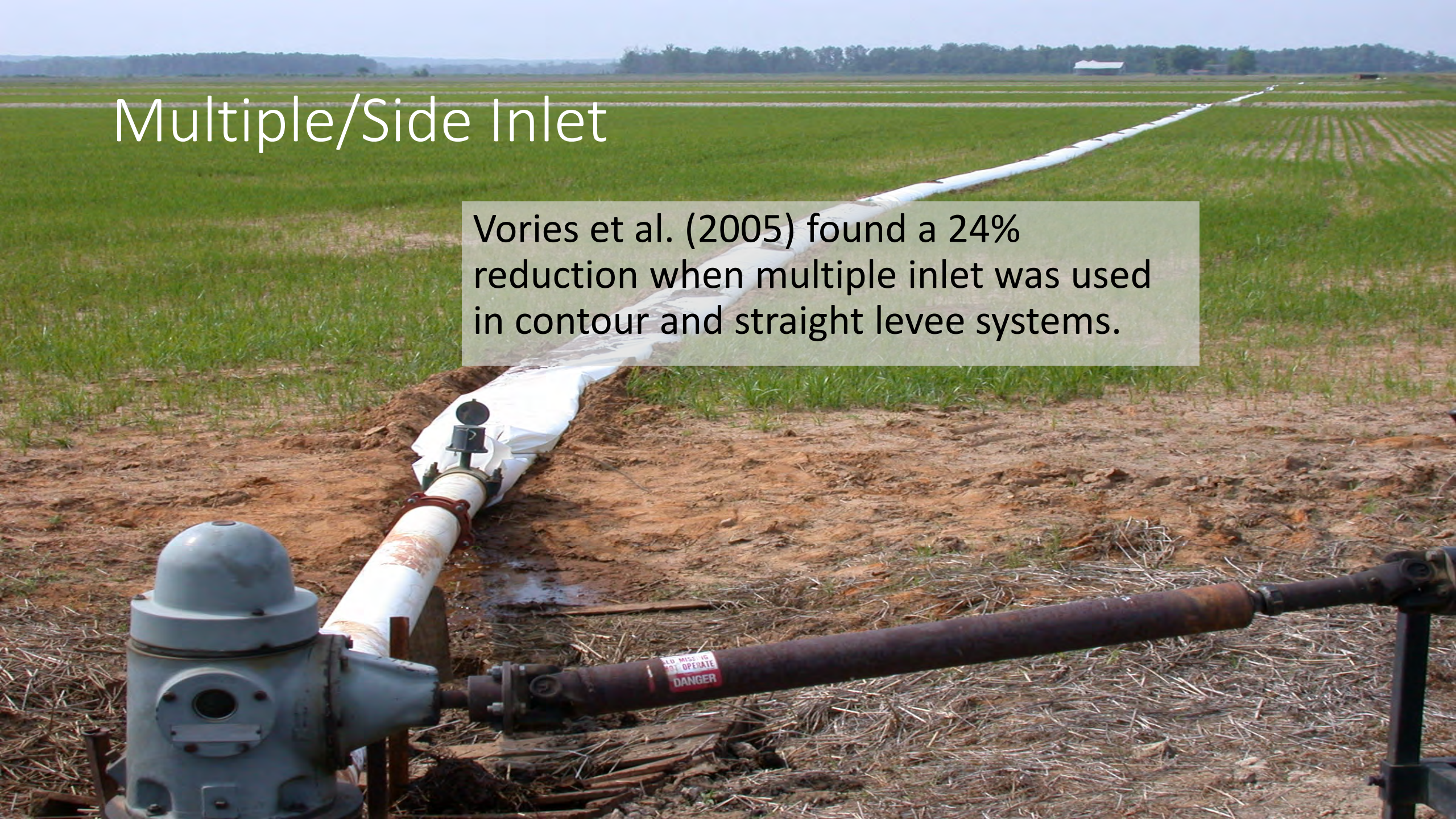
Multiple Inlet Rice Irrigation not a “brand new” Idea -

these pictures were taken in 1991 near Stuttgart, AR

Multiple Inlet Rice Irrigation
Reduced cold water effects
Rainfall capture-water savings
Faster flood – less risk of ammonium volatilization

Image credits: Google Earth, slide courtesy of Joe Massey

Multiple/Side Inlet

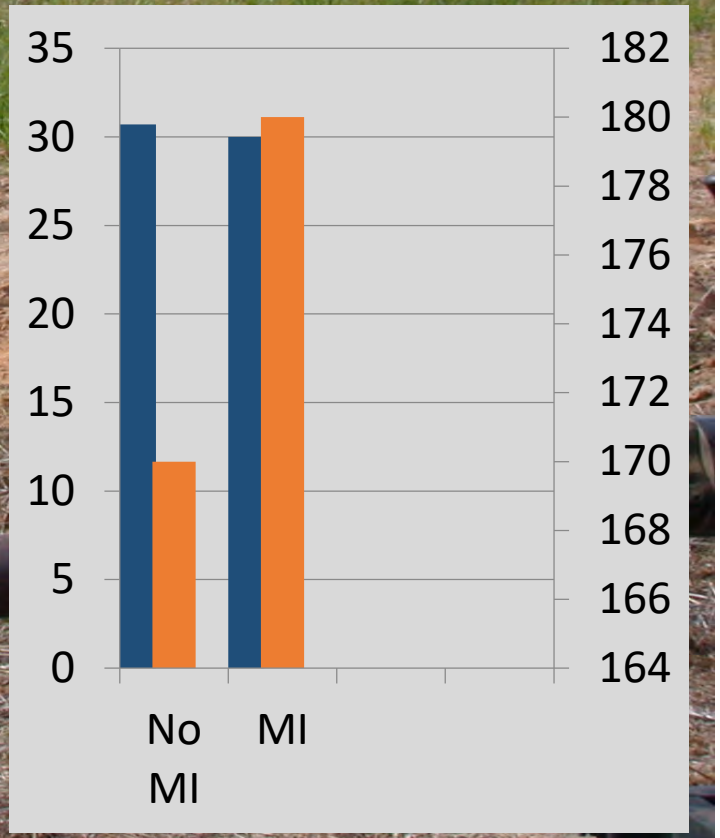


Vories et al. (2005) found a 24% reduction when multiple inlet was used in contour and straight levee systems.

Multiple/Side Inlet

- Fields that did not use multiple inlet used 779 mm (30.7 in) of irrigation water whereas fields that used multiple inlet pumped 770 mm (30.3 in) of irrigation water (p = 0.88).
- While there were no differences in irrigation water use due to the use of multiple inlet irrigation, fields that used multiple inlet irrigation had significantly higher yields (180 bu/acre) than fields that used single inlet irrigation (170 bu/acre) (p = 0.03).

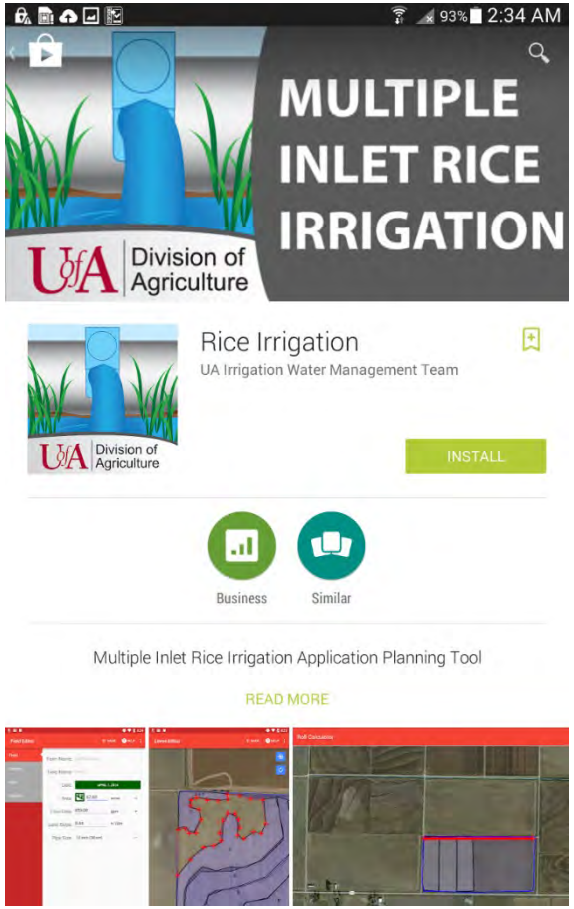
2003-2012 UA Rice Verification Water Use data

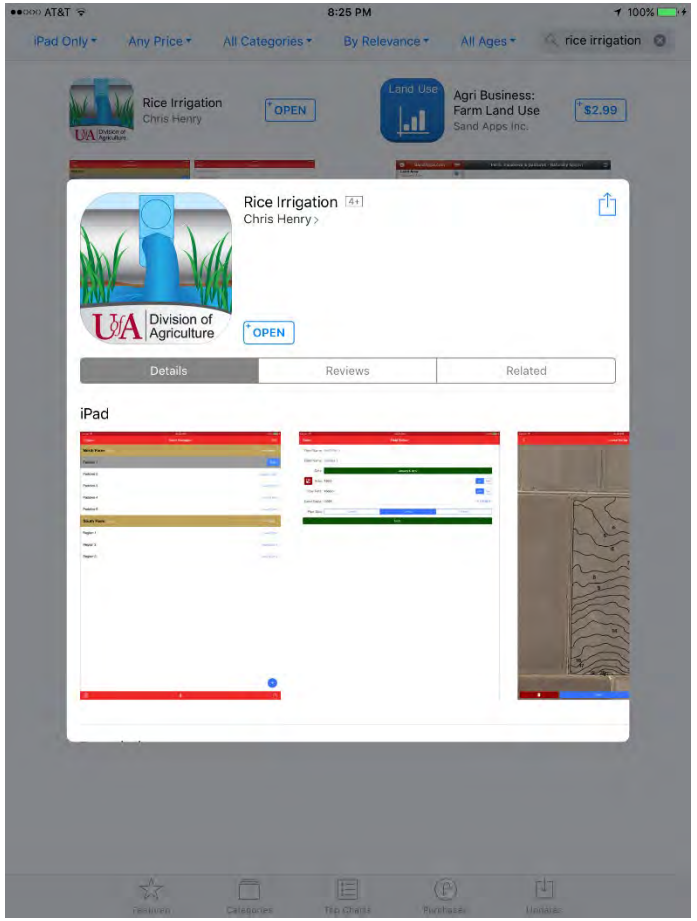


Solution

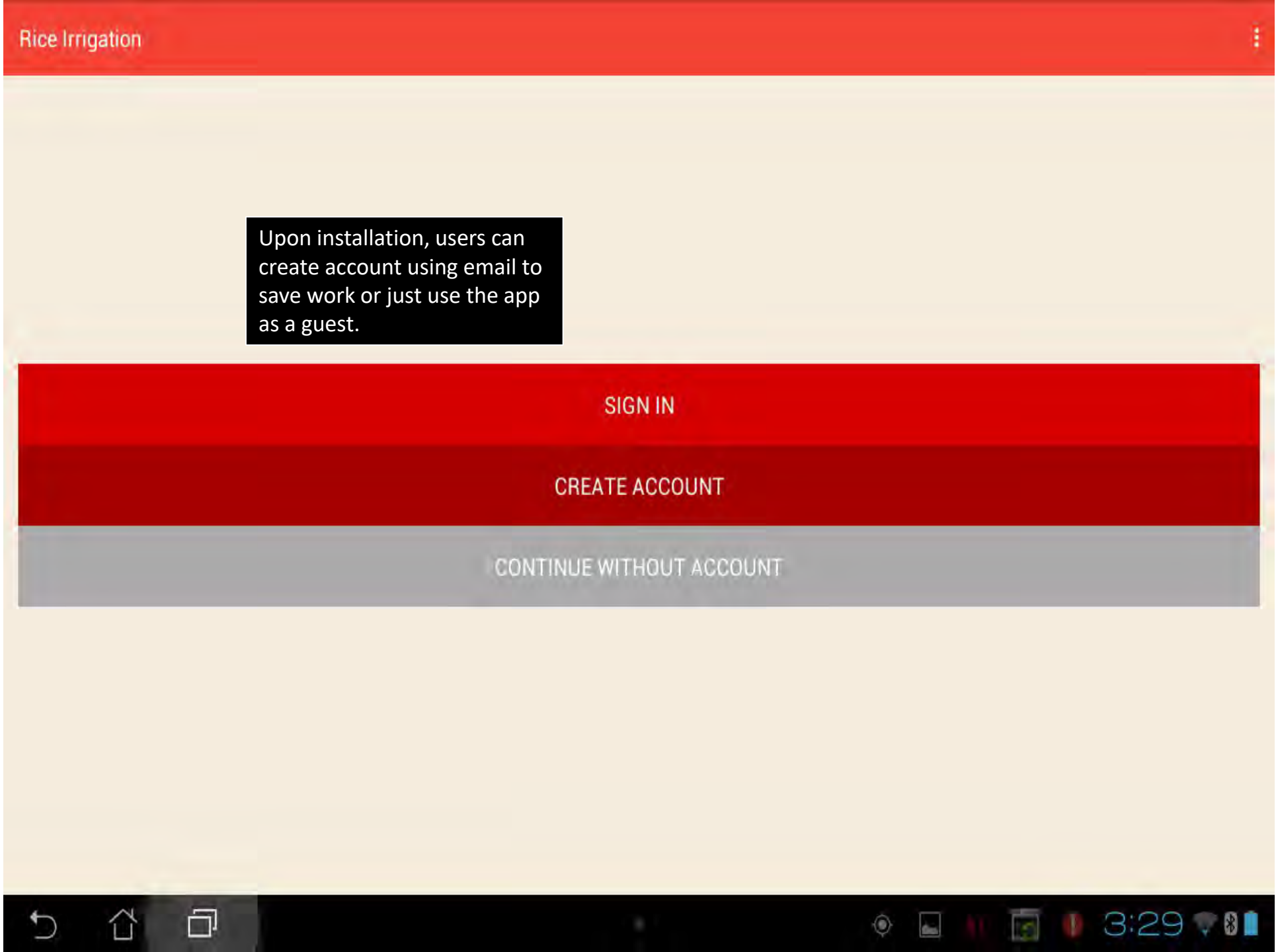
- Use mobile apps, embedded systems, and a ink-jet printer technology to translate CHS and MIRI plans to the pipe as it is being installed by the irrigator.
- Solution must be adaptable between flooded rice fields and furrow irrigated row crop fields to be economically viable.
- “Rice Trailer” solves problem of traversing flooded rice fields with levees. MIRI is designed in “Rice Irrigation” mobile app and implemented real time from phone located on 4 wheeler.
- Hardware was developed to mount a printer, electronics and related hardware to commonly used poly pipe rollers to implement CHS plans in furrow irrigation. A mobile app is used to import CHS plans previously developed and implement them from the tractor seat.

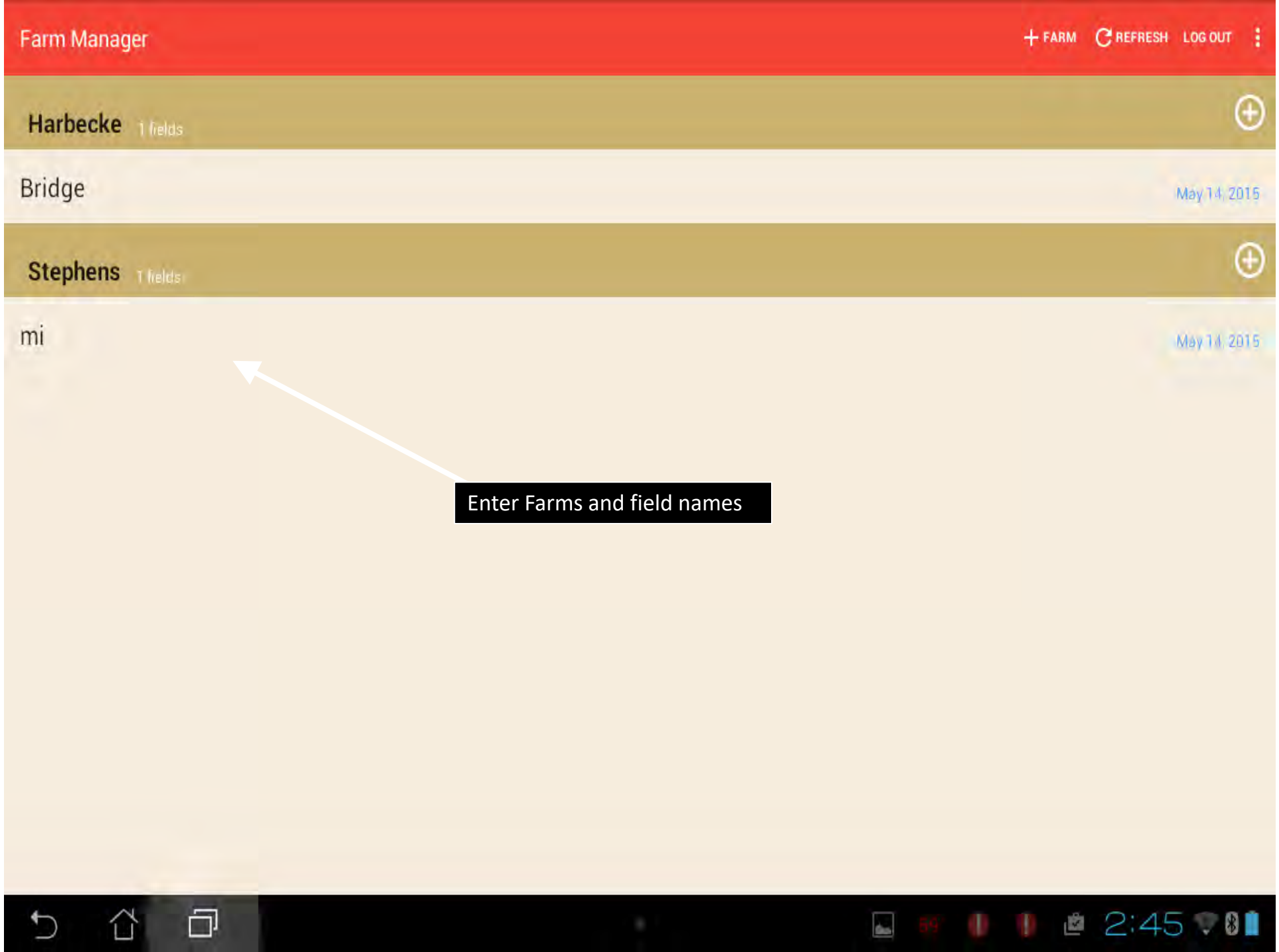
The University of Arkansas Multiple Inlet App can be found on Google Play and the Apple Play Store

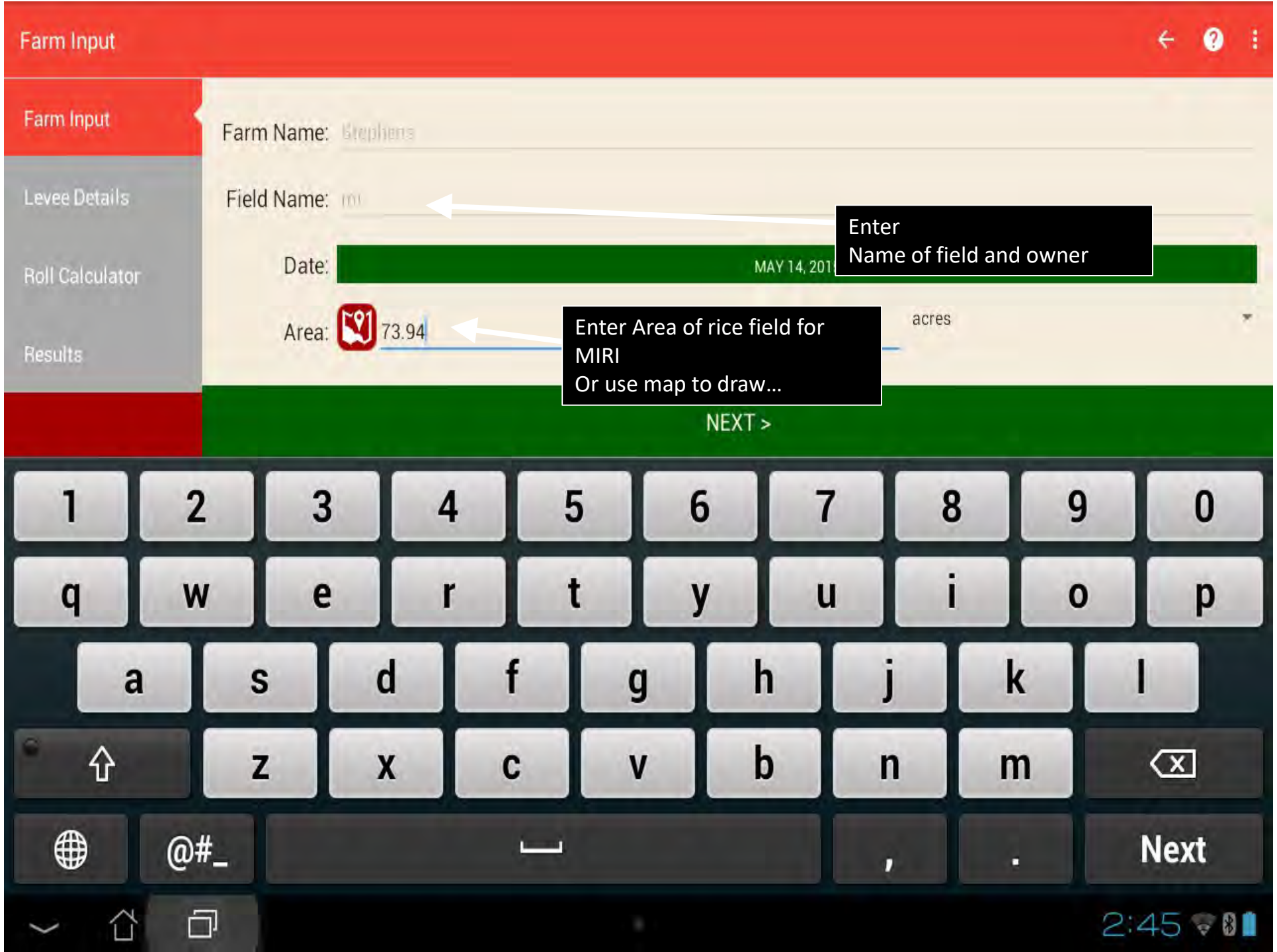


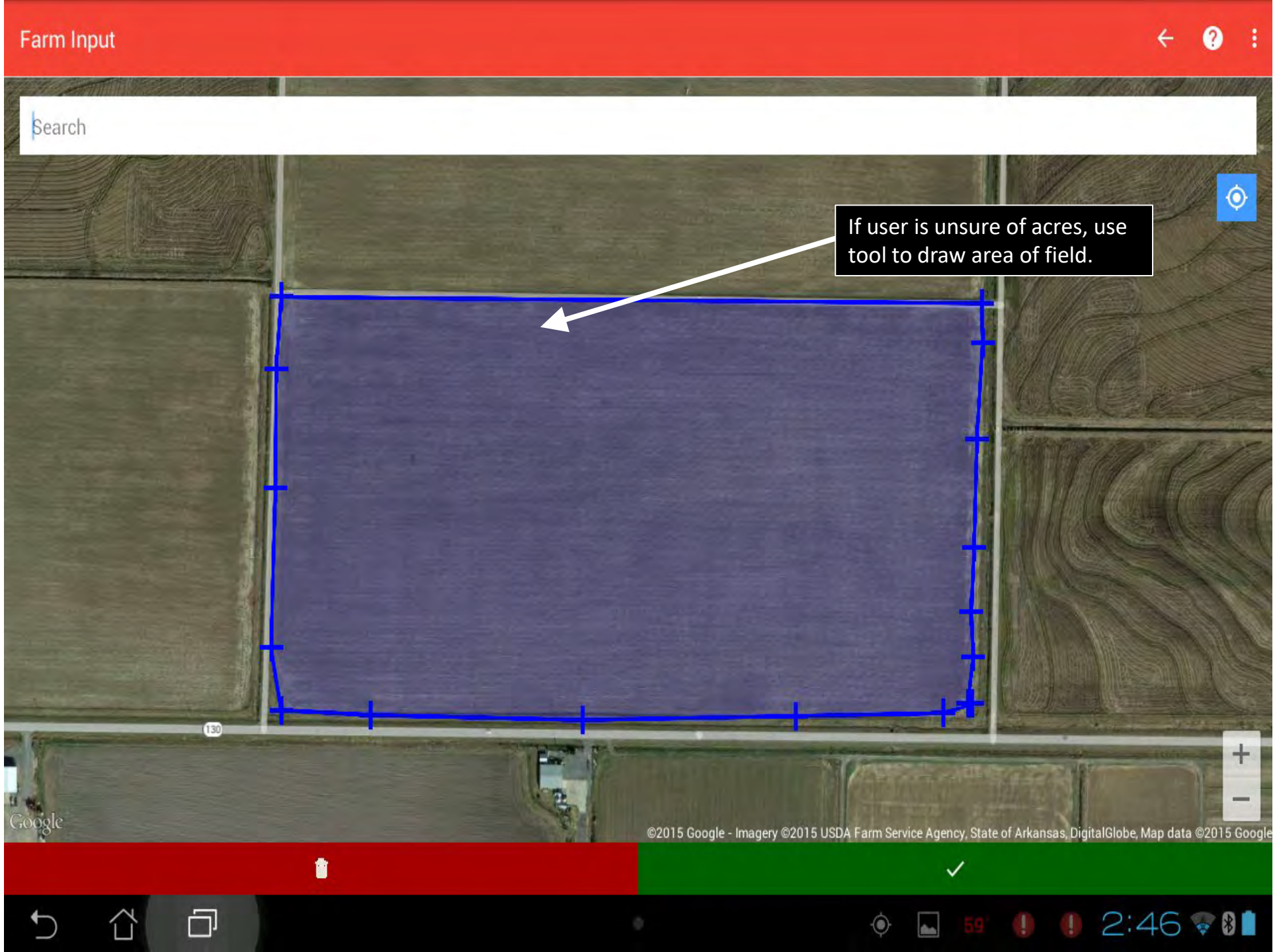


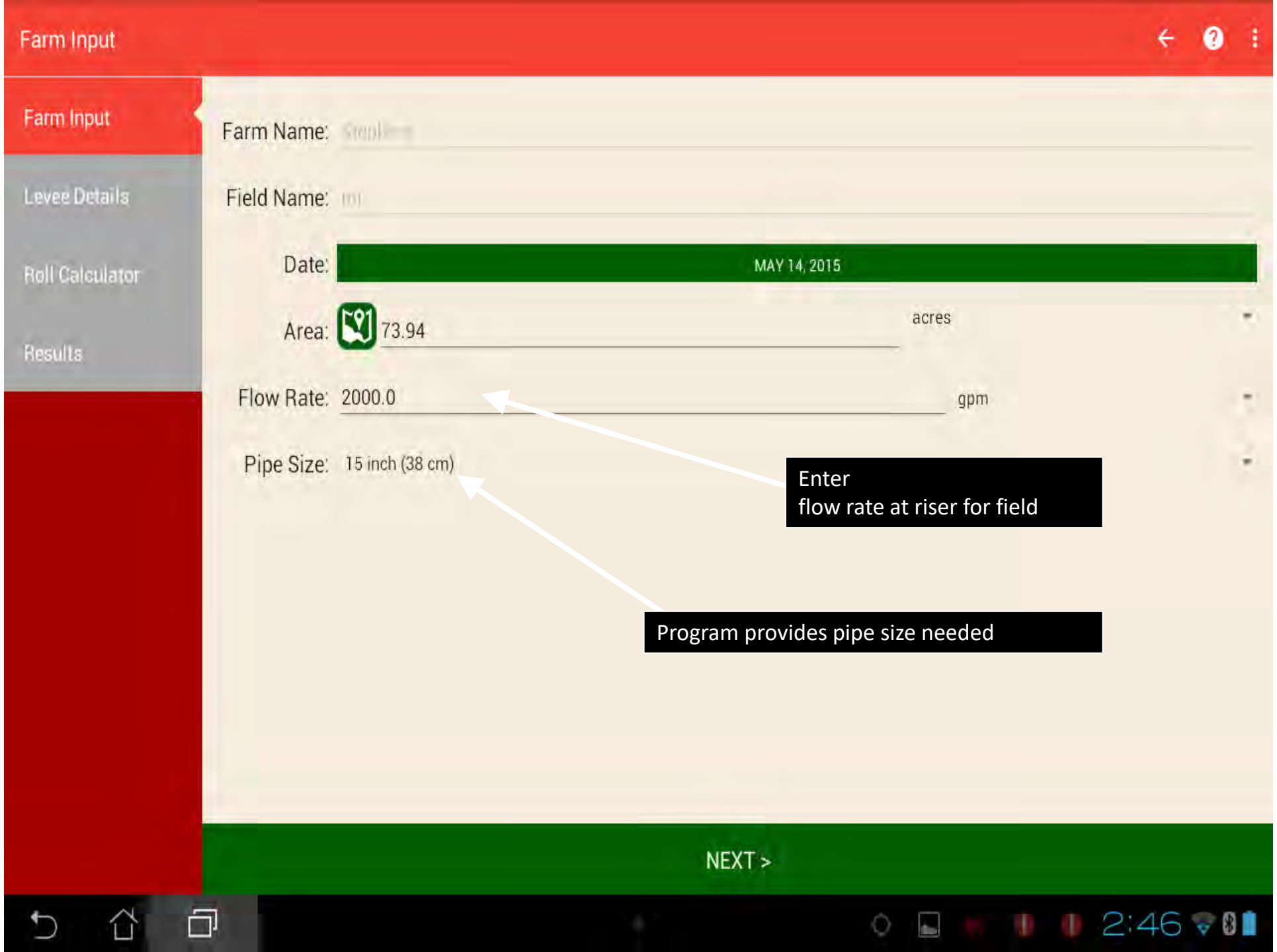
Search for “Rice Irrigation”

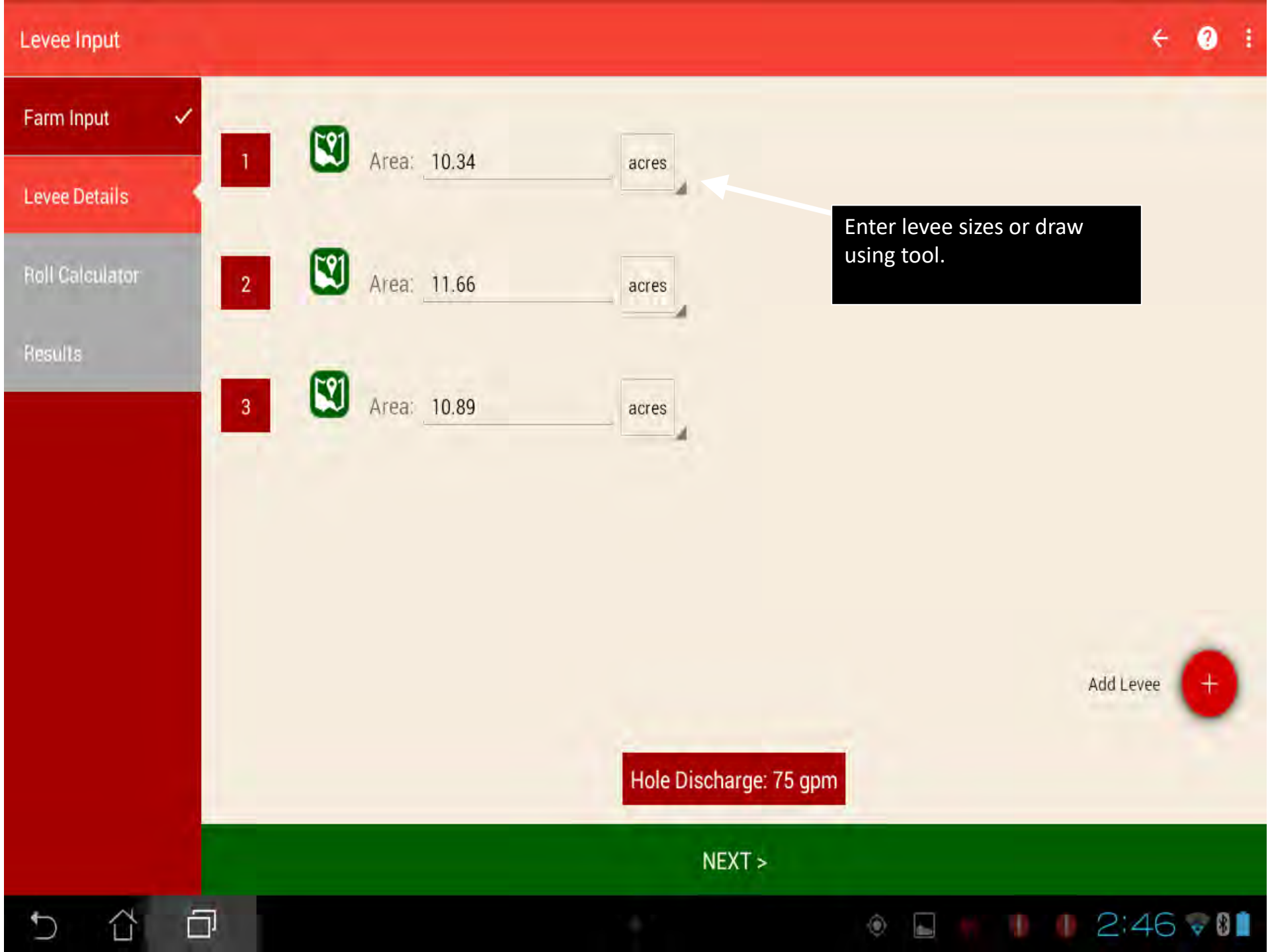

Rice Irrigation
Upon installation, users can create account using email to save work or just use the app as a guest.
SIGN IN
CREATE ACCOUNT
CONTINUE WITHOUT ACCOUNT
3:29


Farm Manager
+ FARM
REFRESH
LOG OUT
Harbecke 1 fields
Bridge
May 14, 2015
Stephens 1 fields
mi
May 14, 2015
Enter Farms and field names
2:45


Farm Input
Farm Input
Levee Details
Roll Calculator
Results
Farm Name:
Field Name:
Date:
MAY 14, 201
Area:
73.94
acres
NEXT >
Enter
Name of field and owner
Enter Area of rice field for
MIRI
Or use map to draw…
Next
2:45


Farm Input
Search
If user is unsure of acres, use tool to draw area of field.
130
Google
©2015 Google - Imagery ©2015 USDA Farm Service Agency, State of Arkansas, DigitalGlobe, Map data ©2015 Google
2:46

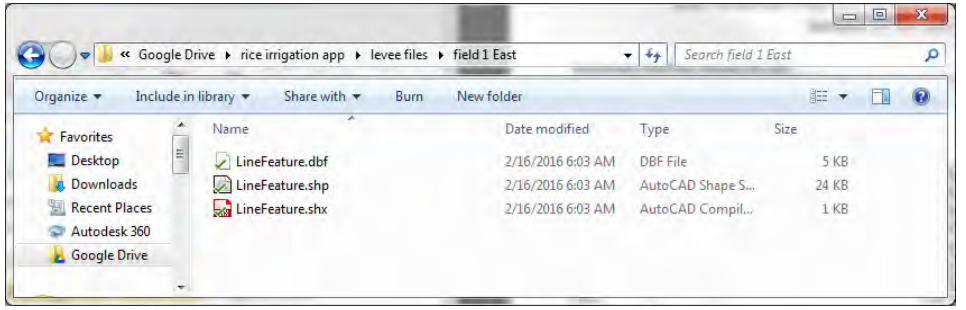

Farm Input
Farm Input
Levee Details
Roll Calculator
Results
Farm Name:
Field Name:
Date:
MAY 14, 2015
Area:
73.94
acres
Flow Rate:
2000.0
gpm
Pipe Size:
15 inch (38 cm)
Enter
flow rate at riser for field
Program provides pipe size needed
NEXT >
2:46

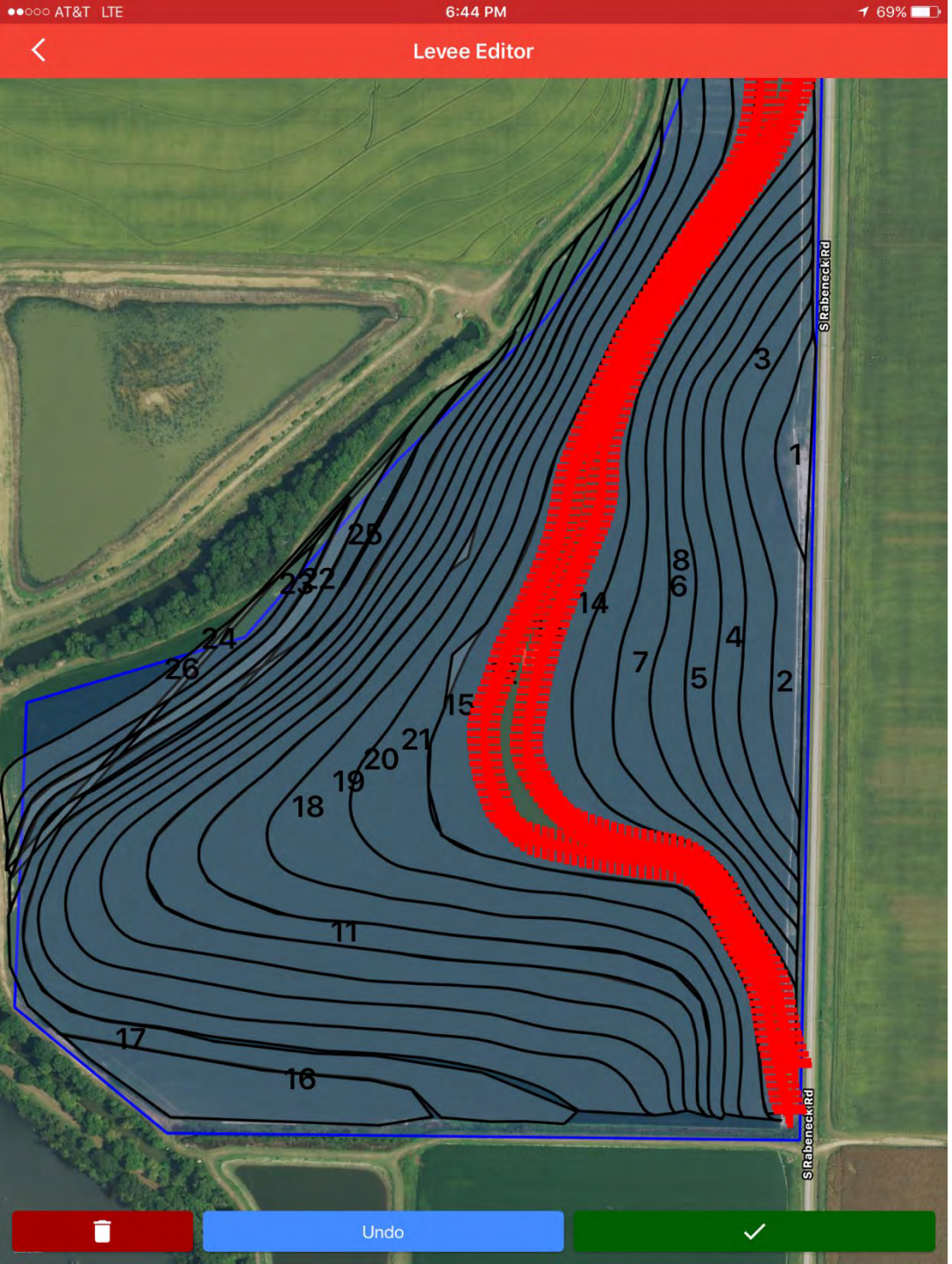

Levee Input
Farm Input
Levee Details
Roll Calculator
Results
1
Area: 10.34
acres
2
Area: 11.66
acres
3
Area: 10.89
acres
Enter levee sizes or draw using tool.
Add Levee
Hole Discharge: 75 gpm
NEXT >
2:46


Levee Input
Use tool to draw each levee within rice field
130
Google
©2015 Google - Imagery ©2015 USDA Farm Service Agency, State of Arkansas, DigitalGlobe, Map data ©2015 Google
2:47

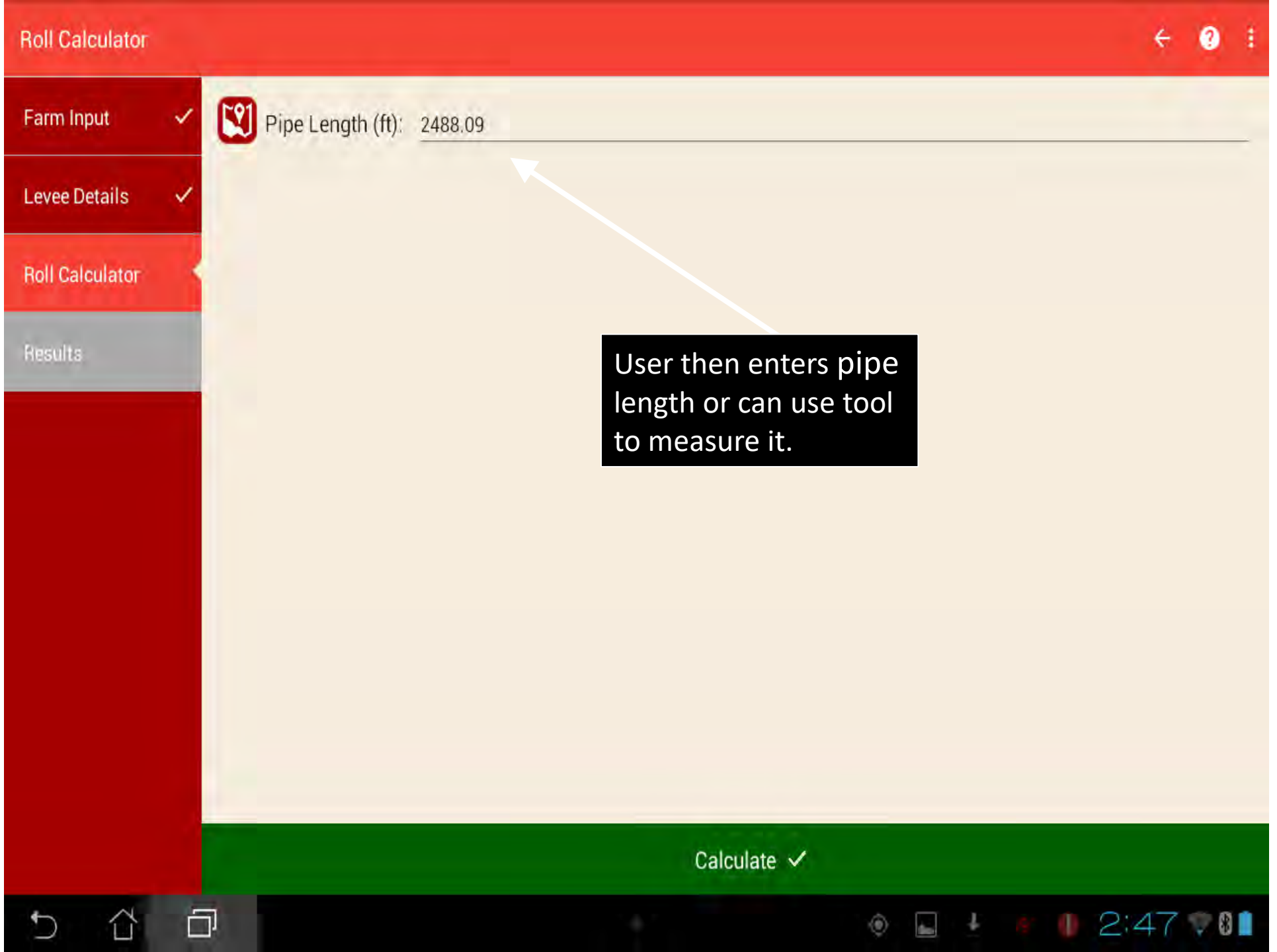
Levees can be imported

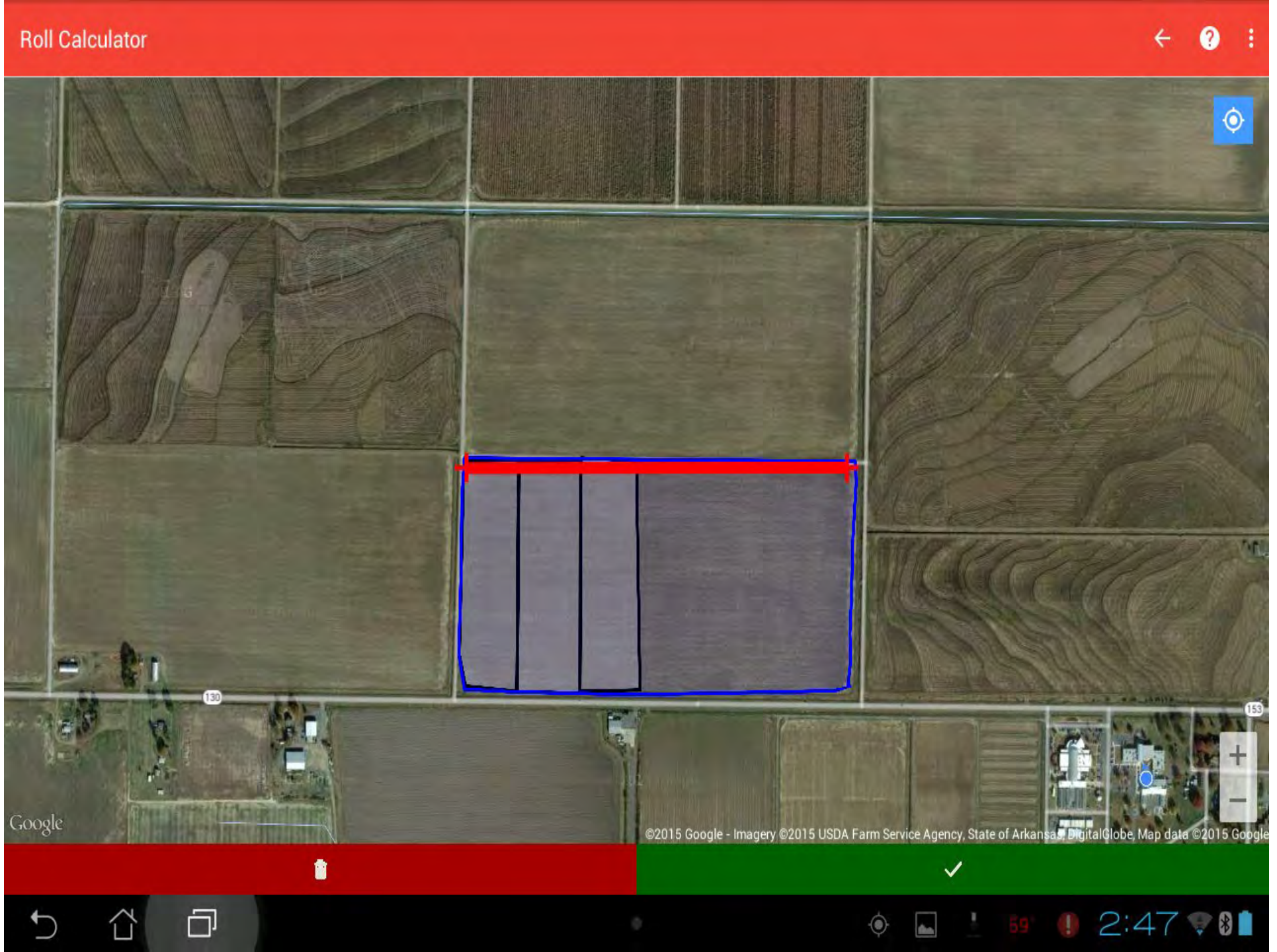
- Create levee files from software, export as ESRI Arcview Shapefile format.
- Create levee files when levees are pulled by recording from RTK guidance. Create a feature line.
- Create folders by field on dropbox.com
- Load levees (SHP, SHX, and DBF) files onto drop box





Fields that have the largest potential for water and fuel savings are the most difficult to implement MIRI. Here a rice field with 26 irregularly shaped levees or paddies was imported and the MIRI plan completed from a shapefile in 8 minutes. Shapefiles can be created using software or by using tractor installed GPS mapping systems when levees are being pulled.


Roll Calculator
Farm Input
Levee Details
Roll Calculator
Results
Pipe Length (ft): 2488.09
User then enters pipe length or can use tool to measure it.
Calculate
2:47


Roll Calculator
130
153
Google
©2015 Google - Imagery ©2015 USDA Farm Service Agency, State of Arkansas, DigitalGlobe, Map data ©2015 Google
2:47

Results

Farm Input ✓

Levee Details ✓

Roll Calculator ✓

Results ✓

6	4.89	1/4	1.25
7	7.72	3/4	1.75
8	10.07	1/2	2.5
9	6.91	3/4	1.75
10	7.65	3/4	1.75
		1	1.0

App then calculates number of holes for each levee and shows gate settings. Additionally it provides length, pipe thickness and number of rolls needed for the field. The results can be saved and shared by email.

70.93 acres

2464.68 ft

Pipe Needed*: 2587.91 ft

Polytube Rolls Needed**: 2

* The pipe length includes 5% allowance for field relief

** It is advised to use pipe thickness of 9mil, Tri-Ply 9mil, or 10 mil

SAVE

SHARE

Plans provide irrigators, with the size of pipe needed, number of rolls, pipe thickness, length of pipe needed, and gate settings for each levee or paddy. Additionally it provides a pumping time estimate to flood the field.

Multiple Inlet Irrigation for Rice Plan

UofA DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System

Rice Irrigation Results for Field: new field

Generated Monday April 11, 2016 by chris

Levee Results for new field

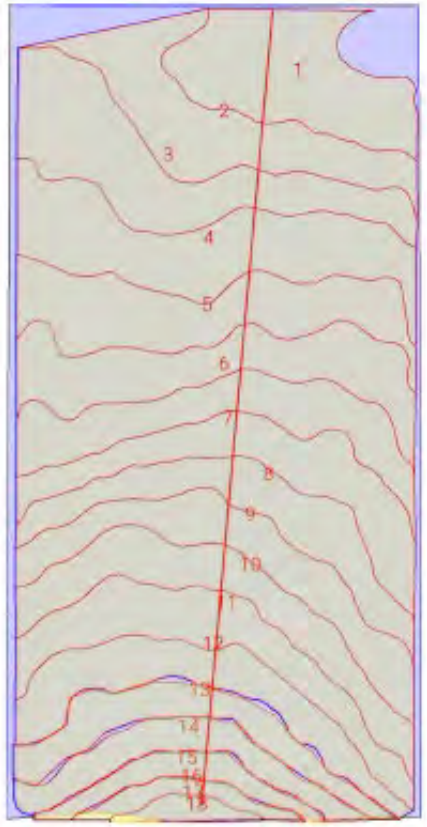
Field Area:68.64 acres
Flow Rate:1200.00 gpm
Pipe Size:15 inch (38 cm)
Measured Pipe Length:2399.86 ft
Pipe Needed*:2433.86 ft
Polytube Rolls Needed**:2
* The pipe length includes allowance for land slope and levee barrier crossing
** It is advised to use pipe thickness of 9mil, Tri-Ply 9mil, or 10 mil

Levee	Area (ac)	# of Holes	
1	4.74	●	1.25
2	4.59	●	1.25
3	5.48	●	1.50
4	5.78	●	1.50
5	4.83	●	1.25
6	4.61	●	1.25
7	3.95		1
8	4.01		1
9	3.59		1
10	3.88		1
11	3.91		1
12	3.97		1

Multiple Inlet Irrigation for Rice Plan

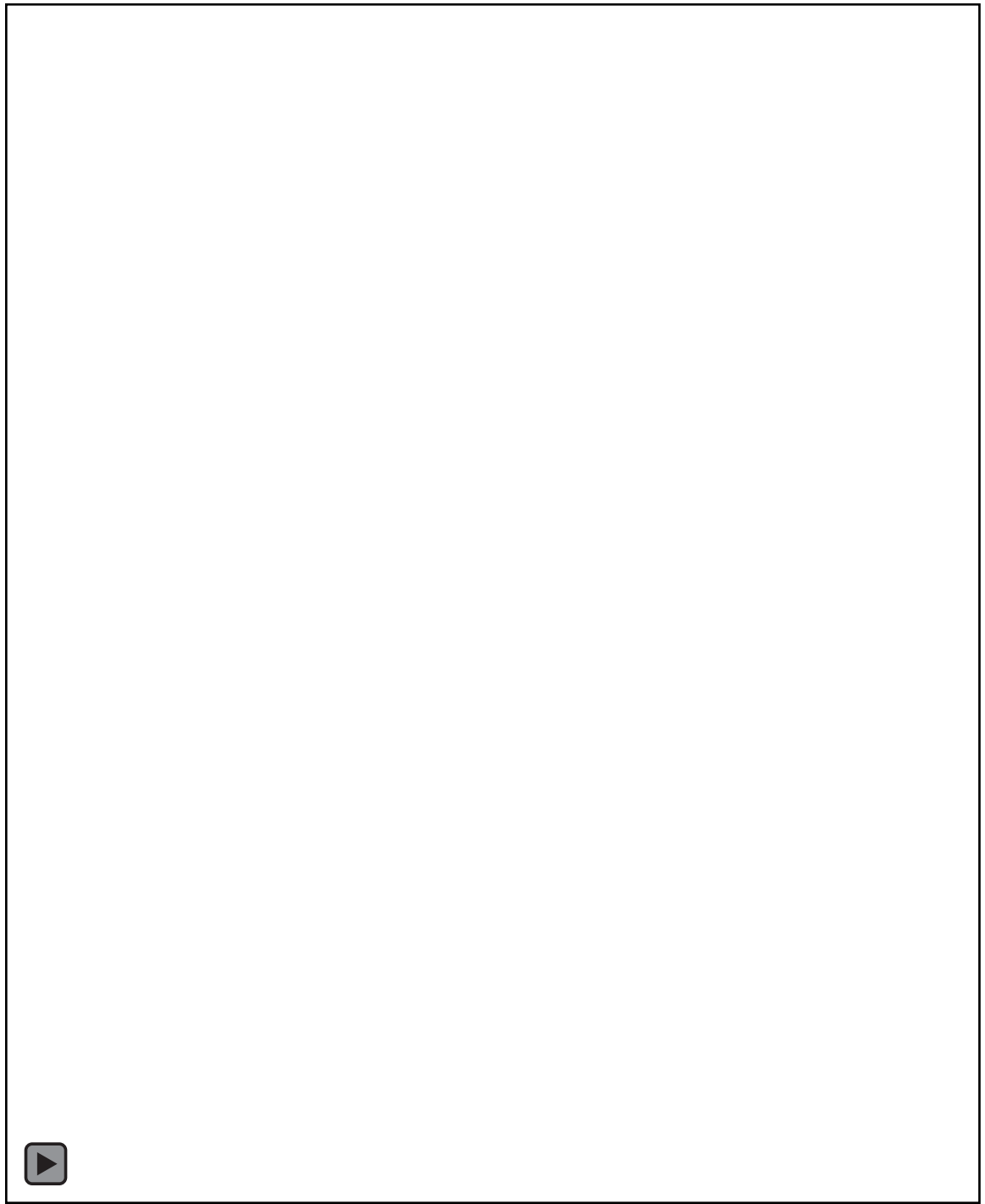
UofA DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System

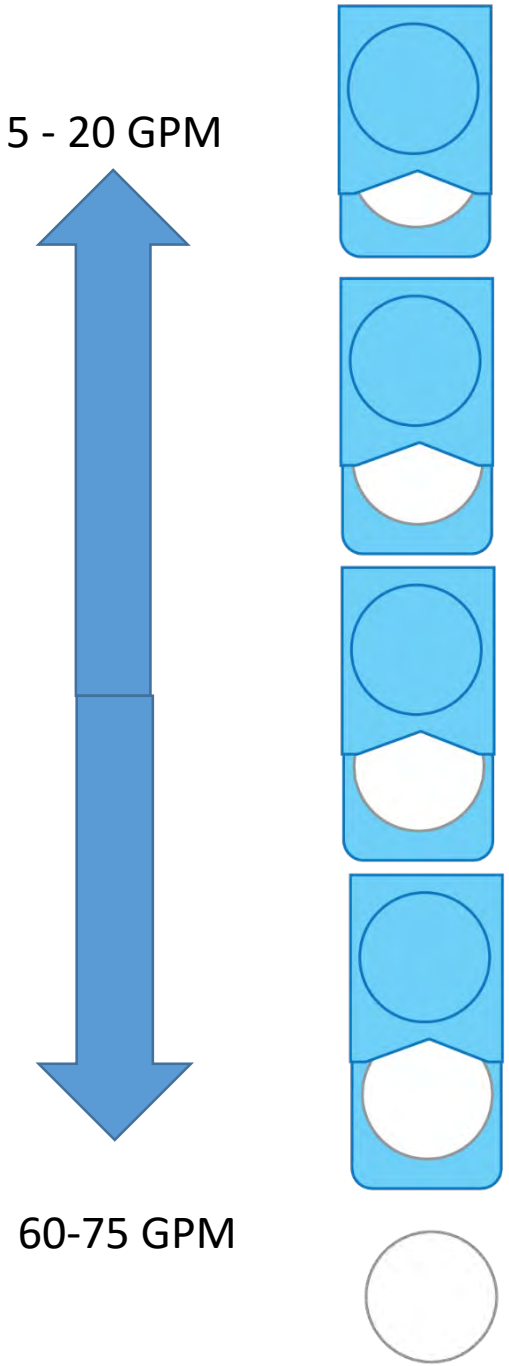
Field Drawing for new field



Additionally UA has developed a MIRI ATV trailer to aid in the implementation of MIRI, it can be used for multiple inlet (through the middle of the field) and for side inlet, when it is possible to place pipe along the field edge. The trailer is light enough to be pulled with an ATV so that it does not damage the levee and includes a small plow which provides a small trench to keep the pipe from rolling and twisting during use.

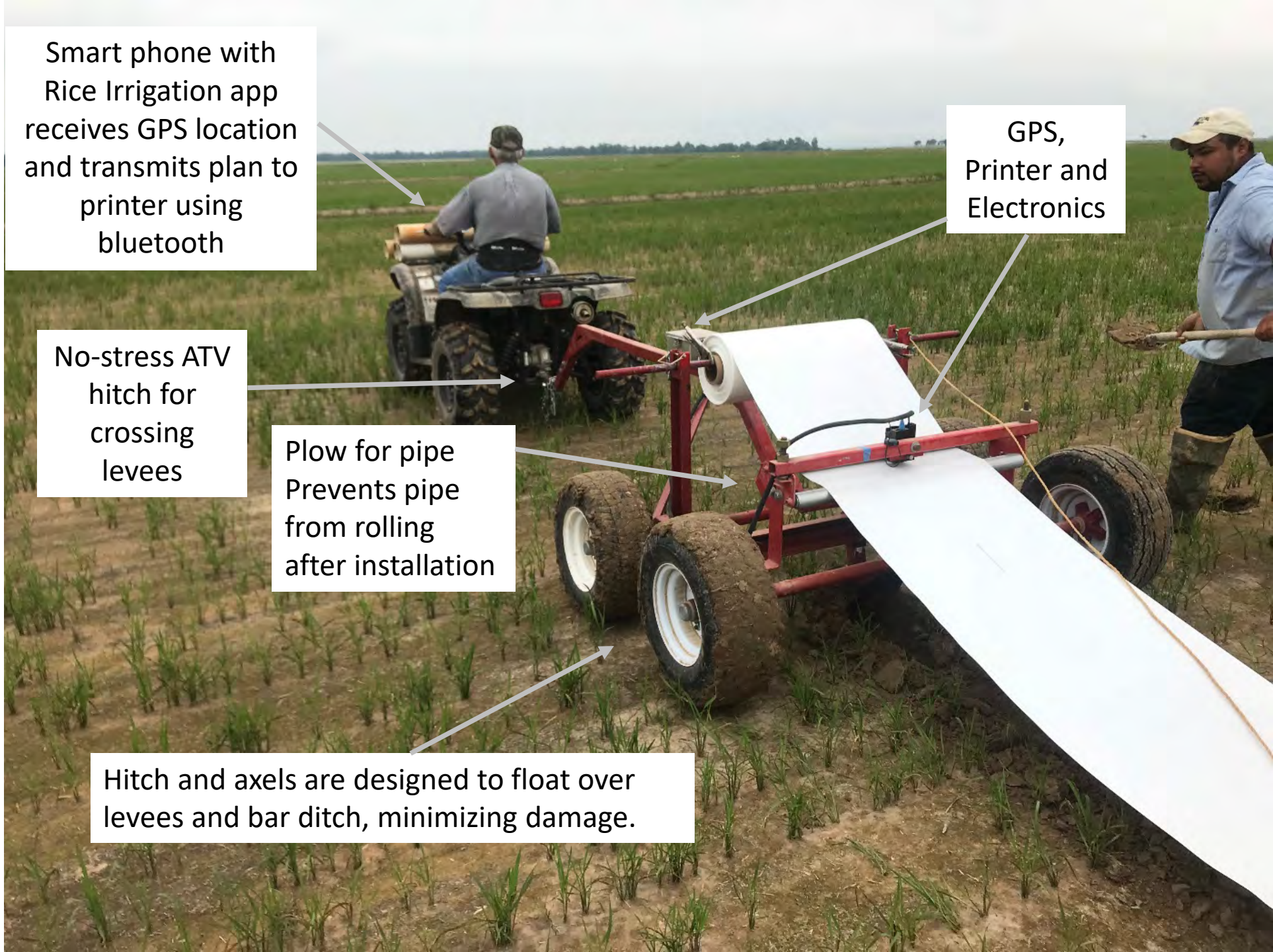
Blue gates are used in MIRI to adjust the flow to each levee. The video show how they are installed.



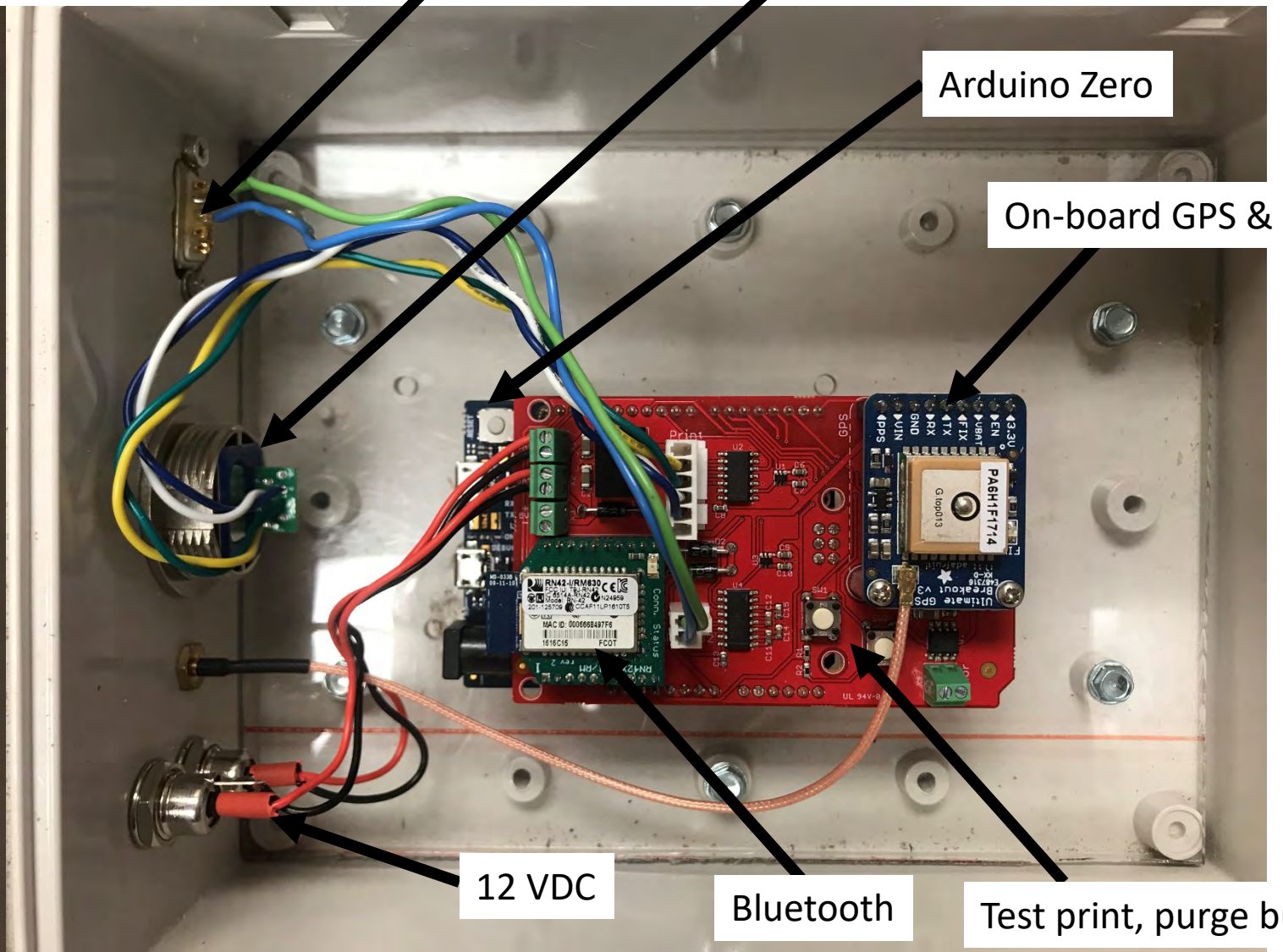


The poly pipe printer then prints the hole plan developed using the “Rice Irrigation” app on the pipe as it is installed

Levee 14
Set blue
Gate to ¼
open


Smart phone with Rice Irrigation app receives GPS location and transmits plan to printer using bluetooth
GPS, Printer and Electronics
No-stress ATV hitch for crossing levees
Plow for pipe Prevents pipe from rolling after installation
Hitch and axels are designed to float over levees and bar ditch, minimizing damage.

PCB Printer Shield Details



Levee 4

1.5 means two holes, one fully open one with a blue gate set half open.

Printer is moved to Poly Pipe Toolbar for furrow irrigation. App imports Delta Plastics Pipe Planner Design.

Printer and roller apparatus (green) installed between poly pipe and OEM trencher.

Operator imports plan, locates plan on map, then starts printing. User can how often prints are made for person punching plan after pipe is filled.


GPS
Printer
Plow
Hicks


SAMSUNG
DP Pipe Plan Parser
PRINT SETTING
3/8
1/2
9/16
5/8
11/16
3/4
CONNECT ANOTHER DEVICE
FINISHED
Approach pipe to begin printing.
Device is not moving yet


SERVICED

Printed result identifies when hole sizes change

Printed result identifies when hole sizes change even when hole punches are required on both sides of pipeline such as when pipe is used to irrigate on both sides

Even Build-ups are identified on the pipe for proper placement and height. This was also a location for a hole size change.

Pipe Planner Irrigation Design Results

PIPE PLANNER

Farm Name:
Field Name: 18 acres
Set: Set 1 (24 hrs)
Hole Spacing: Every Furrow
Flow Per Outlet 1.35
Minimum Pressure : 0.00 ft
Maximum Pressure : 1.10 ft
Hole Size: 1/4,5/16,3/8,7/16,1/2,9/16,5/8,11/16,3/4,13/16,7/8,15/16,1,Enable Gates

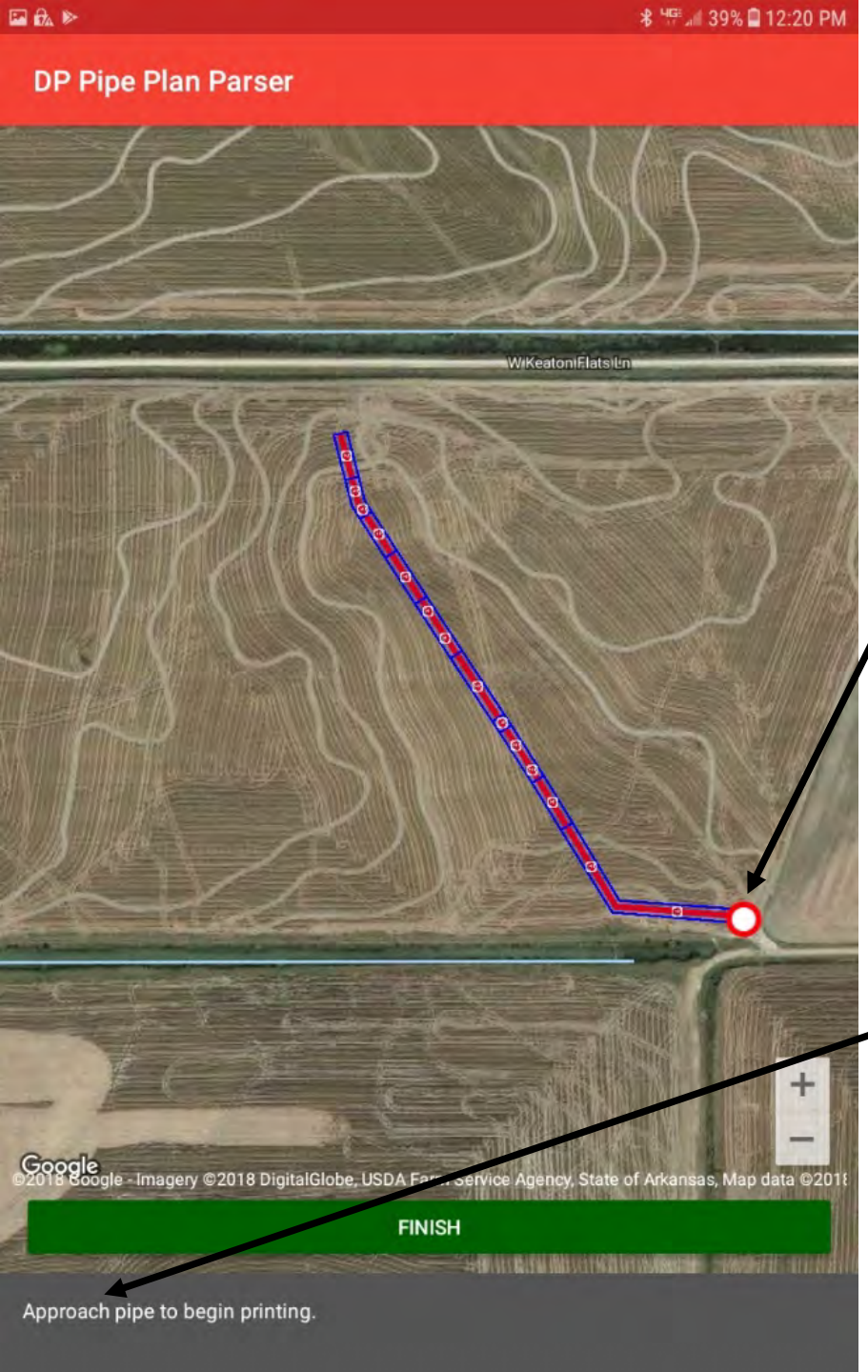
Uniformity: 82 %
Min. Head Pressure: 0.50 ft
Max Head Pressure:: 1.10 ft
Set Area: 17 ac
Flow In: 1000 gpm

Pipe Size (in)	Pipe Function	Pipe Length (ft)	Hole Size (in)	Furrow Count	Build Up Height (ft)
12x7	Supply	0 - 10 ft			
12x7	Irrigation	10 - 187 ft	L: 7/16 R: 1/4	49	
12x7	Irrigation	187 - 366 ft	L: 1/2 R: 1/4	55	
12x7	Irrigation	366 - 607 ft	L: 7/16 R: 1/4	80	
12x7	Irrigation	607 - 717 ft	L: 3/8 R: 1/4	37	
	Build Up	717 ft			1.10
12x7	Irrigation	717 - 756 ft	L: 7/16 R: 5/16	13	
12x7	Irrigation	756 - 774 ft	L: 3/8 R: 5/16	6	
12x7	Irrigation	774 - 1000 ft	L: 3/8 R: 1/4	64	
	Build Up	1000 ft			1.10
12x7	Irrigation	1000 - 1004 ft	L: 1/2 R: 1/4	1	
12x7	Irrigation	1004 - 1075 ft	L: 7/16 R: 1/4	19	
12x7	Irrigation	1075 - 1150 ft	L: 3/8 R: 1/4	20	
	Build Up	1150 ft			1.11
12x7	Irrigation	1150 - 1191 ft	L: 7/16 R: 1/4	11	
12x7	Irrigation	1191 - 1246 ft	L: 3/8 R: 1/4	16	
	Build Up	1246 ft			1.21

Efficient Irrigation Management from Delta Plastics

Computerize Hole Selection Pipe Plans can be very complicated with many hole size changes. This one has 12 changes with 3 buildups.

CHS pipe plans are designed using www.pipeplanner.com a tool provided by Delta Plastics

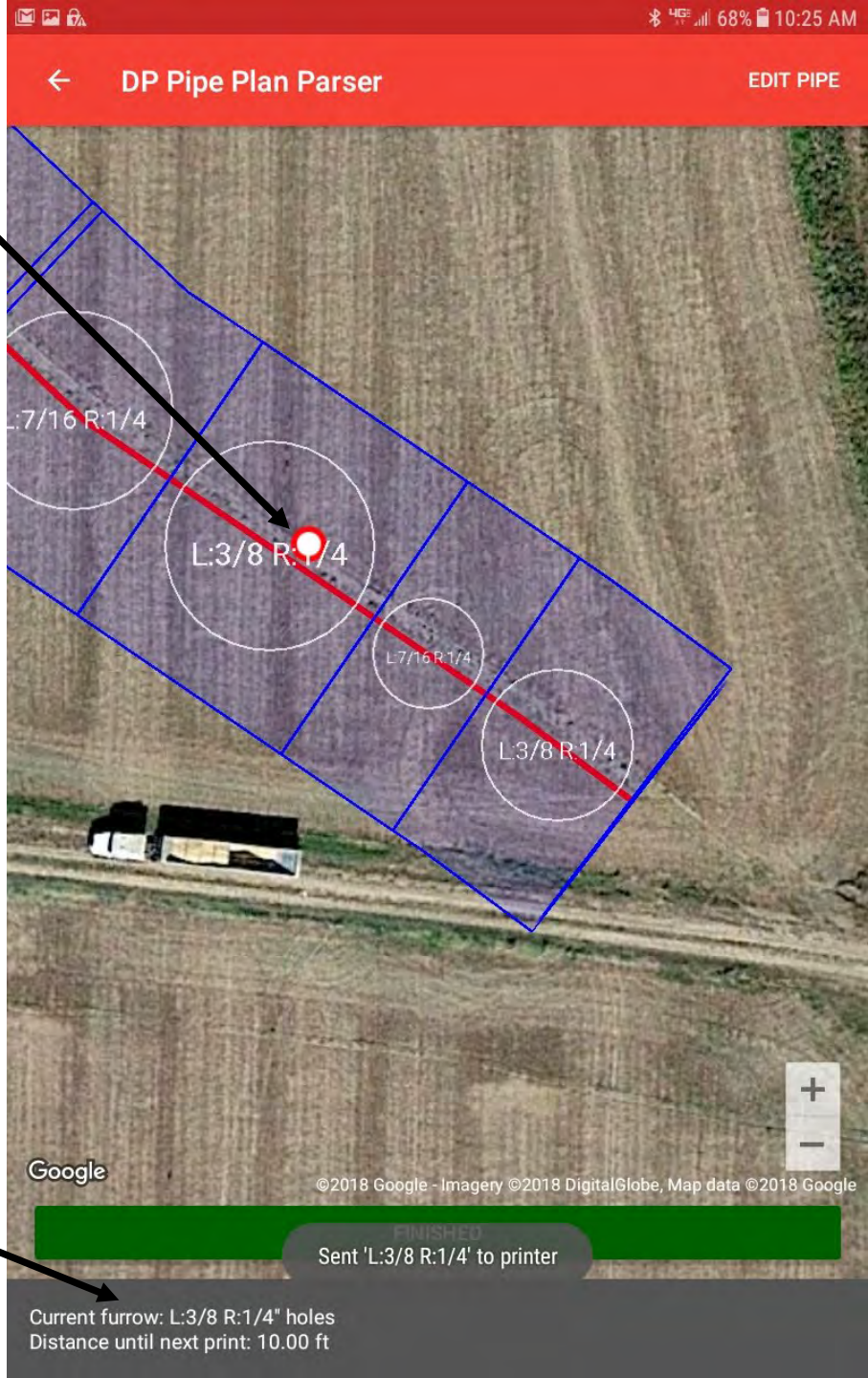


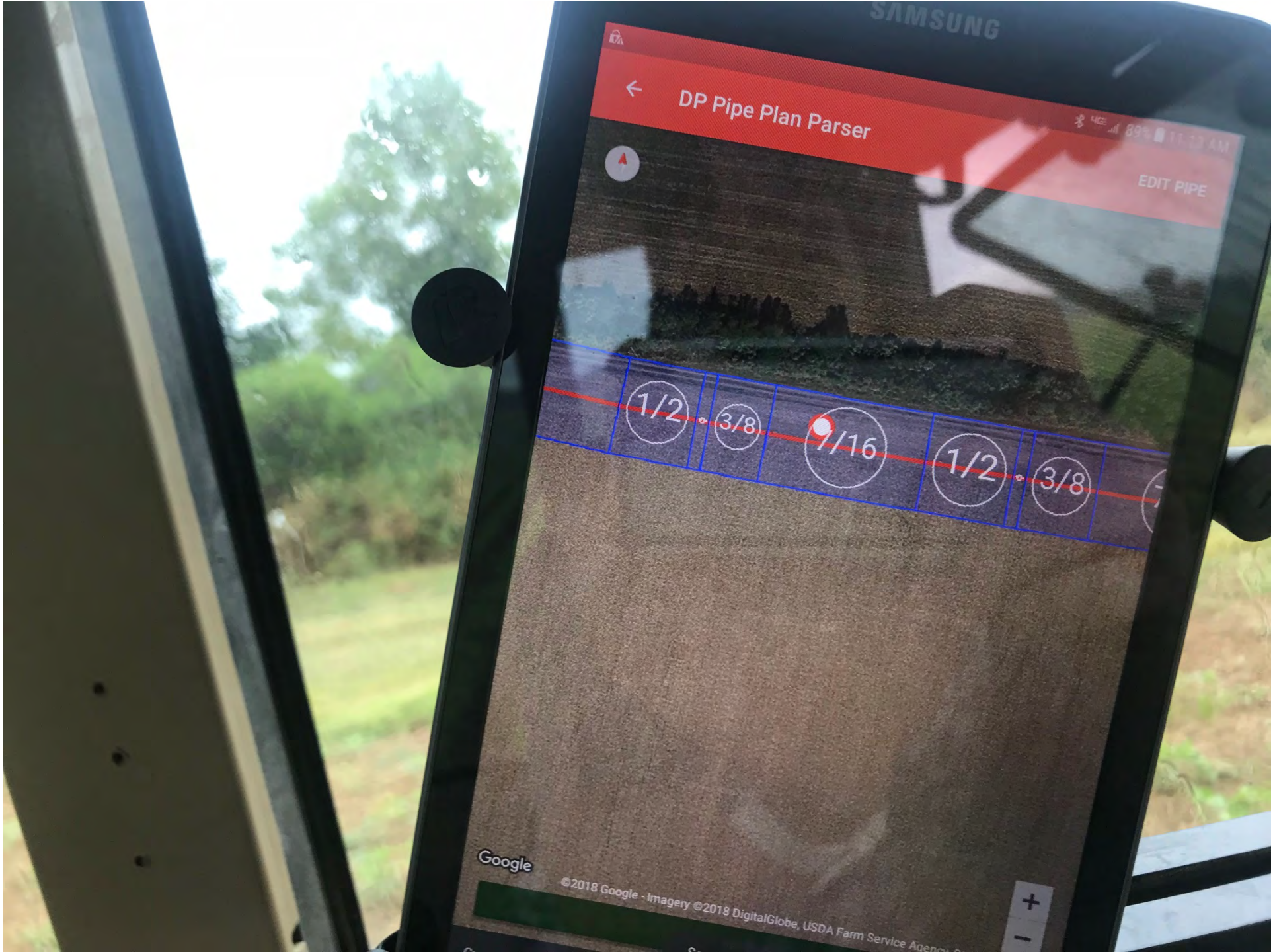
Operator can see real time location in field relative to the CHS plan. Here multiple hole sizes are changing frequently because row lengths are changing at every row

User has uploaded plan and location of pipe. Red dot is the tractor and poly pipe installer.

Printing commences when printer and pipe enter zone

Operator can see current print sequence and distance to next print and hole assignment changes




SAMSUNG
DP Pipe Plan Parser
EDIT PIPE
1/2
3/8
9/16
1/2
3/8
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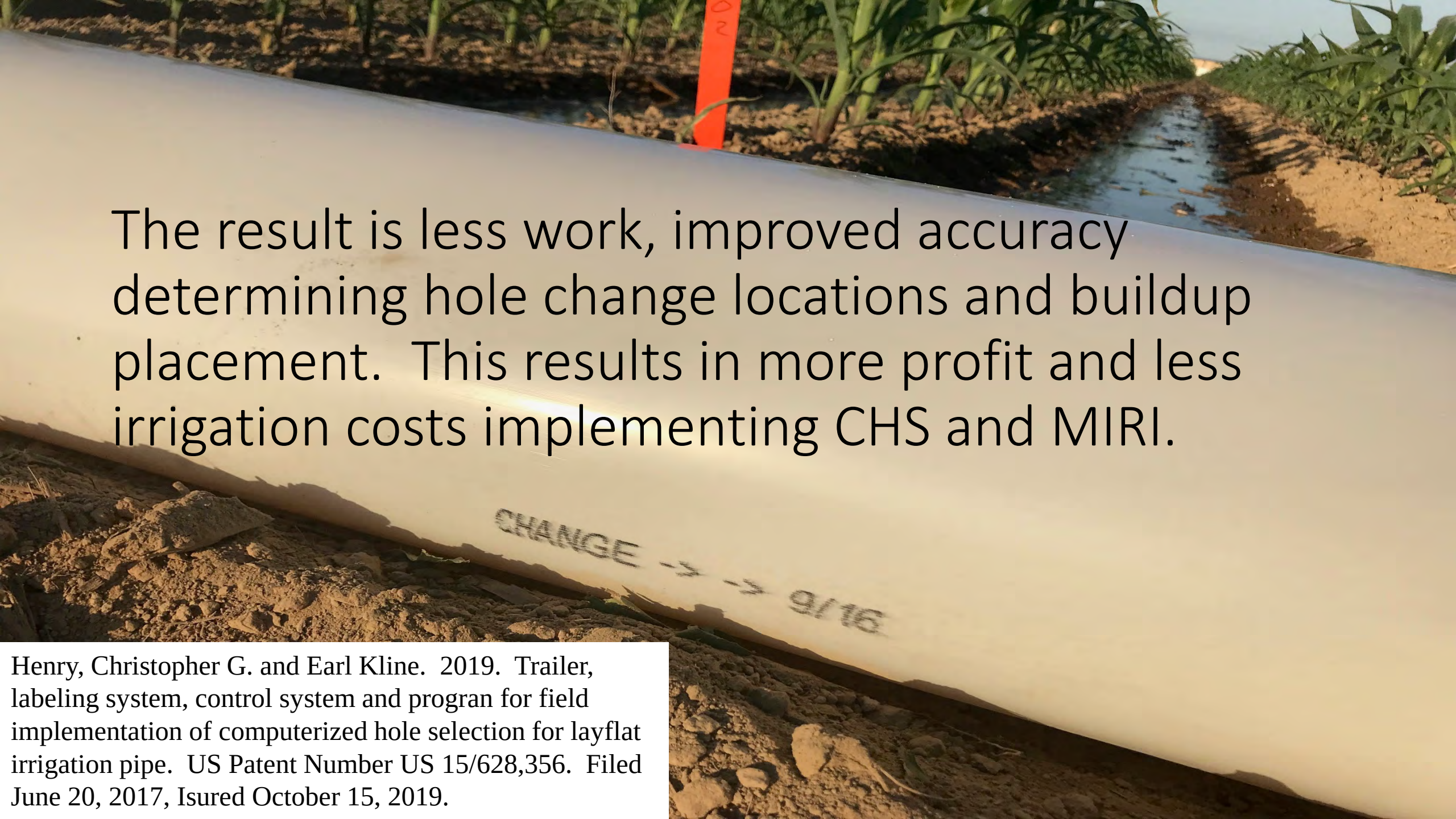

The result is less work, improved accuracy determining hole change locations and buildup placement. This results in more profit and less irrigation costs implementing CHS and MIRI.

Henry, Christopher G. and Earl Kline. 2019. Trailer, labeling system, control system and progran for field implementation of computerized hole selection for layflat irrigation pipe. US Patent Number US 15/628,356. Filed June 20, 2017, Isured October 15, 2019.