Irrigation Modernization and Design of Pipe Distribution Networks

LEVEL OF SERVICE, IRRIGATOR FLOWS, AND LAYOUT PREPARATION



nhc
northwest hydraulic consultants

water resource specialists

Level of Service

No	Consideration	Units	Indicative Level of Service		
			High	Medium	Low
1A	Area commanded by a field hydrant	ha	2	5	25
1B	Typical distance from hydrant to fields	m	150	225	500
2	Number of farmers sharing a field hydrant	No	<2	2-10	>10
3	Irrigator flow (provided at field hydrant)	l/s	3-6 (NP) 6-10 (P)	6-10 (NP) 10-20 (P)	>10 (NP) >20 (P)
4	Irrigation flow available 24/7 (on demand), or on flexible or fixed rotation	%	24/7	50%	25% or less
5	Pressure at field hydrant	m	>20	2-10	<2
6	Management systems, SCADA, for flow and pressure control, and metering	-	Fully automated	Remote monitoring/ local control	None
7	Water quality (free of sediment)	-	Sand trap and filters	Sand trap only	No facilities

NP=non paddy, P = paddy

Irrigator Flows and Pressures

	Units	Non-Paddy Cropping	Paddy Cropping
Irrigator flows	l/s	4 to 6	8 to 15
Irrigator Pressures at field Hydrant	m	20 to 25 (drip or sprinkler)	0.5 to 2

Select the irrigator flow for efficient irrigation. This depends on:

- Farmer practices and how water is applied to crops (basins, furrows, borders, drip, sprinkler)
- Soil type and land slopes
- Crops cultivated (paddy and non-paddy)

Irrigator Flows

Stream size	Sandy loam			Clay loam		
l/s	m2	ha	acres	m2	ha	acres
5	100	0.010	0.025	200	0.020	0.049
10	200	0.020	0.049	400	0.040	0.099
15	300	0.030	0.074	600	0.060	0.148
30	600	0.060	0.148	1200	0.120	0.297
60	1200	0.120	0.297	2400	0.240	0.593
90	1800	0.180	0.445	3600	0.360	0.890

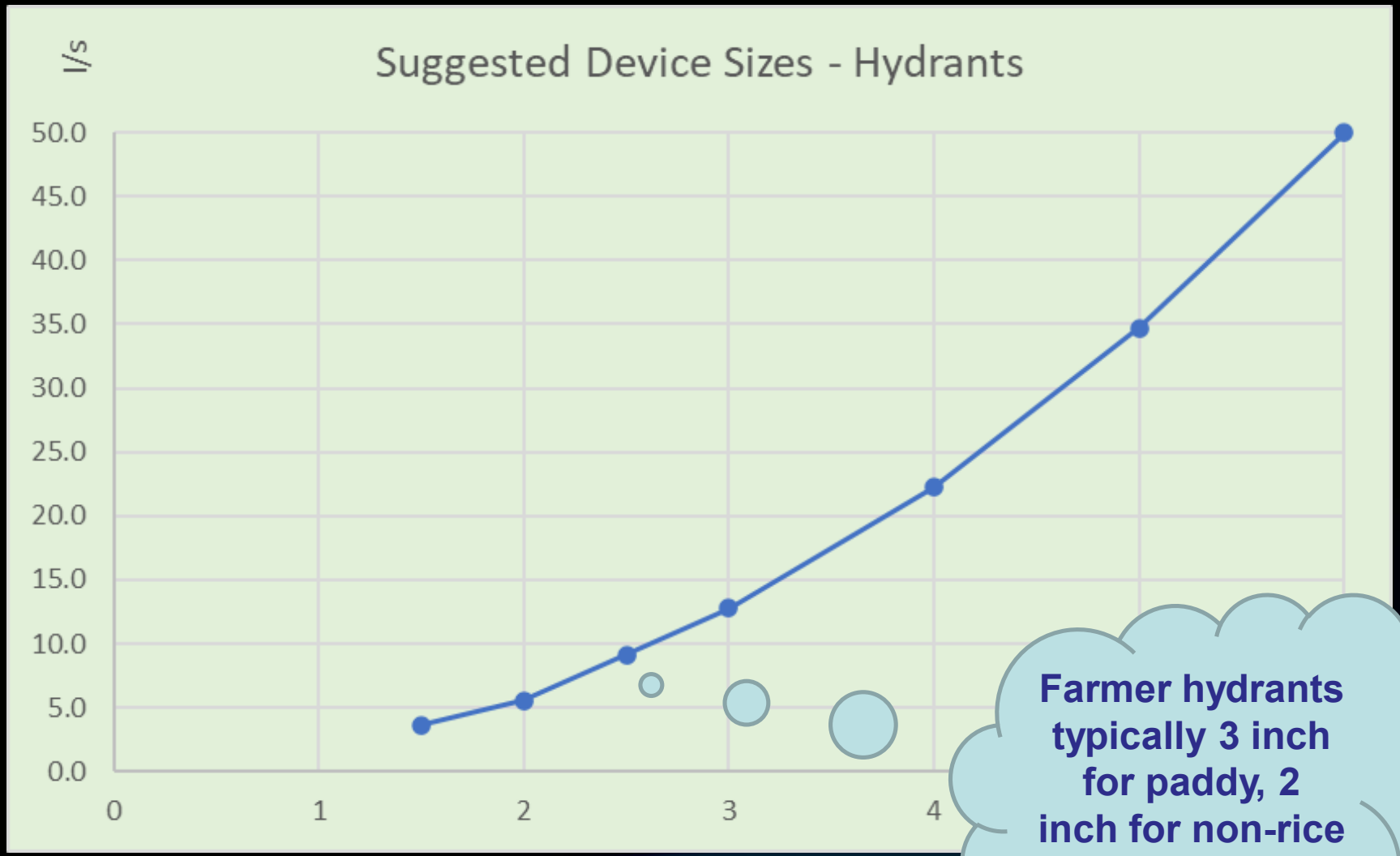
FAO 2002

Irrigator flows are usually 4-6 l/s for non-rice crops, and 8-15 l/s for paddy

Slope. %	Max. Furrow Stream Size, l/s	Average irrigation depth				
		Clay		Loam		
0.20	2.5	370	470	220	270	470
0.30	2.0	400	500	280	400	500
0.50	1.2	400	500	280	370	470
1.00	0.6	280	400	250	330	370
1.50	0.5	250	340	220	280	340
2.00	0.3	220	270	180	250	300

Surface irrigation systems and practices, M Kay

Irrigator flows and hydrant sizes



Farmer hydrants typically 3 inch for paddy, 2 inch for non-rice crops

nhc

water specialists

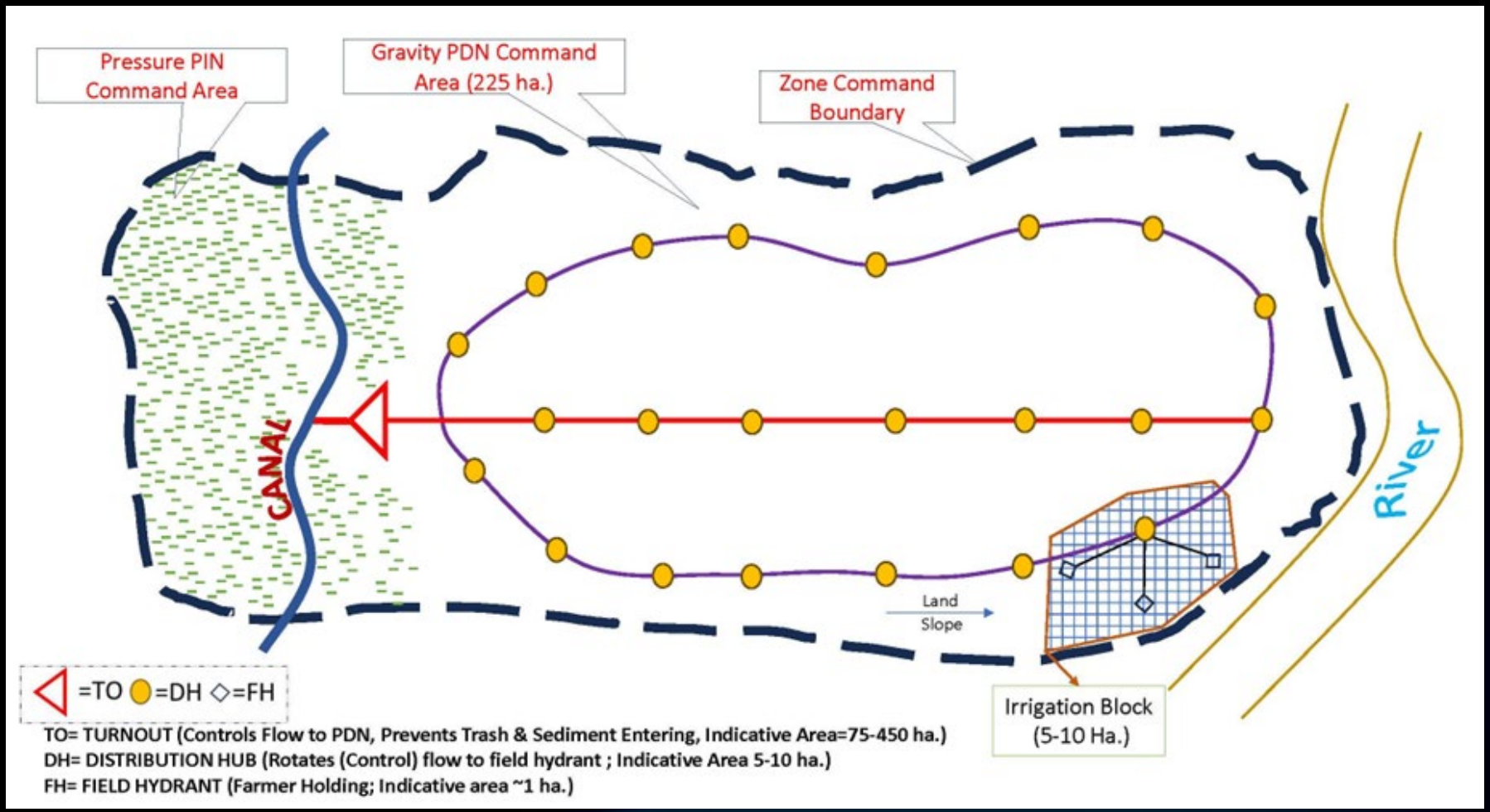
Layout Preparation

Typical Hierarchy for Pipe Distribution Systems

Hydraulic Unit	Structure	Indicative Areas, ha			
		2,000 – 8,000	250 – 3,000	75 – 500	50 – 225
		5-Tier	4-Tier	3-Tier	2-Tier
System Unit: Block	Head of a PDN System (Pumping station/ DC/ Turnout)	2,000 – 8,000	250 – 3,000	75 – 500	50 – 225
Primary Unit: Zone	Flow & Pressure Control Hubs	250 – 3,000	75 – 500	n/a	n/a
Secondary Unit: Sub-Zone		75 – 500	n/a	n/a	n/a
Tertiary Unit: Chak	Outlet (Distribution Hub)	20 – 40	20 – 40	20 – 40	5 - 10
Quaternary Unit: Sub-Chak*1	Hydrant (Single/ Cluster)	3 – 8 *1	3 – 8 *1	3 – 8 *1	n/a
Field Unit (average farmer holding)	Farm Hydrant	~1	~1	~1	~1

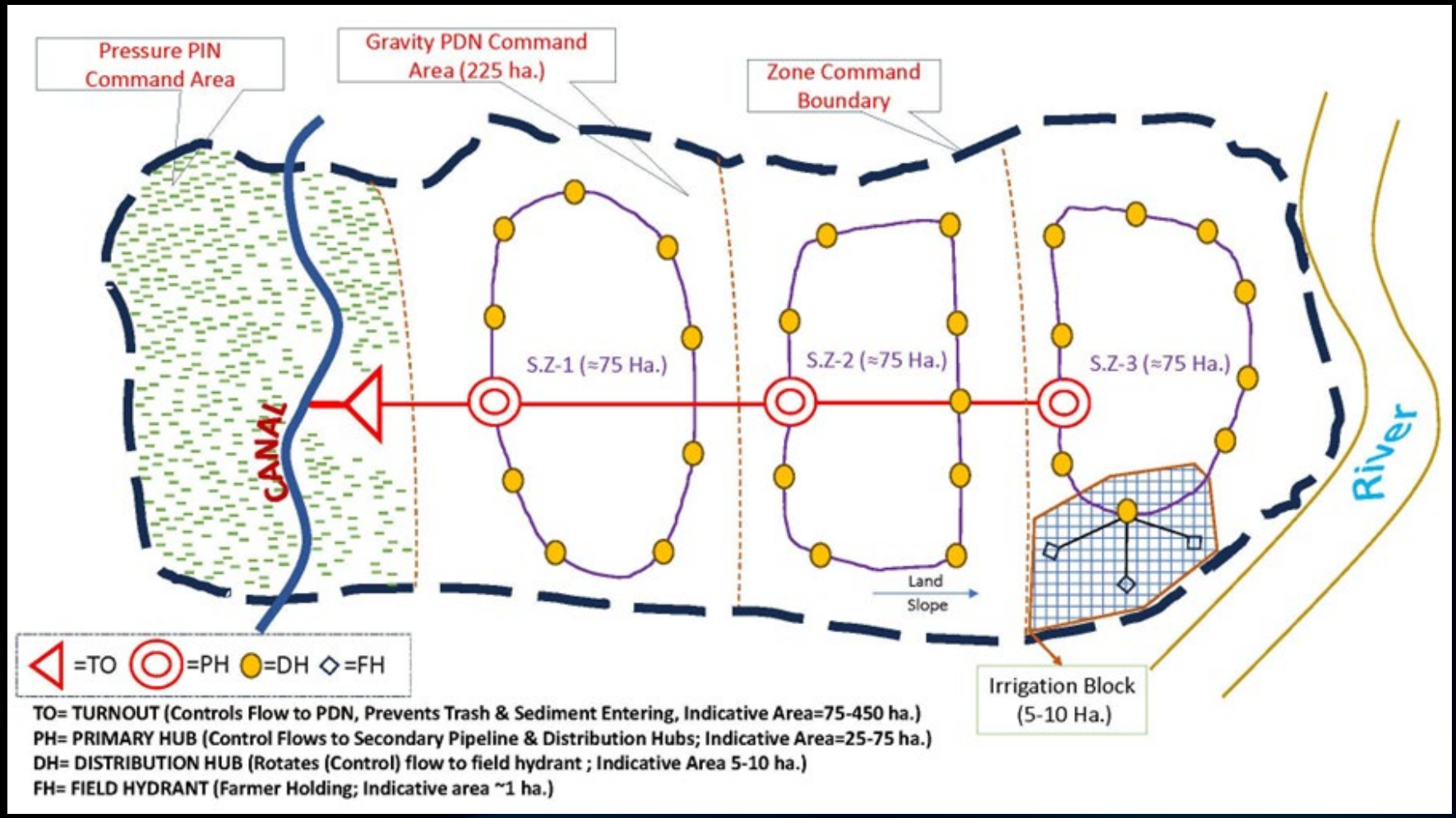
2-tier PDN system layout with water supplied from a Main Canal

- CCA of 230 ha
- Outlets (distribution hubs) command Chaks of 10 ha (2-tier layout)



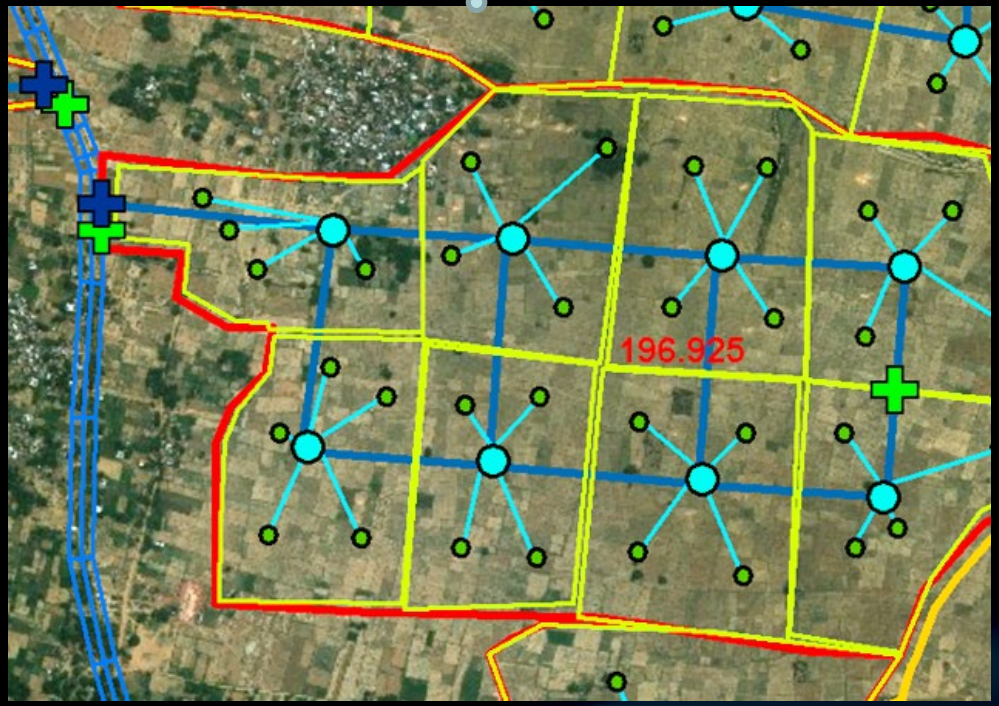
3-tier PDN system layout with water supplied from a Main Canal

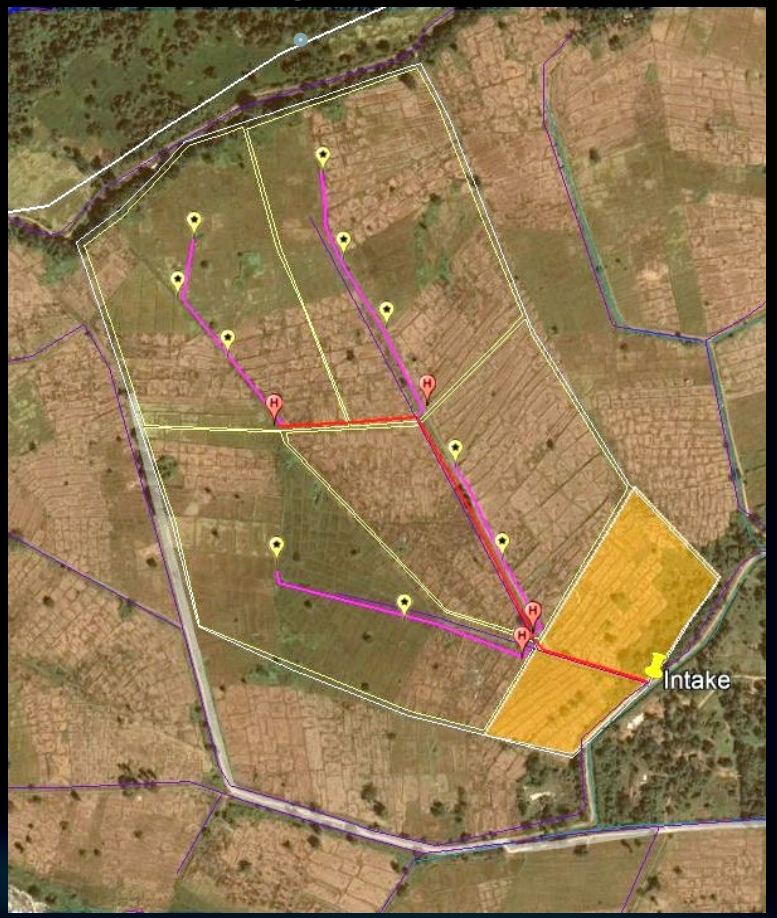
- CCA of 230 ha
- Outlets (distribution hubs) command Chaks of 7.5 ha (3-tier layout)

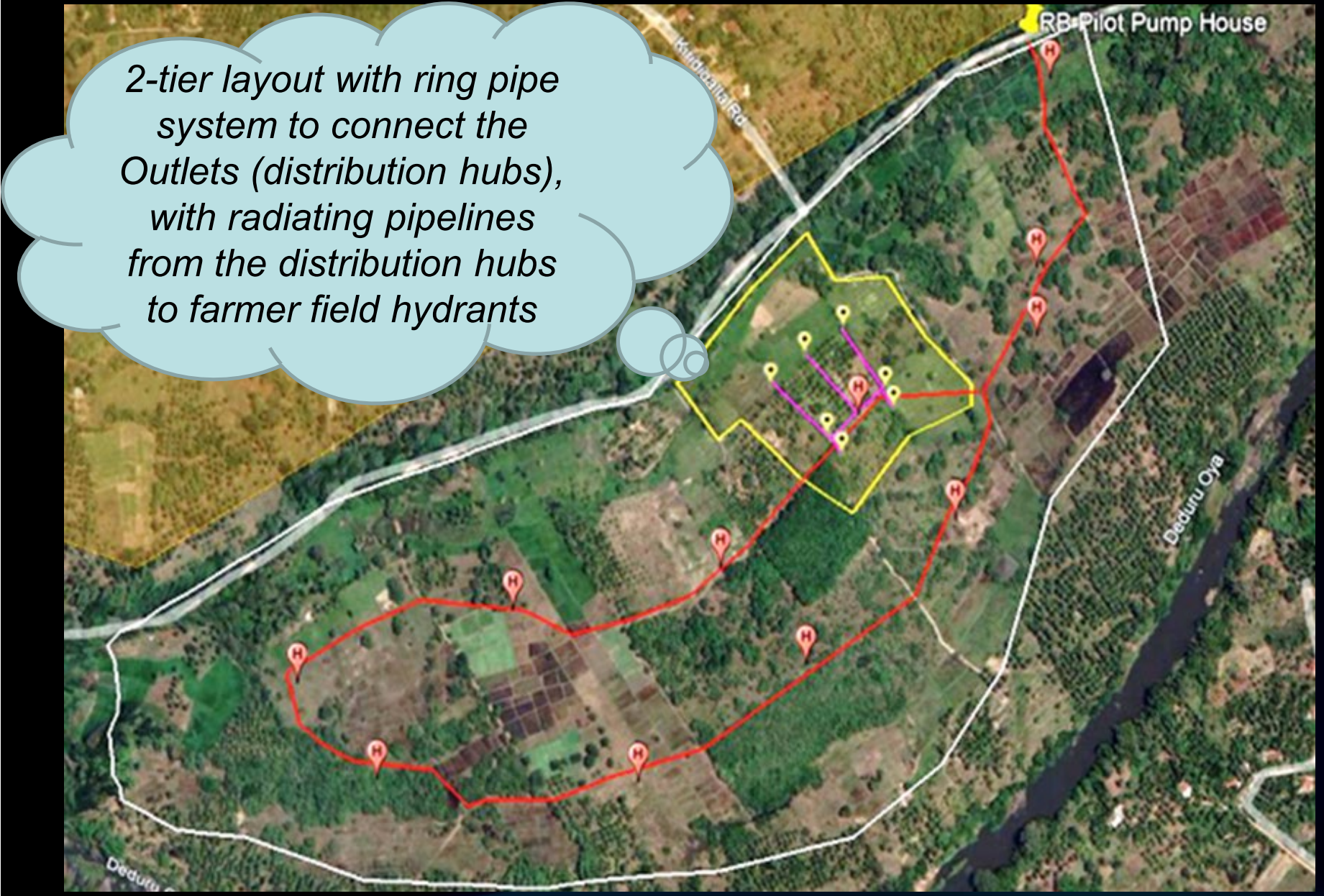


Simple branch layout with 2 tiers

Ring Layout with 3-tiers





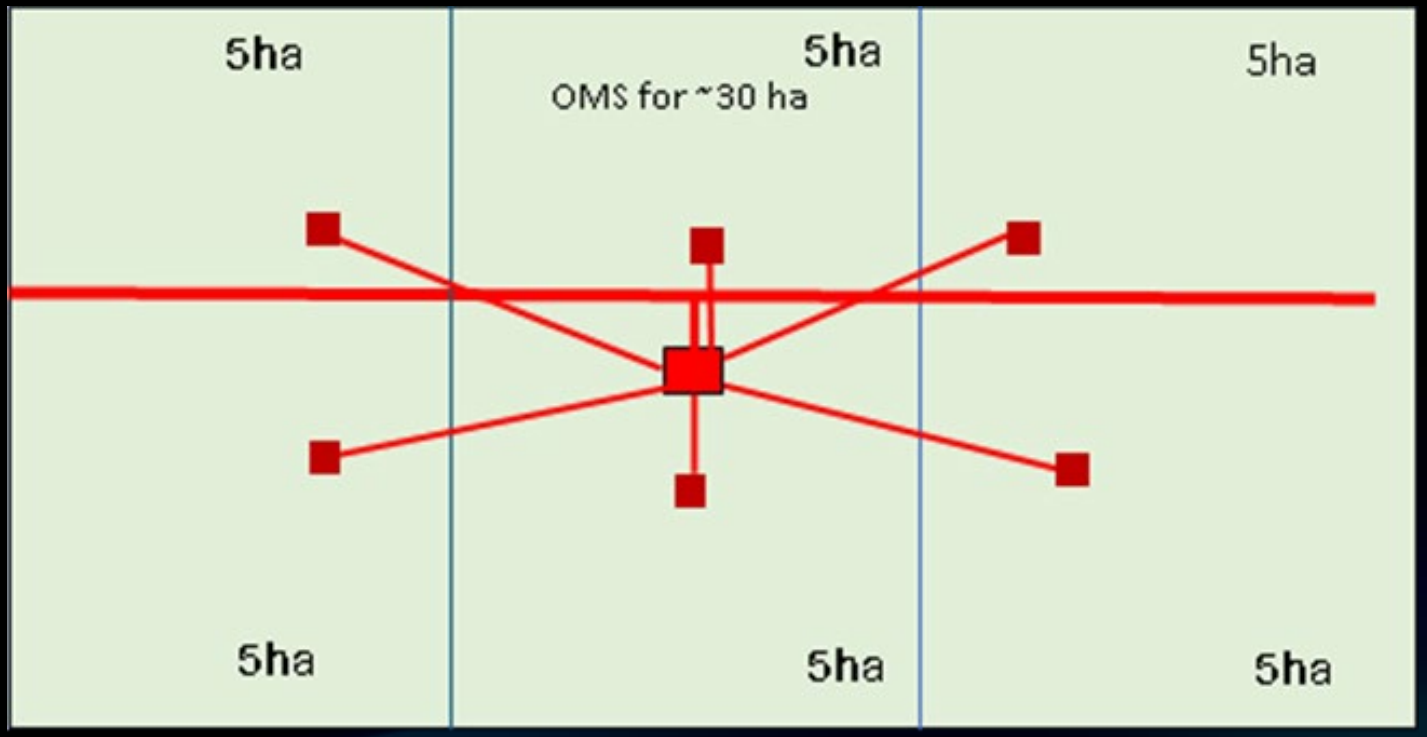

2-tier layout with ring pipe system to connect the Outlets (distribution hubs), with radiating pipelines from the distribution hubs to farmer field hydrants
RB Pilot Pump House
Kandegama Rd
Deduru Oya

Outlet Command Areas and Outlet Management Systems

- For small Chak areas, up to about 10 ha, then sub-chaks are not adopted, and the outlet management system, OMS, would only ensure that the flow rate is limited, and the pressure adequate. Managing flow rotations is not required. A manifold may be included as part of the outlet to which farmers can connect their hoses to convey water from the outlet to their fields.
- Larger Chak areas (~20-40 ha) should be divided into sub-chaks, and for these the OMS would need to control flows and pressures and flows to each of the sub-chaks. From the sub-chaks, farmers can connect their hoses to convey water to their fields.

Outlet Management System for 30 ha Chak

Outlet commands a 30-ha unit, which is divided into 5 ha subunits. For a design duty of 0.45 l/s, the Outlet flow is 13.5 l/s. This may be supplied to three of the manifolds in the subunits at a time, on a 50% on/ off rotation, giving irrigator flows of 4.5 l/s. Farmers connect to the subunit manifolds and manage rotations to their fields.



Scheme Flow, Outlet Flow and Number of Outlets

Scheme design flow = crop water requirement (l/s/ha) / efficiency x net command area (ha) x flexibility factor

Continuity Rule

Scheme design flow (l/s) = number of Outlets (distribution hubs) x Outlet Flow (l/s)

- For most pipe distribution systems, this continuity rule should be followed.
- For many schemes, the Outlet Flow = Irrigator Flow.
- If the Outlet flow is larger than the irrigator flow, then the outlet flow may be supplied to two or three sub-chaks at a time, as presented above.
- The irrigator flows are rotated to the farmers' fields from the Outlet, or from manifolds in each sub-chak.

Stepped Process:

- Step 1: Delineate command area, gross and net. Mark up key features (drainage lines, roads, etc)
- Step 2: Calculate the water requirement for the scheme (l/s)
- Step 3: Decide the appropriate irrigator flow (l/s)
- Step 4: Calculate the number of Outlets (Distribution Hubs) – the basic planning unit. From the Outlets the irrigator flow is supplied to farmers on rotation, either directly, or via manifolds at sub-chak level.
- Step 5: Decide on number of tiers to be adopted and delineate boundaries.
- Step 6: Decide on the pipeline layout to connect all the Outlets
  - Respect hydraulic tier boundaries
  - Branching and/ or loop pipe systems
  - Minimum cost

Spreadsheet to Calculate the Numbers of Field Units, Outlets, & Primary Hubs with Continuity of Flow

		Units	Quantity
	Scheme net irrigable area	ha	635
	Scheme design flow	l/s	434
1	No. of Farmer (field) Units or field hydrants		
	No of farmers in benefit area	No	530
	Average farmer land holding	ha	1.20
	Area commanded by one field hydrant	ha	1.20
	No of field hydrants	No	530
2	No. of Outlets/ Distribution Hubs		
	Irrigator flow	l/s	4.95
	No of Outlets		88.0
	Net area commanded by each Outlet	ha	7.2
	Number of farmers per Outlet	No	6.0
	Field Hydrants commanded by hub-hydrant	No	6.0
3	No. of Flow & Pressure Control Hubs (Subzones)		
	No of Subzones	No	7
	Net area commanded by each Subzone	ha	90.7
	No of Outlets in Subzone	No	12.9
	Number of farmers per Subzone	No	75.6
	Flow to each Subzone	l/s	62.1

For successful design need to understand what farmers want and need:

- What crops are to be grown?
- Current layout and standard of service?
- Current practices – basin, furrows, use of hoses, pumps, etc.
- Measure irrigator flows and discuss with farmers what flow suits them and the crops they will grow

Farmers must be properly consulted for design of pipe systems:

- **Location of field hydrants**
- **Irrigator flows (l/s)**

Pipe system designs should fit in with the farmers on-farm investments

Thank you