SMALL-SPACE IRRIGATION DESIGN MANUAL

A practical guide to planning raised-bed, gravity-fed, and low-pressure drip irrigation systems

Designed for:
Home and community gardens, urban farms, teaching gardens, and small-scale specialty-crop operations

Includes:
Site planning • System layouts • Basic calculations • Installation steps • Maintenance logs • Troubleshooting

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Educational resource | Version 1.0 | October 2026

Purpose: help growers choose, size, install, and maintain an efficient irrigation system for small growing spaces. Adapt the examples to local conditions and the actual flow and pressure of your water source.

How to Use This Manual

Use this guide from the planning stage through seasonal maintenance. Start by measuring the garden and checking the water source. Select a system that matches the layout, crop needs, available pressure, and time you can devote to maintenance.

- **Plan:** sketch beds, containers, paths, slope, water access, and drainage.
- **Choose:** select gravity-fed drip for suitable elevated tanks, or a pressure-regulated drip system for a municipal supply.
- **Size:** estimate water demand and confirm that the source can supply the system's required flow.
- **Install:** use a filter, appropriate tubing, connectors, and emitters; flush lines before final operation.
- **Test and maintain:** check every zone, monitor soil moisture, clean filters, and keep simple records.

Important safety and design note

This manual is an educational planning aid, not a site-specific engineering design. Water pressure, source capacity, local plumbing rules, backflow prevention, and water quality vary. Follow local code and manufacturer instructions. For potable municipal supplies, use an approved backflow-prevention arrangement as required by local authorities. Never connect an irrigation system to a drinking-water line in a way that could allow contaminated water to flow backward.

Contents

1. Understand the system • 2. Survey the site • 3. Estimate water needs • 4. Gravity-fed systems • 5. Low-pressure municipal drip • 6. Layout examples • 7. Installation • 8. Scheduling and water management • 9. Maintenance and troubleshooting • 10. Worksheets and logs • 11. Glossary and references

1. Understand the System

Drip irrigation delivers water slowly near plant roots. When designed and maintained correctly, it can reduce evaporation and keep foliage drier than overhead watering. Small systems commonly use a water source, shutoff valve, filter, pressure control where needed, mainline tubing, distribution tubing, emitters or dripline, end caps or flush valves, and optional timers.

Component	Purpose	Design check
Water source	Supplies water to the system.	Confirm reliable flow, water quality, and access.
Shutoff valve	Allows isolation for repair or seasonal shutdown.	Place where it is easy to reach.
Filter	Captures particles that can clog emitters.	Match filter type and mesh to emitter maker's guidance.
Pressure regulator	Reduces supply pressure to the system's operating range.	Use when source pressure exceeds the tubing/emitter rating.
Mainline	Carries water from source to beds or zones.	Size for total flow and run length.
Dripline / emitters	Deliver measured water near roots.	Choose emitter flow and spacing for crops and soil.
Flush end / end cap	Allows debris to be flushed from tubing.	Make ends accessible for routine flushing.

Common small-space approaches

Gravity-fed: water flows from an elevated tank. Available pressure is limited by the vertical height between the water surface and the emitter. Use only emitters and filters designed to work at the available pressure, and test the system before relying on it.

Low-pressure municipal drip: household or site water is reduced to the pressure required by the selected drip components. Use compatible pressure control, filtration, and approved backflow protection. Municipal supply pressure is not automatically suitable for drip tubing.

Container or raised-bed watering: short drip lines, microtubing, or carefully placed emitters serve individual containers or beds. Check each container separately because potting mix and plant size can change water needs.

2. Survey the Site Before Buying

A simple sketch and a few measurements can prevent overspending and uneven watering. Draw the garden to scale if possible, then mark each bed, row, container group, path, slope, water source, and drain or low point.

Site survey checklist

- Measure each bed's length and width; note row direction and plant spacing.
- Record the distance from the water source to the farthest bed.
- Note elevation changes. Gravity-fed systems are especially sensitive to height.
- Identify full-sun, shaded, windy, and rain-exposed areas.
- Check soil texture and drainage. Sandy soils often need shorter, more frequent watering; clay soils may need slower application and soak-in time.
- Confirm the water source can be used for irrigation and has sufficient flow.
- Plan access to valves, filters, connectors, and line ends for cleaning.

Zone by similar water needs

Group plants with similar rooting depth, water demand, and sun exposure on the same valve or zone. For example, a leafy-greens bed may need a different schedule from established fruiting crops or containers. Separate zones also make it easier to control flow and diagnose problems.

Quick planning worksheet

Item	Record
Garden / project name	_____
Water source and connection	_____
Bed dimensions and number of beds	_____
Longest tubing run	_____
Approximate elevation difference	_____
Crop groups / zones	_____
Soil type and drainage observations	_____
Local restrictions or backflow requirements	_____

3. Estimate Water Needs and System Flow

Water demand changes with crop, growth stage, weather, soil, mulch, and rainfall. Use local Extension guidance as a starting point, then adjust using soil-moisture checks and plant response. Avoid using a single fixed schedule for every garden.

Useful calculations

Bed area: length × width. A bed 4 ft × 8 ft has an area of 32 square feet.

Approximate gallons applied: gallons per hour (GPH) × runtime in hours. If a zone delivers 12 GPH for 30 minutes, it applies about 6 gallons.

Total zone flow: add the rated flow of all emitters operating at the same time. Example: 20 emitters rated at 0.5 GPH each require about 10 GPH total, before accounting for pressure variation and product tolerances.

Pressure from elevation: gravity provides approximately 0.433 psi for each vertical foot of water head. A water surface 5 ft above the emitter provides only about 2.2 psi before losses through filters, valves, and tubing. This may be too little for many standard drip components.

Example: a small raised-bed setup

Design item	Example value	What it means
Beds	Two beds, each 4 × 8 ft	64 sq ft total growing area.
Drip lines	Two lines per bed, 8 ft each	Four lines; 32 ft of dripline total.
Emitter specification	0.5 GPH emitters at 12-inch spacing	Confirm product's rated pressure and spacing.
Approximate emitters	About 32 across 32 ft of line	Actual count depends on product and end layout.
Approximate flow	32 × 0.5 = 16 GPH	Run as one zone only if source and components can supply it.

The example is for illustrating arithmetic, not a universal recommendation. Verify the manufacturer's flow rating, spacing, operating pressure, maximum run length, and filtration requirements before purchasing.

4. Gravity-Fed Irrigation for Raised Beds

Gravity-fed irrigation can work where a clean water tank can be safely elevated and the selected components operate at very low pressure. Because pressure is limited, keep the layout simple, use short runs, and test the output at the far end of every line.

Basic arrangement

Elevated, secured tank → shutoff valve → compatible filter → mainline → bed valve(s) → low-pressure dripline or emitter tubing → flushable ends.

Design and installation considerations

- Use a stable, load-rated platform. Water weighs about 8.34 pounds per US gallon, so a 20-gallon tank holds roughly 167 pounds of water, plus the tank and platform.
- Secure the tank against tipping, wind, and accidental impact. Do not elevate a heavy tank on an improvised or unstable stand.
- Calculate pressure from the vertical distance between the water surface and the emitters—not just the platform height.
- Choose low-pressure emitters or dripline with a documented minimum operating pressure compatible with the available head.
- Use a filter that works at low flow and does not consume too much of the limited pressure. Clean it often.
- Keep tubing runs short and use a simple manifold if several beds are supplied.
- Test output into a measuring cup at the beginning and end of each line; compare results and adjust the design if flow is uneven.

Gravity-fed system limitations

A standard pressure-compensating emitter may not function correctly at very low head. A clogged filter, narrow tubing, elevation differences, or long runs can sharply reduce delivery. If output is inconsistent, use a system designed for low pressure, shorten the runs, increase available head only with a safe structure, or consider a properly regulated pressurized supply.

5. Low-Pressure Municipal Drip for Small Gardens

Municipal water often provides more pressure than drip components require. A suitable system typically uses approved backflow protection, a shutoff, filtration, and a pressure regulator matched to the irrigation products. Follow local plumbing requirements and the component manufacturer's installation order.

Typical arrangement

Approved backflow-prevention device (as required) → shutoff → filter → pressure regulator → mainline → zone valve or manifold → dripline / emitters.

Design checklist

- Check the water source's available flow and pressure; do not assume a hose bib's pressure stays constant under flow.
- Select tubing and emitters with compatible pressure ratings and flow requirements.
- Use the filter type and rating specified by the dripline or emitter manufacturer.
- Use a regulator sized for the expected flow. An undersized regulator can restrict flow; an oversized or incompatible regulator may not regulate accurately.
- Keep each zone's total flow within the source and product limits.
- Use outdoor-rated, UV-resistant tubing and secure fittings to reduce leaks.
- If using a timer, choose one compatible with the source pressure and required flow; test its shutoff and battery operation.

Water source protection

Irrigation water can contact soil, compost, animals, tools, and produce. Prevent backflow into potable water supplies and keep connections protected from contamination. For food-producing operations, follow applicable produce-safety requirements and use water-quality practices appropriate to the water source and intended use.

6. Layout Examples

Example A — Two raised beds

Place a mainline along the short end of two adjacent beds. Install a small manifold with a separate valve for each bed. Run two or more drip lines lengthwise in each bed, depending on crop spacing and soil. Cap or install flush ends so lines can be cleaned.

Source	Manifold	Bed 1	Bed 2
Water + filter	Valve A →	2 drip lines	2 drip lines
	Valve B →	separate control	separate control

Example B — Container garden

Run a small mainline along the container row. Use microtubing to deliver water to each pot, or group containers of similar size and crop type on a common branch. Secure emitters so water reaches the growing medium rather than the pavement. Check each pot because root volume and drying rates vary.

Example C — Narrow teaching garden

Divide the garden into zones that can be operated one at a time. Keep valves labeled and place the filter where learners can safely observe and clean it. Use the layout as a teaching tool to demonstrate water measurement, maintenance, and conservation.

Illustrative not-to-scale schematic

Water source	Filter / regulator	Mainline	Zone valve	Drip lines
Tank or tap	Protect + control	Along bed edge	One per zone	Near plant roots

Keep the design accessible: label the shutoff, make filter and flush ends reachable, and avoid placing connections where they will be crushed by foot traffic or tools.

7. Installation: Step by Step

1. **Lay out the system.** Mark tubing routes, valves, and line ends before cutting. Keep lines away from sharp edges and heavy traffic.
2. **Install source controls.** Fit the required backflow protection for a municipal connection, then the shutoff and other components in the order recommended by the manufacturer.
3. **Install filtration and pressure control.** Confirm flow direction arrows and ensure components are accessible for cleaning.
4. **Run the mainline.** Cut tubing squarely, push fittings fully into place, and secure the line without kinking it.
5. **Connect dripline or emitters.** Keep emitter spacing and line placement appropriate for crop rows and soil conditions.
6. **Flush before closing ends.** Briefly run water through open line ends to remove dirt and plastic shavings; then close ends using flush valves or end caps.
7. **Test each zone.** Operate one zone at a time. Check for leaks, blocked emitters, weak far-end flow, and pooling.
8. **Measure output.** Collect water from representative emitters for a fixed time and compare outputs. Correct obvious differences before setting a schedule.
9. **Document the design.** Record tubing lengths, emitter type, filter and regulator specifications, zone flow, and the date installed.

Commissioning checklist

Check	Pass / action
Backflow protection and connection comply with local requirements	■ Pass ■ Fix
Filter installed in correct direction and cleaned	■ Pass ■ Fix
Pressure regulator matches system components (if used)	■ Pass ■ Fix
No leaks or kinked tubing	■ Pass ■ Fix
All zones wet evenly; far-end flow checked	■ Pass ■ Fix
Line ends can be flushed and valves are labeled	■ Pass ■ Fix
Initial runtime and soil-moisture observations recorded	■ Pass ■ Fix

8. Scheduling and Water Management

Irrigation runtime is a starting point—not a substitute for checking the soil. Water slowly enough for the soil to absorb it, and avoid repeated watering that keeps roots saturated. A finger check, soil probe, or tensiometer can help determine whether water is reaching the active root zone.

A practical scheduling routine

- Check soil moisture before watering, especially after rainfall.
- Water early in the day when practical, and adjust for heat, wind, crop stage, and soil.
- After a run, check moisture several inches below the surface near the root zone—not only at the surface.
- If water runs off, puddles, or drains out of containers quickly, shorten the cycle or split it into shorter runs with soak time.
- If plants wilt despite wet soil, investigate root health, drainage, heat stress, disease, or clogged emitters rather than simply adding more water.
- Use mulch where appropriate to reduce evaporation, while keeping stems and crowns clear.

Runtime calculation example

If a zone's measured delivery is 8 gallons per hour and you want to apply about 4 gallons, a simple estimate is 4 ÷ 8 = 0.5 hour (30 minutes). This only estimates water delivered; verify how much enters the root zone and adjust for rainfall, runoff, and soil conditions.

Avoid overgeneralizing

There is no single correct number of minutes for all gardens. A short run on sandy soil may be appropriate where a long run would cause leaching; heavier soil may require slower application and soak periods. Use local Cooperative Extension recommendations for your crops and region.

9. Maintenance and Troubleshooting

Symptom	Possible causes	Recommended action
Some emitters are dry	Clogged emitter, debris, kinked tubing, closed valve.	Check valve; flush line; clean filter; inspect tubing and emitter.
Far end has weak flow	Long run, low pressure, excessive zone flow, elevation loss.	Shorten/split zone; verify pressure and product limits; reduce restrictions.
Puddles or runoff	Runtime too long, compacted soil, poor placement, leak.	Check for leaks; reduce cycle length; add soak intervals; improve placement.
Plants wilt while soil is wet	Poor drainage, root damage, heat stress, disease.	Check root zone and drainage; do not automatically increase irrigation.
Filter clogs frequently	Dirty source water, algae, sediment, inadequate filtration.	Clean per instructions; inspect source; choose compatible filtration.
Fittings leak	Loose or mismatched fittings, damaged tubing, excessive pressure.	Shut off water; replace damaged parts; verify pressure rating.
Gravity system output changes	Tank level changes, insufficient head, clogged filter.	Test at different tank levels; clean filter; simplify layout or redesign.

Routine maintenance schedule

Frequency	Task
Before each watering / weekly	Look for leaks, disconnected tubing, pooling, and dry spots.
Weekly during active use	Check filter condition and soil moisture; verify timer and valves.
Monthly or as needed	Flush line ends; inspect emitters and fittings; record repairs.
After repairs or layout changes	Run each zone and confirm uniform output.
End of season / freeze risk	Drain and store components as directed; protect timers and fittings from freezing.

10. Worksheets and Logs

Copy or print these pages for each garden or zone. Records help growers identify changes in water use, spot recurring clogs, and make informed adjustments.

A. Irrigation system inventory

Field	Record
Garden / zone name	_____
Water source	_____
Filter type / specification	_____
Regulator / pressure rating (if applicable)	_____
Tubing type and lengths	_____
Emitter type, spacing, and rated flow	_____
Estimated / measured zone flow	_____
Installation date and installer	_____

B. Irrigation monitoring log

Date	Zone	Runtime	Rain / weather	Soil moisture / plant observations	Action taken
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

C. Maintenance and repair log

Date	Issue / inspection	Repair or action	Parts used / follow-up
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

11. Glossary and Further Guidance

Term	Plain-language definition
Backflow prevention	A device or arrangement required to protect a potable water supply from reverse flow.
Dripline	Tubing with built-in water outlets that apply water slowly along a row.
Emitter	A small outlet that releases water at a rated flow under specified pressure.
Flow rate	The volume of water delivered over time, commonly gallons per hour (GPH).
Head / water head	The height of water above an outlet; height creates pressure in a gravity-fed system.
Mainline	The larger supply tubing that feeds branches or irrigation zones.
Pressure regulator	A component that reduces and controls downstream water pressure.
Zone	A section of the system operated together by one valve or control.

Recommended sources to consult

- Your local Cooperative Extension office for crop-specific irrigation scheduling, soil testing, and regional guidance.
- Manufacturer instructions for dripline, emitters, filters, regulators, timers, and fittings.
- Local water utility and plumbing authority for backflow prevention and connection requirements.
- USDA Natural Resources Conservation Service (NRCS) for conservation planning and irrigation-related technical resources.

Before finalizing a system

Confirm the source's actual flow and pressure; verify all components are compatible; follow local codes; test every zone; and keep records. When system performance is inconsistent, diagnose the cause before increasing watering time.

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Educational use. Product specifications, local requirements, and site conditions vary. This manual does not replace manufacturer instructions, local code, or professional advice for complex systems.