# Open-Channel Flow (Manning) — Validation Report

Independent verification of the Kouzouki calculation engine against closed-form statics, published design-standard values and worked examples

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| **Engine** | Kouzouki — Open-Channel Flow (Manning) |
| **Basis** | Manning Q = (1.49/n) A R^(2/3) S^(1/2), R = A/P, with the trapezoidal area A = (b+zy)y and wetted perimeter P = b + 2y sqrt(1+z^2); Froude Fr = V/sqrt(g A/T). |
| **Validation type** | Independent validation |
| **Report date** | 2026-06-20 |
| **Result** | **PASS** — 5/5 checks within tolerance |

## 1. Validation cases

Each case feeds the tool a defined input set and compares its output against a value derived independently of the engine (cited per row). Tolerance is 1% unless noted.

### MN1. Trapezoidal area & wetted perimeter

Inputs: channel_shape=Trapezoidal, bottom_width=4.0, side_slope=2.0, channel_diameter=3.0, flow_depth=2.0, manning_n=0.013, channel_slope=0.005, design_flow=0.0

| Checked quantity | Independent value | Tool output | Dev. | Verdict |
|---|---|---|---|---|
| Flow area A = (b+zy)y<br>Geometry | 16 ft^2 | 16 ft^2 | 0.00% | **PASS** |
| Hydraulic radius R = A/P<br>Geometry | 1.236 ft | 1.236 ft | 0.01% | **PASS** |

### MN2. Manning discharge

Inputs: channel_shape=Trapezoidal, bottom_width=4.0, side_slope=2.0, channel_diameter=3.0, flow_depth=2.0, manning_n=0.013, channel_slope=0.005, design_flow=0.0

| Checked quantity | Independent value | Tool output | Dev. | Verdict |
|---|---|---|---|---|
| Velocity V = (1.49/n)R^(2/3)S^(1/2)<br>Manning | 9.334 ft/s | 9.33 ft/s | 0.05% | **PASS** |
| Discharge Q = V A<br>Continuity | 149.4 cfs | 149.4 cfs | 0.03% | **PASS** |

### MN3. Froude number / regime

Inputs: channel_shape=Trapezoidal, bottom_width=4.0, side_slope=2.0, channel_diameter=3.0, flow_depth=2.0, manning_n=0.013, channel_slope=0.005, design_flow=0.0

| Checked quantity | Independent value | Tool output | Dev. | Verdict |
|---|---|---|---|---|
| Froude Fr = V/sqrt(g D_h)<br>Open channel | 1.425 | 1.425 | 0.03% | **PASS** |

## 2. Assumptions

- Uniform (normal) steady flow; US customary units (k = 1.49).
- Manning's n is the channel roughness (Chow's tables) - an input.
- Prismatic channel, hydrostatic pressure distribution.

## 3. Limitations

- n and the slope S are design inputs; results scale strongly with both.
- Normal flow only - not gradually/rapidly varied flow profiles.
- Circular section assumes part-full; check the part-full curve near full.

## 4. Sources of the independent values

**How the independent values are obtained.** Every value in the Independent-value column of Section 1 is computed in a validation harness (validation/cases.py) written and run separately from the calculation engine. Each is an independent re-derivation of the governing closed-form equation, or a value read from a cited published worked example or design-standard table - never copied from the engine's own output. The match therefore confirms the engine reproduces the cited source within tolerance. The source beside each value (Section 1) and the references below identify the governing standard section, equation, or publication.

**Basis of the independent values**

Manning Q = (1.49/n) A R^(2/3) S^(1/2), R = A/P, with the trapezoidal area A = (b+zy)y and wetted perimeter P = b + 2y sqrt(1+z^2); Froude Fr = V/sqrt(g A/T).

**Per-check citations (Section 1):** Geometry; Manning; Continuity; Open channel.

## 5. Conclusion

All 5 independent checks reproduce the reference values within tolerance. The engine correctly implements the governing equations for this tool.

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Reproduce: **python scripts/run_tool_validation.py** → **python scripts/make_tool_validation_pdfs.py**. This report is for verification/demonstration; results are for preliminary design and must be confirmed by a licensed engineer against the current adopted code and project-specific conditions.