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

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The Lay-Flat Pipe System for Irrigation
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

1/2" hole
Pressure 0.1 PSI
1.5 GPM

1/2" hole
Pressure 1 PSI
4.7 GPM
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
Efficient Irrigation Management

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
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
### Pipe Planner Irrigation Design Results

**Farm Name:** Kris Keller  
**Field Name:** West of lake  
**Set:** Set 1 (22 hrs)  
**Hole Spacing:** Every Farrow  
**Flow Per Outlet:** 1.59 gpm  
**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, 3/4, 13/16, 1/1, 11/16, 3/8, 13/16, 7/8, 11/16, 1/2, Enable Gates

<table>
<thead>
<tr>
<th>Pipe Size (in)</th>
<th>Pipe Function</th>
<th>Pipe Length (ft)</th>
<th>Hole Size (in)</th>
<th>Farrow Count</th>
<th>Build Up Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15x10</td>
<td>Supply</td>
<td>0 - 68 ft</td>
<td></td>
<td></td>
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<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>68 - 294 ft</td>
<td>L: 5/16 R: 5/16</td>
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<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>294 - 513 ft</td>
<td>L: 3/8 R: 5/16</td>
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<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>513 - 604 ft</td>
<td>L: 7/16 R: 5/16</td>
<td>60</td>
<td></td>
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<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>604 - 827 ft</td>
<td>L: 1/2 R: 5/16</td>
<td>65</td>
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<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>827 - 974 ft</td>
<td>L: 9/16 R: 5/16</td>
<td>58</td>
<td></td>
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<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>974 - 1037 ft</td>
<td>L: 1/2 R: 5/16</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>1037 - 1098 ft</td>
<td>L: 7/16 R: 5/16</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>1098 - 1204 ft</td>
<td>L: 3/8 R: 5/16</td>
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<td></td>
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<tr>
<td>15x10</td>
<td>Irrigation</td>
<td>1204 - 1513 ft</td>
<td>L: 5/16 R: 5/16</td>
<td>128</td>
<td></td>
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<tr>
<td>Build Up</td>
<td></td>
<td>1513 ft</td>
<td></td>
<td></td>
<td>0.93</td>
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</tbody>
</table>

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.delta-plastics.com/irrigation-resources](http://www.delta-plastics.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
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) ($p = 0.03$).
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.”
Upon installation, users can create an account using email to save work or just use the app as a guest.
<table>
<thead>
<tr>
<th>Farm</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harbecke</td>
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</tr>
<tr>
<td>Bridge</td>
<td></td>
</tr>
<tr>
<td>Stephens</td>
<td>1</td>
</tr>
<tr>
<td>mi</td>
<td></td>
</tr>
</tbody>
</table>

Enter Farms and field names
Enter Name of field and owner

Enter Area of rice field for MIRI
Or use map to draw...
If user is unsure of acres, use tool to draw area of field.
Enter flow rate at riser for field.

Program provides pipe size needed.
Enter levee sizes or draw using tool.
Use tool to draw each levee within rice field.
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.
User then enters pipe length or can use tool to measure it.
The app calculates the number of holes for each levee and shows gate settings. Additionally, it provides length, pipe thickness, and the number of rolls needed for the field. The results can be saved and shared by email.

<table>
<thead>
<tr>
<th>Farm Input</th>
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<th>4.89</th>
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<tr>
<td>Levee Details</td>
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<tr>
<td>Roll Calculator</td>
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<td>10.07</td>
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<tr>
<td>Results</td>
<td>9</td>
<td>6.91</td>
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<tr>
<td></td>
<td>10</td>
<td>7.65</td>
</tr>
</tbody>
</table>

**Results**

Pipe Needed:

Polytube Rolls Needed**: 

- 70.93 acres
- 2464.68 ft
- 2587.91 ft
- 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.
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.
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 shows 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.
Smart phone with Rice Irrigation app receives GPS location and transmits plan to printer using bluetooth.

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

- RS-232 input from external GPS
- RJ-45 communication to Printer
- On-board GPS & Antenna
- Arduino Zero
- Bluetooth
- 12 VDC
- Test print, purge buttons
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.
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

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.
Printing commences when printer and pipe enter zone.

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.

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

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