PLUMBING
DRAINS

The drain-waste-vent (DWV) system is the first plumbing to be installed in a house. It includes the sewer lines, building drain lines, fixture traps and plumbing vents.

DRAIN AND SEWER MATERIALS

Aboveground: Codes vary on the type of materials allowed for aboveground drain lines. The most commonly accepted materials include ABS, PVC, cast iron, and copper.

For best results, always use cast iron for drain lines that run through a living space. To save money, switch back to ABS or PVC under the house, but only cast iron will provide silent drains in the living space.

Belowground: Most building sewers and drain lines below grade are made of ABS and PVC. While both types of pipe must be cleaned before joining, ABS pipe is much more forgiving to work with in substandard conditions.

SIZING DRAINS

The smallest drainpipe allowed for underground use is 2 in., and the smallest building sewer allowed is 3 in. in diameter.

Minimum drain sizes for individual fixtures are shown in **Figure A**. Best practice calls for upsizing these minimums.

FIGURE A: MINIMUM TRAP/DRAIN SIZES FOR VARIOUS FIXTURES

Type of Fixture	Min. Trap Size (in.)
Bathtub	1½
Shower	2
Residential toilet	Integral
Lavatory	1¼
Bidet	1¼
Washing Machine	2
Laundry tub	1½
Floor drain	2
Kitchen sink	1½
Dishwasher	1½

While this table shows the minimum drain size required for each type of fixture, most custom plumbers recommend upsizing drains to prevent problems.

SIZING BRANCH LINES AND HOUSE MAINS

For branch lines, drain stacks, and building sewers, the sizing is based on *drainage fixture units* (dfu), which are different from fixture-unit values for supply piping (**Figure B**). One dfu equals one cubic foot of water per minute. Each fixture is rated for a specified dfu, which determines the trap size and the size of the drain following from it (**Figure C**).

FIGURE B: DRAINAGE FIXTURE UNIT (DFU) VALUES FOR VARIOUS FIXTURES TYPE OF FIXTURE OR GROUP OF FIXTURES

Type of Fixture or Group of Fixtures	Drainage Fixture Unit Value (dfu)
Clothes washer standpipe	2
Bathroom group	6
Bathtub	2
Bidet	2
Dishwasher	2
Floor drain	2
Kitchen sink	2
Laundry tray	2
Lavatory	1
Mop basin	2
Shower	2
Toilet	4

Drain sizes must never be reduced in diameter, though they often are enlarged as branch lines accommodate more and more fixtures.

Combined drains from several fixtures are sized based on the total dfu minus a factor based on the low probability that all the fixtures will discharge at the same time (**Figure C**).

FIGURE C: DRAIN SIZES BASED ON DRAINAGE FIXTURE UNIT (DFU)

Diameter of Pipe (in.)	1 1/2	2	2 1/2	3	4
Max. DFU for house main and sewer (¼ in./ft.)	3	21	24	42	216
Max. DFU for horizontal fixture branches (¼ in./ft.)	3	6	12	20	160
Max. DFU for 1-story stacks	2	6	9	20	90
Max. DFU for 2-story stacks	4	10	20	48	240

The minimum size of any building drain serving a toilet must be 3 in. All horizontal drains are typically installed at a slope of ¼ in. per ft., though code does allow drains from 3 to 6 in. in diameter to be installed at a slope of ⅛ in. per ft.

GROUNDWORK

Underground drainpipes must be adequately supported. The bottom of the trench should be backfilled with 4 in. of 1/4-in. fines to continuously and uniformly support the drain line.

Trenching

Sewer lines should be below the frostline.

Sewer lines must be at least 12 in. below water lines that run in the same trench (some codes permit 10 in.). Sewer lines and water lines running at the same depth must be laid in separate trenches spaced at least 5 ft. apart.

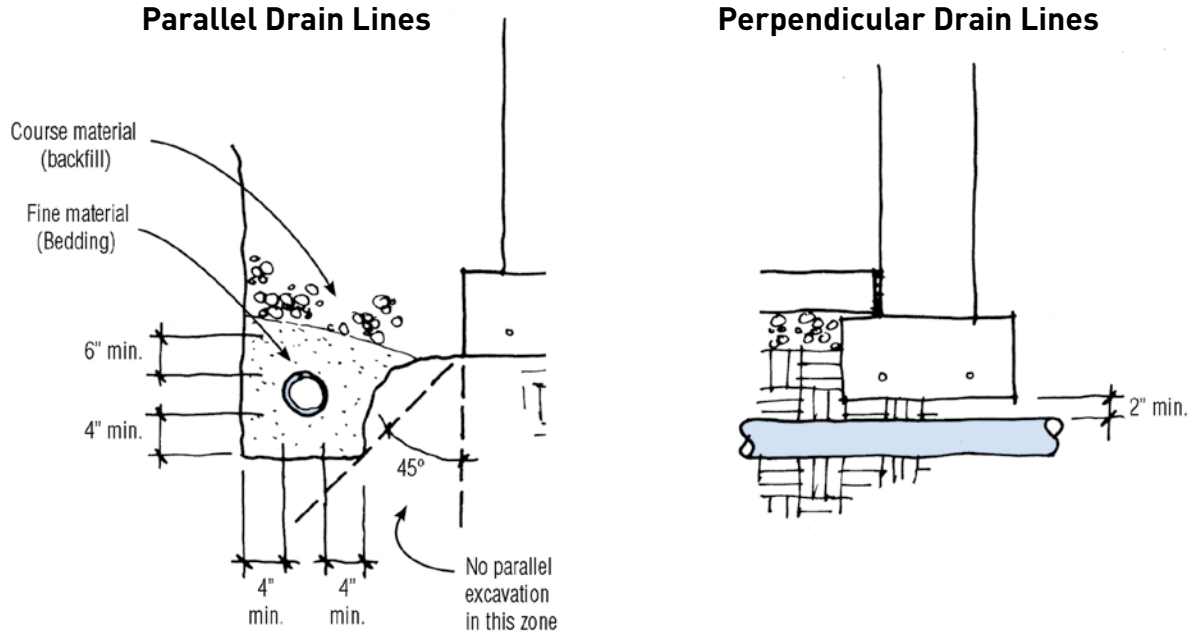
Excavations near footings. Drain lines running parallel to a foundation footing must not fall within a 45-degree angle outside the footing (**Figure D**).

Drain lines running perpendicular to the footing should pass a minimum of 2 in. below the footing. Do not bring the drain line through the footing.

A drain line may pass through the foundation, but it must be sleeved with a pipe at least two sizes larger than it.

Backfill. Backfill with 1/4-in. fines (some codes allow 3/4-in. material) at least 6 in. above the drain lines.

FIGURE D: DRAIN LINES NEAR FOOTING



Any drainpipe trench parallel to the footing must not fall within the zone of a 45-degree angle from the base of the footing (at left).

All plastic piping below grade must be well supported by a continuous bed of fine sand 1/4 to 3/4-inch screen, depending on code). This material should extend at least 4 in. on each side of and below the pipe, and 6 in. above the pipe.

Drainpipes passing below the footer (perpendicularly) must have clearance of at least 2 in. between the top of the pipe and bottom of footing (at right).

DRAIN SLOPE AND ORIENTATION

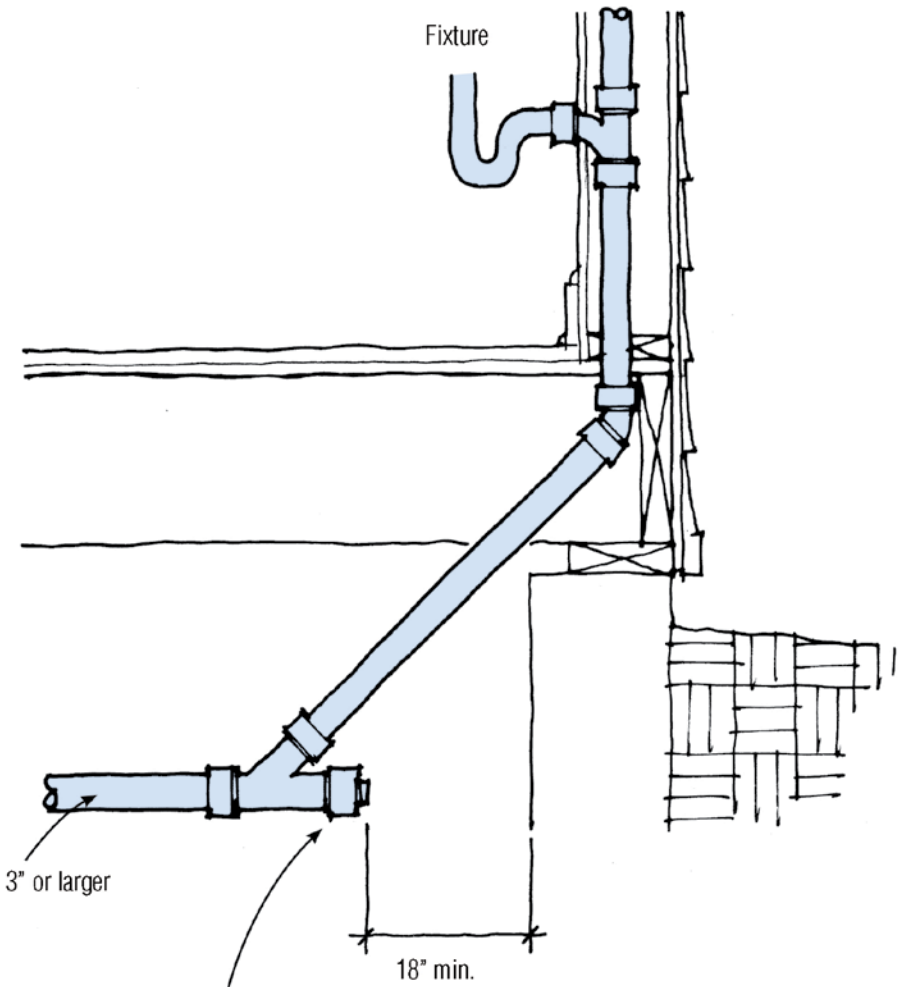
Horizontal drains should have a 2% slope, equivalent to 1/4-in. drop per foot of length. This allows the contents to develop a velocity (approximately 2 ft. per second) that is fast enough that things won't bog down and slow enough that the water flows ahead of solid and semi-solid wastes.

Vertical drains should be plumb to allow the water and waste to fall as a unit (called a *slug*). On a horizontal run that drops to vertical, the turn can be abrupt. But vertical drops that turn to horizontal and turns on horizontal runs should have room to make a wide *sweep* and a *cleanout*, if practical.

CLEANOUTS

- Cleanoutsare generally required wherever drain lines change direction more than 45 degrees.
- Cleanouts are typically the same size as the drain lines they serve.
- Each cleanout must be installed with the flow of the drain so that a snake inserted into it will also go with the flow.
- Horizontal drains that are 4 in. in diameter or less must be equipped with cleanouts at least every 40 ft. For drains over 4 in. in diameter, cleanouts may be spaced every 100 ft., but they should not exceed the length of a typical 75-ft. sewer cable.
- All cleanouts must be accessible. They can't be buried in the wall and must have clear space in front of them — at least 12 in. for drain lines less than 3 in. in diameter, and at least 18 in. for drains 3 in. and larger (**Figure E**).
- A cleanout is typically required within 4 ft. of the base of any vertical stack.

FIGURE E: CLEANOUT CLEARANCE



A cleanout must have clearance in front of it. Most codes require a minimum of 12 in. for drain lines smaller than 3 in., and 18 in. of clearance for drains 3 in. and larger.

Vent Cleanout

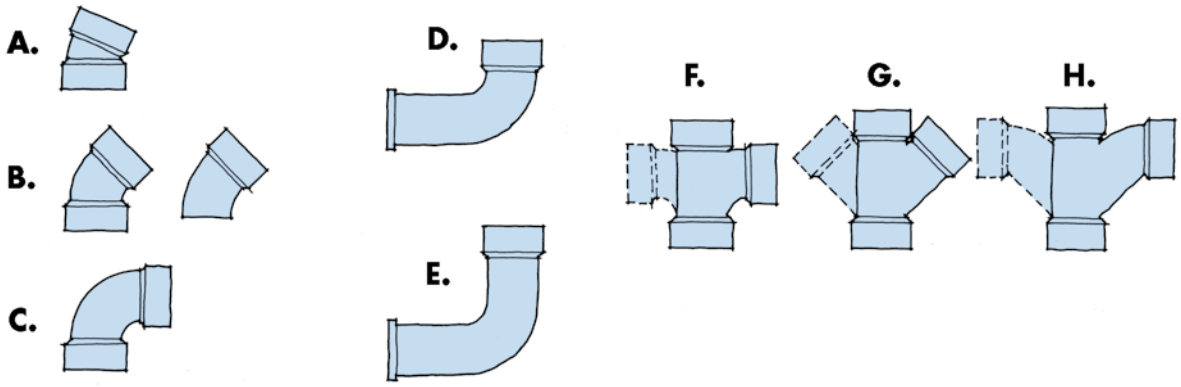
In a pinch, a vent stack may serve as a cleanout — if it meets local code and the following requirements:

- The vent stack is completely vertical, with no offsets.
- The vent stack is the same diameter as the drain line it serves.
- The drain line below the vent does not have more than one 90-degree turn.
- A 4-in. vent may not reduce to less than 3 in.; a 3-in. vent may not reduce to less than 2 in.

DRAINPIPE FITTINGS

Most plumbing codes are specific about which type of fitting can be used on drain lines to change direction. The guidelines shown in **Figure F**, are typical of what most codes allow. Note the limitations on quarter bends, short sweeps, and sanitary tees.

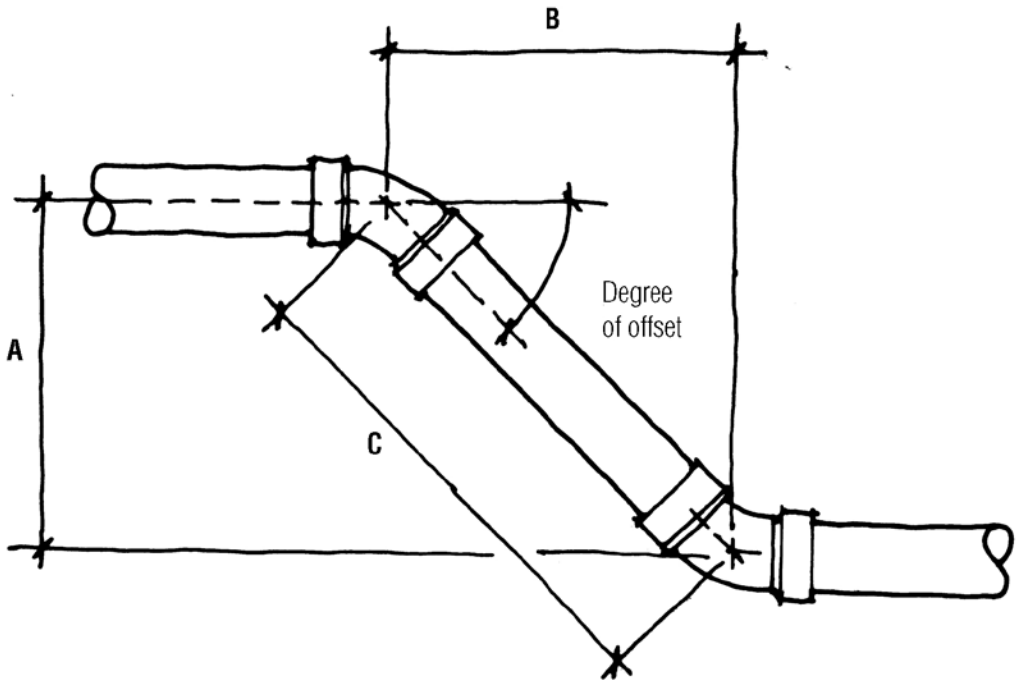
FIGURE F: FITTINGS FOR CHANGE OF DRAINPIPE DIRECTION



Type of Fitting	Horizontal to Vertical	Vertical to Horizontal	Horizontal to Horizontal
A. 1/16 bend (22 1/2 degrees)	OK	OK	OK
B. 1/8 bend (45 degrees)	OK	OK	OK
C. 1/4 bend (90 degrees)	OK	OK	OK
D. Short sweep	OK	OK	OK
E. Long sweep	OK	OK	OK
F. Sanitary tee	OK	NO	NO
G. Wye	OK	OK	OK
H. Combination wye and 1/8 bend	OK	OK	OK

Parallel offsets. Allow plenty of room for an offset between parallel pipe runs. **Figure G** shows a method of calculating offset distances and the length of pipe required between common offset fittings.

FIGURE G: CALCULATING PARALLEL OFFSETS



Degree of Offset	When A=1, B=	When B=1, A=	When A=1, C=
60	0.573	1.732	1.155
45	1.000	1.000	1.414
30	1.732	0.577	2.000
22½	2.414	0.414.	2.613

When the distance A or B is known, multiply this distance by the appropriate factor in the table to find the length of the other legs in an offset. Since the derived length is measured to the center of the fitting, the actual pipe length will need to be shortened.

DRAINPIPE INSTALLATION

Rough-in drain requirements for individual fixtures can be found in Kitchen Rough-In.

Supporting Pipe

Spacing for pipe supports depends on the material used (**Figure H**).

FIGURE H: DRAINPIPE SUPPORT

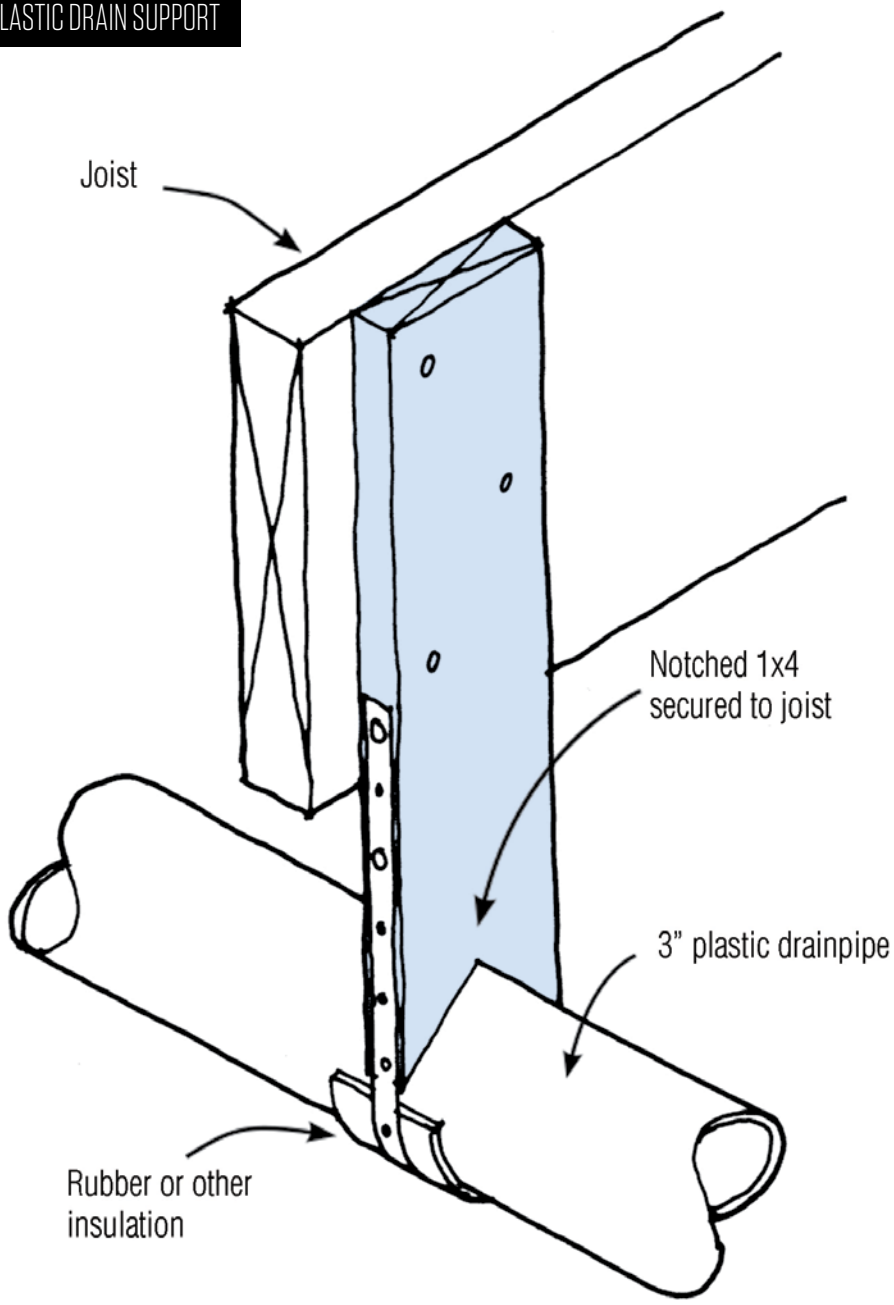
Drain Lines	Max. Horizontal Spacing	Max. Vertical Spacing
ABS and PVC	4 ft.	10 ft.
Cast iron	5 ft.	15 ft.
Copper or copper alloy (1½ in. and larger)	8 ft.	10 ft.

Copper pipe must be supported with hangers that do not promote galvanic action, which will cause corrosion. Do not use copper strapping to support cast-iron drain lines.

Support materials.
Wire or metal plumber's tape is not recommended for pipe support, and may be restricted by code for plastic drain lines.

When hanging pipe, best practice calls for using a solid material, such as notched 1-by or approved pipe hangers from a plumbing supply house (**Figure I**). Solid hangers resist upward thrust and vibration, thereby providing more secure support, while also helping to quiet drain lines. Wrap the pipe with insulation at each pipe support to further dampen vibration.

FIGURE I: PLASTIC DRAIN SUPPORT



A flexible support, such as wire, should not be used to support plastic drain lines. Instead, use a notched 1-by wrapped with rubber or other insulation, as shown here.

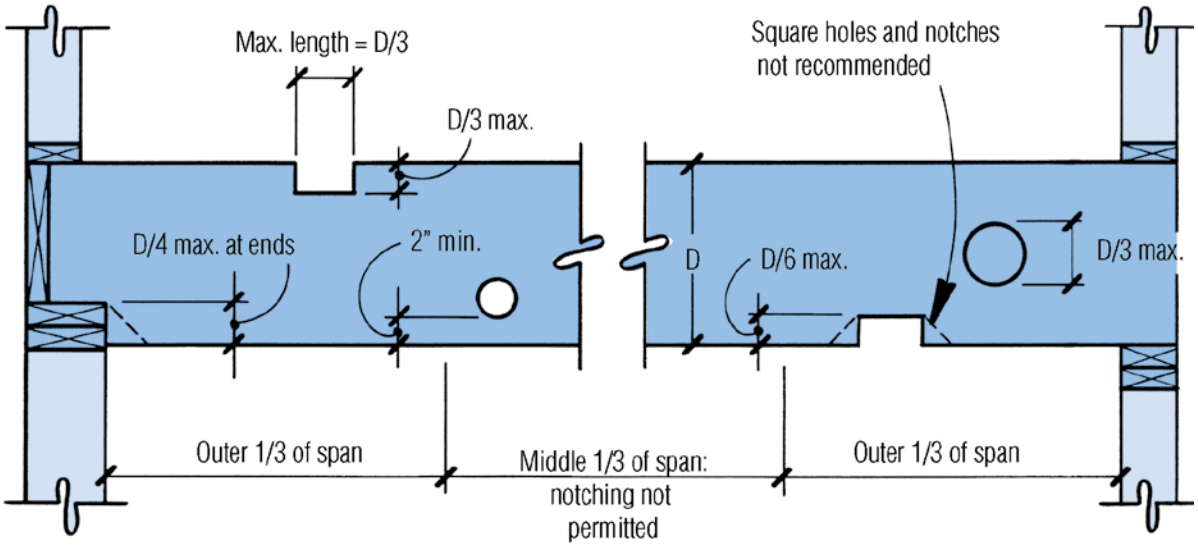
NOTCHING AND BORING STUDS AND JOISTS

For notching and boring framing to accommodate plumbing lines, it's critical that plumbers follow the guidelines shown for lumber joists (**Figure J**), engineered wood I-joists (**Figure K**), regular studs (**Figure L**), and engineered studs for tall walls (**Figure M**).

When using plastic piping (PVC or ABS), install nail guards where lines run near the surface of studs or joists.

FIGURE J: NOTCHING AND BORING LUMBER JOISTS

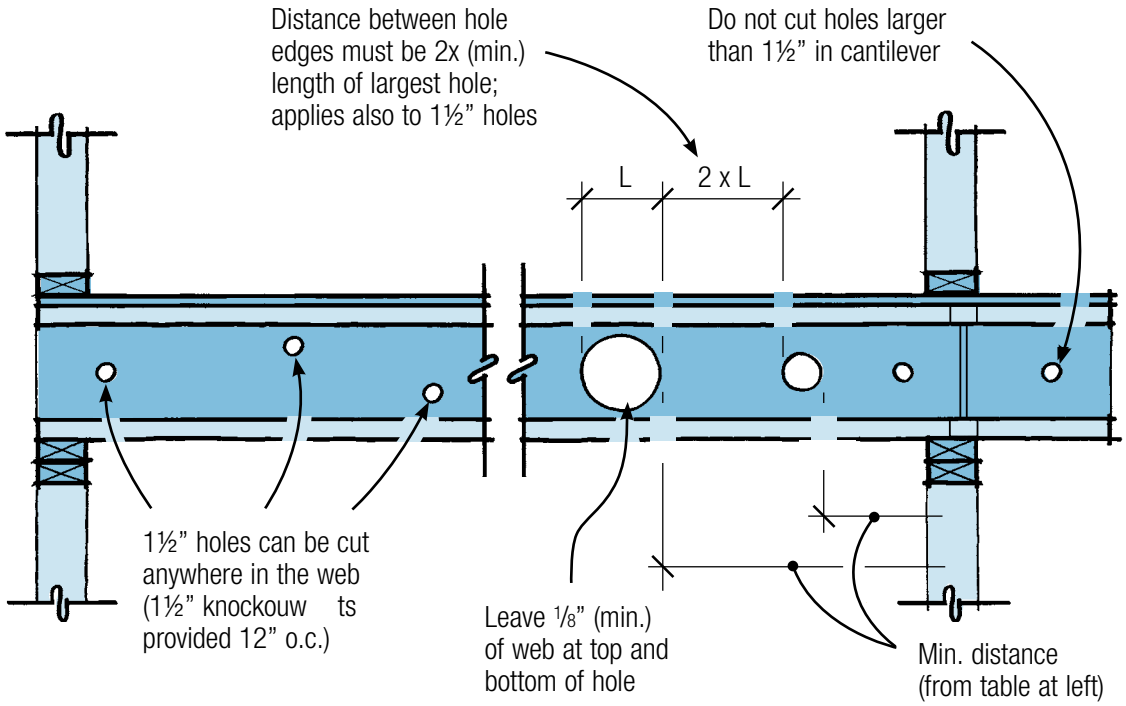
Joist Size	Max. Hole	Max. Notch Depth	Max. End Notch
2x4	None	None	None
2x6	1 1/2	7/8	1 3/8
2x8	2 3/8	1 1/4	1 7/8
2x10	3	1 1/2	2 3/8
2x12	3 3/4	1 7/8	2 7/8



For all calculations using the value D (depth of joist), use the actual, not nominal, dimensions.

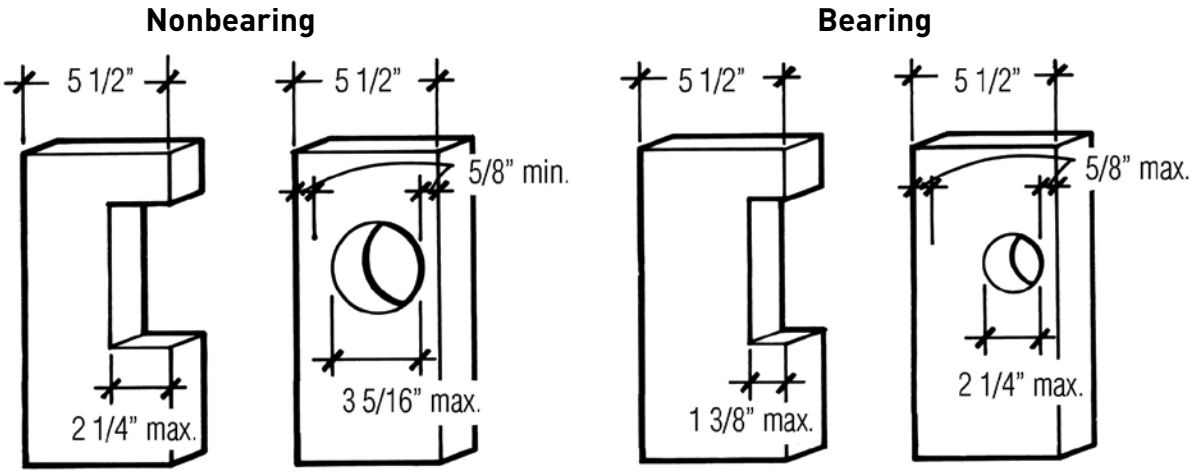
FIGURE K: NOTCHING AND BORING ENGINEERED WOOD I-JOISTS

Min. Distance (ft.-in.) from Inside Face of Support to Near Edge of Hole						
I-Joist Depth	**TJI/Pro**	**Hole Diameter**				
9½"	150	1'-0"	1'-6"	3'-0"	5'-0"	6'-6"
	250	1'-0"	2'-6"	4'-0"	5'-6"	7'-6"
11⅞"	150	1'-0"	1'-0"	1'-0"	2'-0"	3'-0"
	250	1'-0"	1'-0"	2'-0"	3'-0"	4'-6"
	350	1'-0"	2'-0"	3'-0"	4'-6"	5'-6"
	550	1'-0"	1'-6"	3'-0"	4'-6"	6'-0"
14"	250	1'-0"	1'-0"	1'-0"	1'-0"	1'-6"
	350	1'-0"	1'-0"	1'-0"	1'-6"	3'-0"
	550	1'-0"	1'-0"	1'-0"	2'-6"	4'-0"
16"	250	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
	350	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
	550	1'-0"	1'-0"	1'-0"	1'-0"	2'-0"



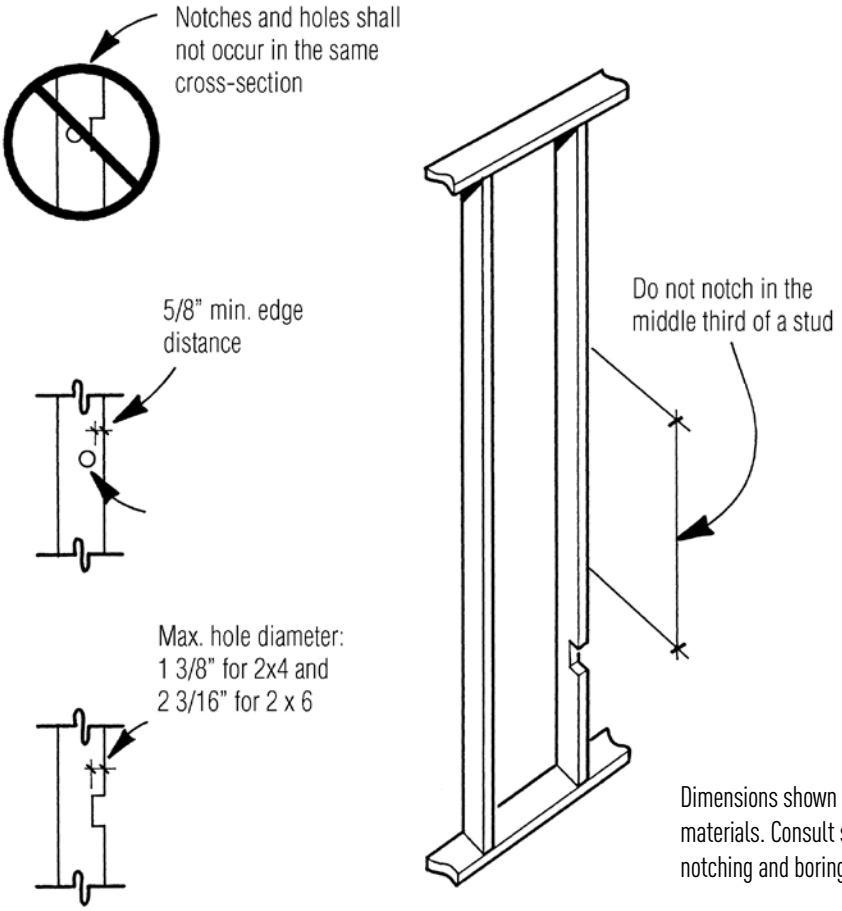
Note: Distances in the charts above are based on uniformly loaded joists, using the maximum loads shown in Trus Joist's brochure. For other load conditions or hole configurations, contact a Trus Joist representative. For simple-span (5-ft. minimum) uniformly loaded joists, one maximum-size hole may be located at the center of the joist span, provided no other holes occur in the joist. **DO NOT** cut into joist flanges when cutting out web. Dimensions shown here, provided courtesy of Trus Joist, may not apply to all wood I-joists. Consult specific manufacturer's specs for notching and boring guidelines.

FIGURE L: NOTCHING AND BORING REGULAR STUDS



Notches in loadbearing walls under 10 ft. tall should not exceed 24% of stud depth and should never be made in the middle third of the stud's length. Bored holes should not exceed 40% of a loadbearing stud's depth and should be at least 5/8 in. from the edge.

FIGURE M: NOTCHING AND BORING ENGINEERED STUDS

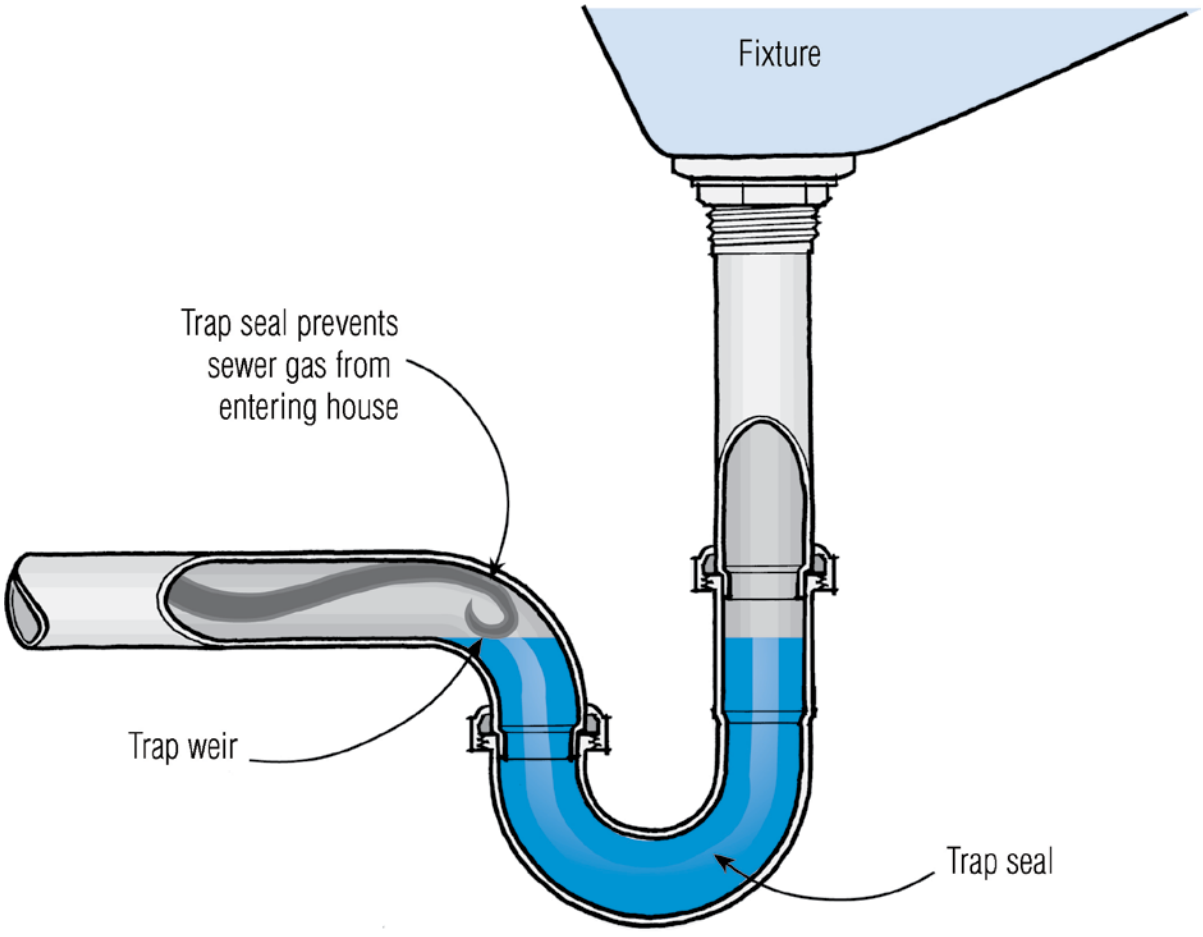


Dimensions shown here may not apply to all engineered materials. Consult specific manufacturer's specs for notching and boring guidelines.

TRAPS

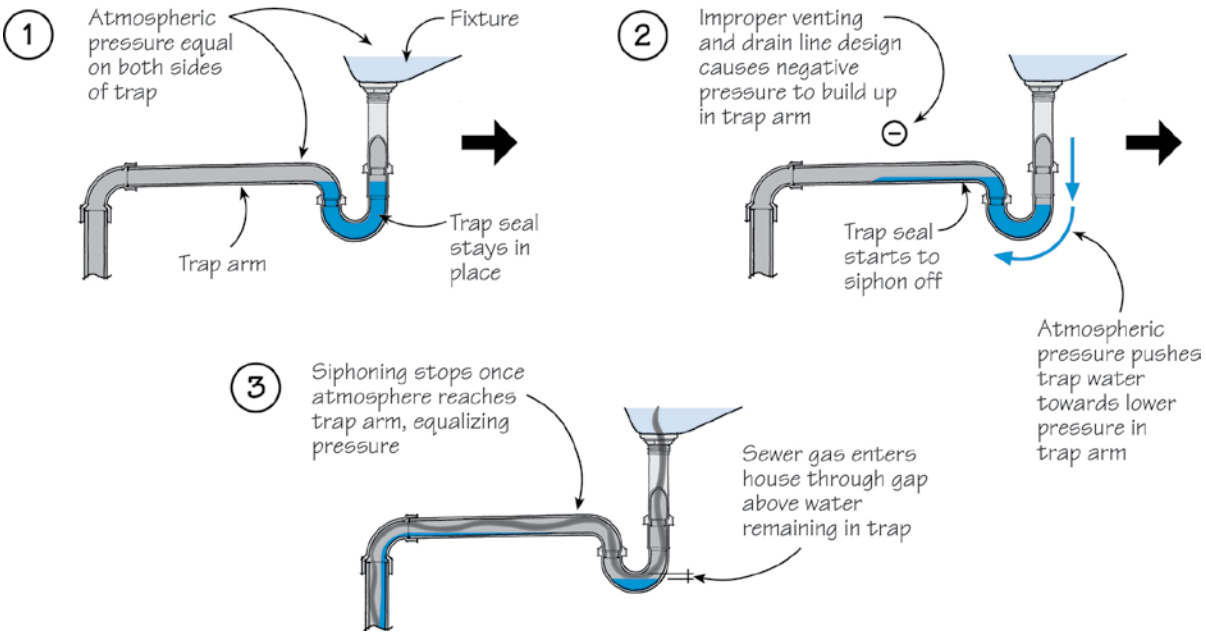
A *trap* — the bend in the drain below every plumbing fixture — creates a water seal that blocks sewer gases from escaping into the house (**Figure N**). A *vent* prevents the trap water from siphoning away. Vents maintain equal air pressure on both sides of the trap seal. This keeps negative pressure from building up so that a slug of water running down the drain doesn't pull the trap water out with it (**Figure O**).

FIGURE N: TYPICAL TRAP SEAL



Standard P-trap: All drain traps should have a short horizontal leg before turning down or merging with a drain stack. S-traps are not allowed. With adequate venting, the leg prevents the slug of water from siphoning off.

FIGURE O: HOW TRAPS FAIL WITHOUT VENTING



Without venting, pressure imbalances cause traps to fail. The seal remains as long as the pressure on each side of it is equal (1). But as soon as water drains through the line, it creates negative pressure behind it (2), pulling nearby traps dry (3). Proper venting provides the air needed for the drain to flow freely without creating pressure differences.

Trap Rules

The following guidelines apply to all fixture traps:

- No fixture trap outlet may be larger in diameter than the drain to which it is connected.
- No fixture can be double trapped.
- A slip joint is allowed anywhere on the inlet side of the trap. On the outlet side, the slip joint may not be allowed above the top of the water seal. In any case, any trap made with slip joints must be accessible through a minimum 12x12-in. opening.
- Each fixture trap must have a water seal that is at least 2 in. deep and not more than 4 in. deep.
- Most codes require a horizontal leg on the discharge side of the trap that's at least two pipe diameters long. This leg must be sloped 1/4 in. per foot from the top of the water seal toward the vertical discharge.
- Code limits the horizontal distance before the trap arm tees into a vent, as shown in **Figure P** and **Figure U**.
- Most codes limit the length of the vertical drop from the fixture inlet to the trap. For sinks, lavs, showers, and bathtubs, the maximum drop is typically 18 to 24 in. (**Figure P**); check with local code.

Toilet Traps

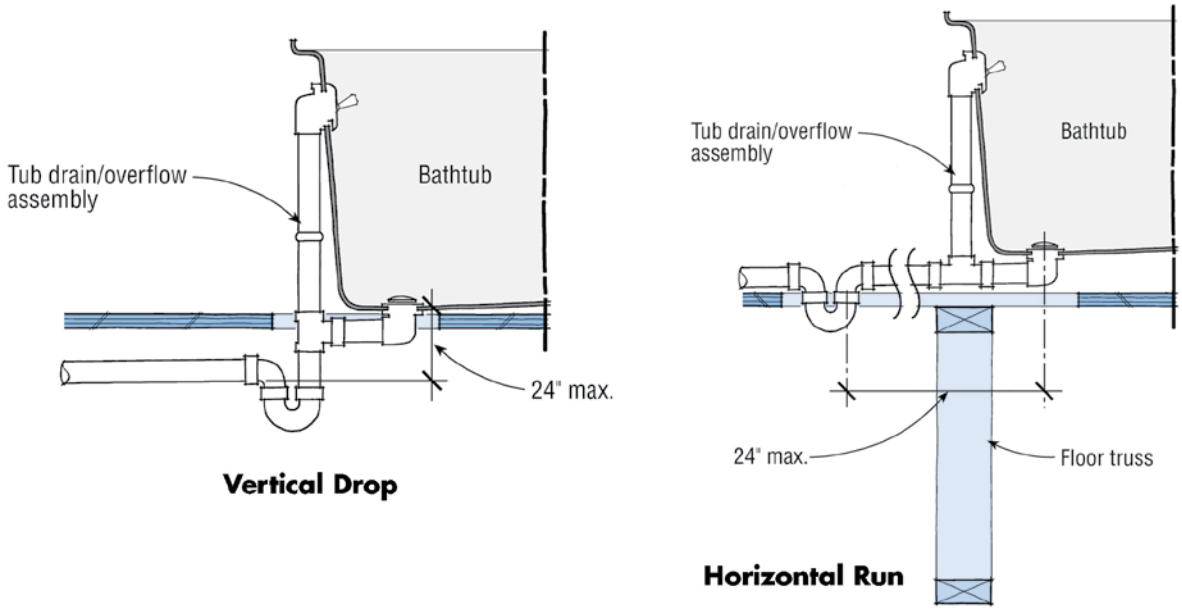
- Toilets have integral traps, and may not discharge into a trapped drain, as this would create a double trap.
- The vertical drop below a toilet may not exceed 24 in. (again, check with local code to confirm this maximum).

Tub and Shower Traps

Most fixtures should be made accessible. The common exceptions are bathtub and shower traps, which may be concealed. However, these fixture traps must be made of approved materials (typically cast iron or cast brass) and may not be equipped with a cleanout. (Cleanouts must always be accessible).

While best practice calls for keeping the trap as close as possible to the fixture, most code inspectors will allow 24 in. of horizontal distance before the trap to get around framing obstacles (**Figure P**). However, be sure to check with your local official. Also, there are offset tub drain-overflow assemblies with side or rear outlets that may help overcome framing obstacles.

FIGURE P: TUB TRAP



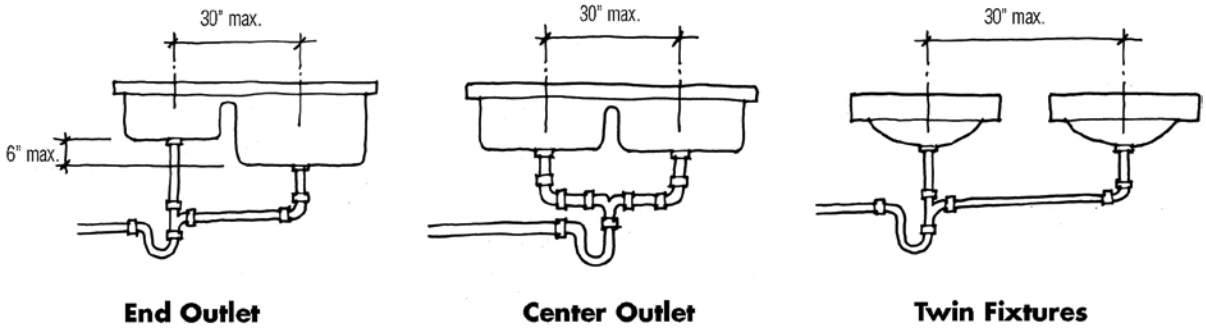
A typical tub drain requires a vertical drop of no more than 24 in. The horizontal distance should be as short as possible (left) but code officials will often allow a distance of up to 24 in. (right) to avoid framing obstacles, such as a truss that cannot be cut.

Traps for Double Sinks

Sinks and laundry trays with two or three compartments may be connected to a single trap with a continuous waste. In this case, the following guidelines must be met:

- The sink compartments must be adjacent to one another and not more than 6 in. deeper than one another (**Figure Q**).
- The sink's drain inlets must be within 30 in. o.c.
- Two or three single-compartment sinks may be used on a single trap, as well, provided the drain inlets are not spaced more than 30 in. o.c. (**Figure Q**).
- If three single sinks are installed on a single trap, the trap must be on the center sink.

FIGURE Q: DOUBLE SINKS ON A SINGLE TRAP

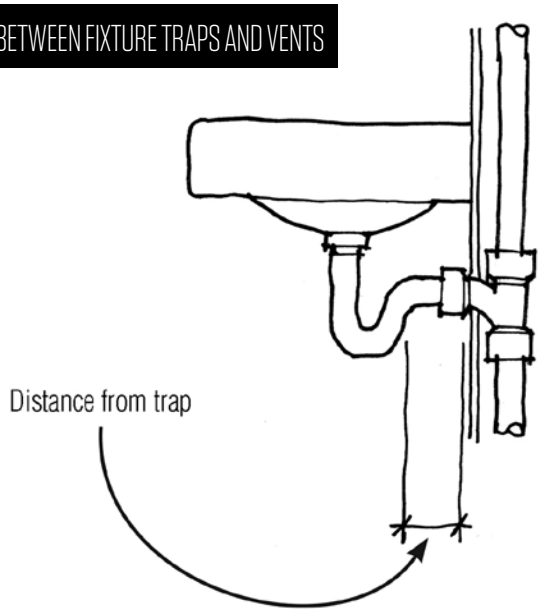


Double-compartment sinks and laundry trays may be connected to a single trap with a continuous waste. Similarly, more than one sink may be tied to a single vent if approved by local code.

Drum Traps

Drum traps are no longer allowed by code.

FIGURE R: MAX. DISTANCE BETWEEN FIXTURE TRAPS AND VENTS



Size of Trap (in.)	Size of Fixture Drain (in.)	Slope (in. per ft.)	Distance from Trap (ft.)
1 ¼	1 ¼	¼	3 ½
1 ¼	1 ½	¼	5
1 ½	1 ½	¼	5
1 ½	2	¼	6
2	2	¼	6
3	3	⅛	10
4	4	⅛	12

BASEMENT AND CRAWLSPACE DRAINAGE

Basements should have a floor drain to remove standing water. Dig a shallow hole at the low point, then run solid PVC drainpipe through the foundation wall to daylight or a municipal sewer.

Backwater valves. A basement drain connected to the municipal sewer should have a backwater valve in the drain line. Under concrete, install backwater valves with sleeves and access panels, so that they can be accessed for maintenance.

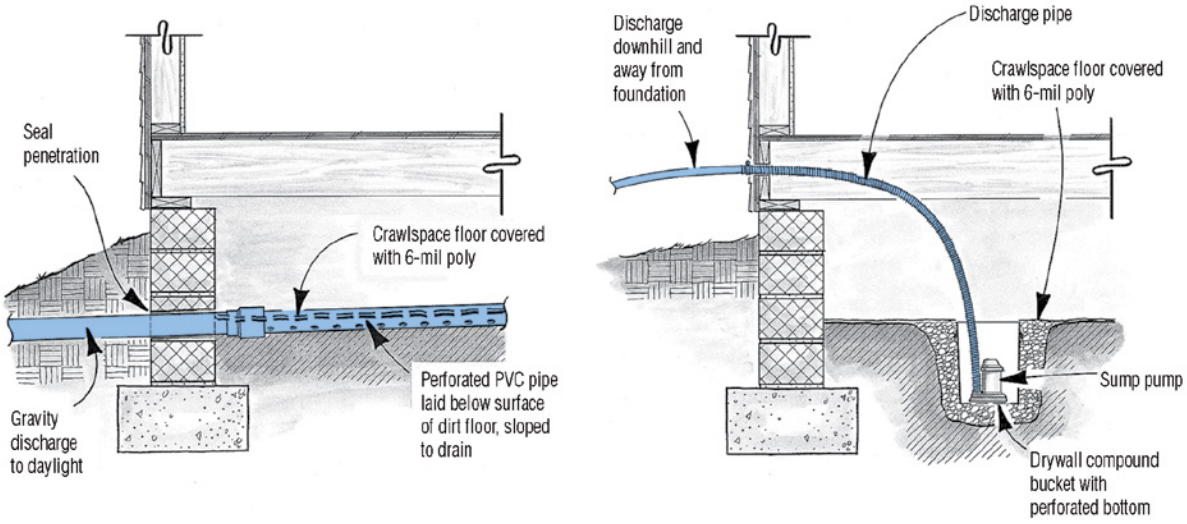
Sump Pumps

If the exterior grade won't permit gravity drainage of a basement drain, use a sump pump and discharge the water well away from the building (**Figure S**).

Retrofit sump pump. To retrofit a sump pump to replace a utility drain, remove the existing drain but leave the trap. Dig a hole for a plastic bucket or sump kit. Connect the sump pump's 2-in. discharge connection to the existing drainpipe under your slab, using watertight threaded or glued fittings. The sump pump must include a check valve in its discharge fitting. This enables it to pump out under pressure any liquid that flows into the sump, even when the utility drains are full.

If a basement or crawlspace is generally wet but water isn't pooling in one spot, dig shallow trenches across the floor and use perforated PVC drainpipe to collect the water. Then pipe it to daylight or to a sump pump.

FIGURE S: CRAWLSPACE DRAINAGE



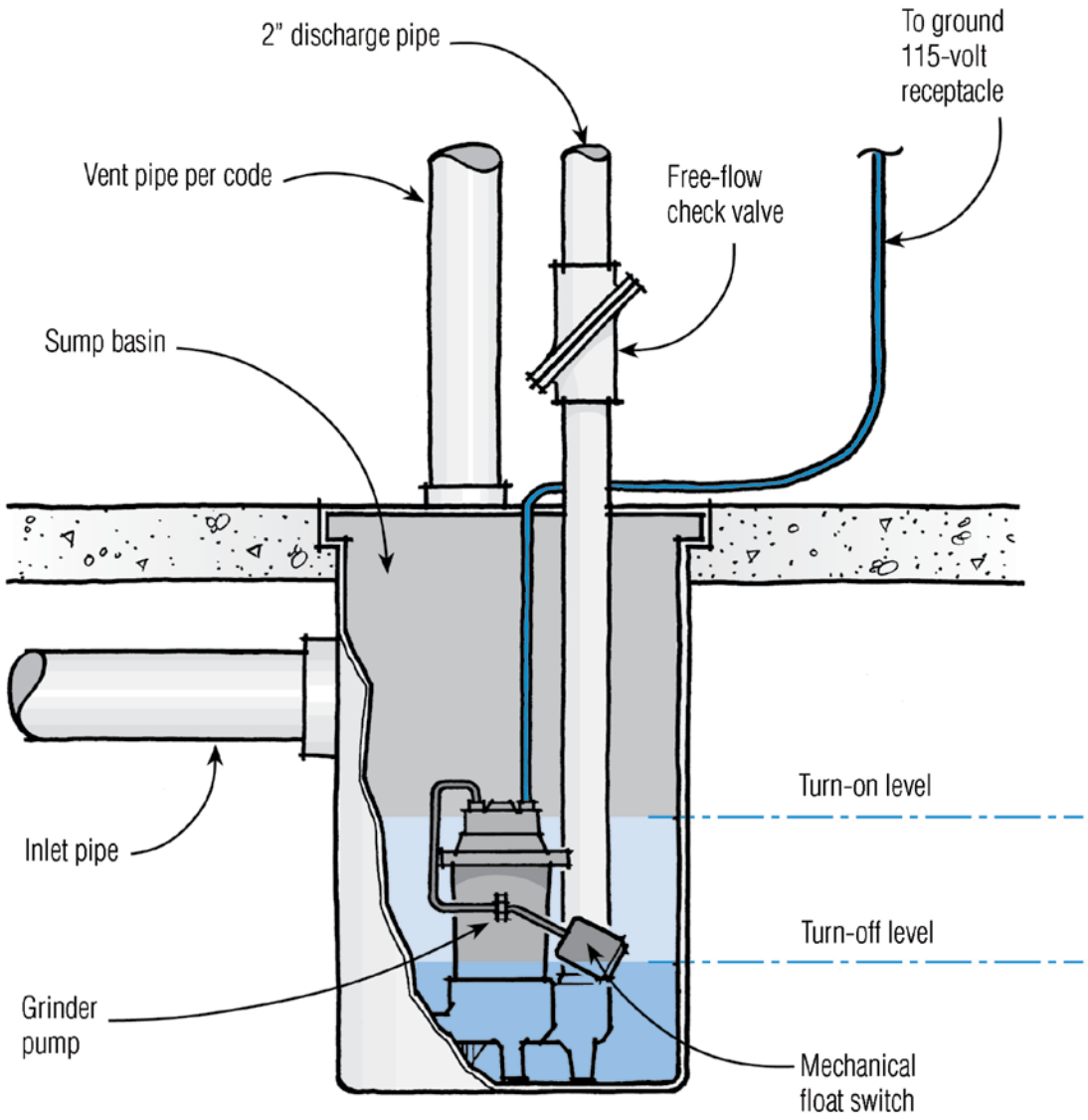
Continuous Drain Through Crawlspace **Sump Pit Alternative**

To remove standing water from a crawlspace, run PVC drainpipe through the foundation to daylight (left). If the exterior grade is too high for gravity drainage, install a sump pump and discharge the water well away from the foundation (right).

Ejector Pumps

A basement toilet that has a discharge outlet below the house main drain will require a sewage ejector pump specifically designed for lifting effluents to the drain line (**Figure T**). A typical installation consists of a drum-shaped plastic or metal reservoir, or sump, which receives discharge from a toilet, tub/shower, and lavatory. Inside the sump basin, which holds about 30 gallons of effluent, is a specially designed pump triggered by a float mechanism. The unit churns the waste and periodically pumps it to the main drainpipe as needed. This churning is loud, so avoid positioning the ejector pump near a bedroom or study.

FIGURE T: EJECTOR PUMP



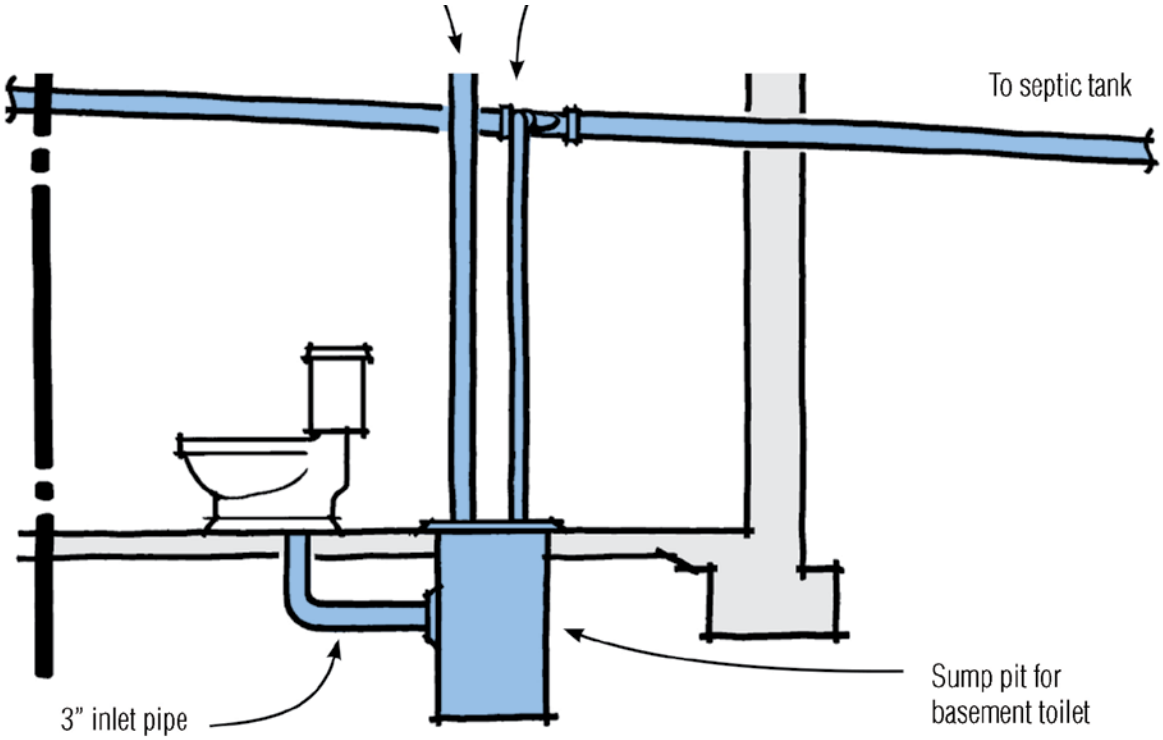
The sump basin receives wastewater from bathroom fixtures. A grinder pump liquifies the sewage and pumps it up to the main drain line that exits the house. A check valve prevents gravity backflow into the basin.

Drainage and vent. The sump pit will require two pipes at the top: a high-pressure discharge pipe, usually 2 in. in diameter, and a dry vent pipe, usually 2 to 3 in. in diameter (**Figure U**). To connect the vent, try to find a dry vent in the house plumbing and tap into that, or run a new vent to the roof.

Sealing. After the ejector pump is installed, seal all openings around the sump pit with hydraulic sealant or caulking to prevent any radon or groundwater from entering the basement. If radon is an issue, be extra careful to properly seal these and other penetrations through the basement floor. (For more, see **Radon Abatement**.)

An option worth considering is an alarm system, which monitors the basin level. An integral float furnished with the pump provides automatic on/off action in response to usage. If the pump does not cycle, an audible alarm sounds to warn against usage until the system is checked.

FIGURE U: VENTING A BASEMENT TOILET



Basement bathrooms may require an ejector pump to lift effluent to the main drain. The ejector pump does not have to be installed in a sump pit below the floor. Kits are available that allow an above-floor installation.