Agentic Modelling Pipeline: Reproducible Rapid Stormwater Modelling Management System with OpenClaw

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ABSTRACT

Configuring urban hydrological models, such as SWMM, for operational or real-time modelling remains onerous for many models. We propose an Agentic SWMM workflow, which embeds 'Skills' and model context protocols to automate model configuration, execution, and extract and plot quantities of interest. To ensure that the entire Agentic SWMM workflow is auditable and reproducible, each run will create an independent manifest file that documents the SWMM version used, parameter mappings, input file hashes, and quality gate (e.g., continuity diagnostics). We demonstrate the workflow on the Tod Creek watershed (located on the Saanich Peninsula, British Columbia) and verified the equivalence between EPA SWMM® command line execution and model context protocol triggered SWMM execution, and between SWMM GUI workflow and the Agentic SWMM workflow. Validation was demonstrated through identical peak. The overall automation workflow (Skills and model context protocol setting), along with plotting services and

evaluation protocols are available as Open Source to support a reproducible Agentic SWMM workflow triggered by natural language.

Keywords: Hydrological Modelling, Agentic AI, SWMM, MCP, Agent Skills

HIGHLIGHTS

- Proposed a new Agentic SWMM framework that integrates SWMM–GIS, SWMM-runner, and SWMM-plot Skills (MCPs embedded for each Skill), thus enabling natural language driven SWMM model setup, orchestration, and standardized result and figure generation, which also mitigates large language model (LLM) hallucination from operational level.
- Proposed reproducibility and reliability Agentic AI running check through a manifest and an automated continuity/consistency quality verification component, which provides Agentic SWMM action audits.
- A multi-layer verification protocol was established to verify the equivalence of Agentic SWMM and SWMM GUI.

INTRODUCTION

OpenClaw is a typical Agentic AI and designed for complex goals (Acharya et al., 2025). It was released by Peter Steinberger on January 29, 2026, in a GitHub repository (Steinberger, 2026; OpenClaw contributors, 2026). Unlike conventional chat-oriented systems (e.g., ChatGPT or Gemini) that primarily optimize for natural-language responses, OpenClaw is designed to complete tasks by orchestrating external tools (e.g., web retrieval, scripts, APIs, file operations) under explicit permissions (Steinberger, 2026). Currently, a major pain point in hydrological modelling is that physics-based modelling software, such as PCSWMM® and MIKE+®, require users to extensively interact with the user interface (UI) and constantly adjust various parameters during the modelling process (Chawanda et al., 2020; Gan et al., 2020). The visualization capabilities are excellent and built-in physics formulas make the process and results interpretable, while the multiple scenarios simulation can lead the modelling running time to be excessively long (Ahmadi et al., 2025). As well, users often need a significant amount of time to understand and familiarize themselves with the interface and to debug software errors. Conversely, with the development of machine learning, hydrology is currently focusing on various alternative models such as long short-term memory (LSTM) and physics-informed neural networks (PINNs), increasing their time series recognition capabilities or adding physical constraints based on PDE residuals (Feng et al., 2024; Qi et al., 2024; Sakar et al., 2026). This allows for the training of data-driven models that can match physics-based models in most contexts, thereby increasing operational efficiency. However, the defining weakness of these models is their poor generalization ability (Panda et al., 2025). Their near-black-box training characteristics make accurate representation of interpretability and physical consistency very difficult, often leading to overfitting issues in data scarce situations (Baniya & Maity, 2026; De La Fuente et al., 2024; Li et al., 2024).

With the development of Generative AI technology, some open-source software, such as SWMM®, can expose communication methods to Generative AI through model context protocol (MCP), enabling software invocation (Anthropic, 2024; Xu et al., 2025). Currently, various AI technologies are flourishing. For example, Claude Code's Agent Skills can package workflows together that an agent can recognize, thus achieving simple migration of automated workflows (Anthropic, 2024). The idea of fully automated workflows originated from N8N, which aims to create simple chatbots or replace humans by triggering specific workflows at specific times (Pawar, 2025); however, its configuration process is often highly complex.

To address the current pain points in hydrology, we propose a configuration framework based on OpenClaw, SKILL, MCP, and SWMM. This enables the configuration of SWMM and the definition of user-defined plots using natural language. In addition, we verified the consistency of the entire system using the Tod Creek Watershed, Saanich, BC, Canada. The results showed that the SWMM configured through natural language was consistent with the results configured manually through the SWMM graphical user interface (GUI), which verified that the core hydrological derivation process does not depend on the Agentic AI, but on the SWMM engine that is invoked.

This paper proposes and demonstrates a practical architecture that integrates (i) OpenClaw as an execution runtime; (ii) Skills as reusable workflow modules; and (iii) MCP as a standard interface layer, to operate the SWMM engine and downstream plotting in a controlled and auditable manner via nature language. The novelty of this work lies in an Agentic orchestrated, end-to-end workflow that encodes the standard operating procedure (SOP) as reusable Skills and invokes SWMM and plotting via MCP tools, enforcing provenance for each run (recorded hash locked inputs, parameter mappings, and continuity-based quality assurance (QA). Thus, the overall pipeline enables repeatable, auditable SWMM experiments beyond GUI-centric operation.

METHODS

The methodology is depicted in Figure 1 to indicate how the Agentic AI (OpenClaw) orchestrated tasks, starting with input Geo-layers data for the case study watershed. As shown in Figure 1, we present a complete workflow that packages the initial multi-source data (DEM, landuse, soil, rainfall) required for modeling into an input package for GIS MCP. End users can interact with SWMM by issuing commands via natural language. In the middle layer, we packaged SWMM's commands as callable tools through the MCP. Since SWMM lacks the lookup table capability to transform raw data layers into model parameters, we generate a built-in transformation lookup table through dialogue in the GIS MCP as well.

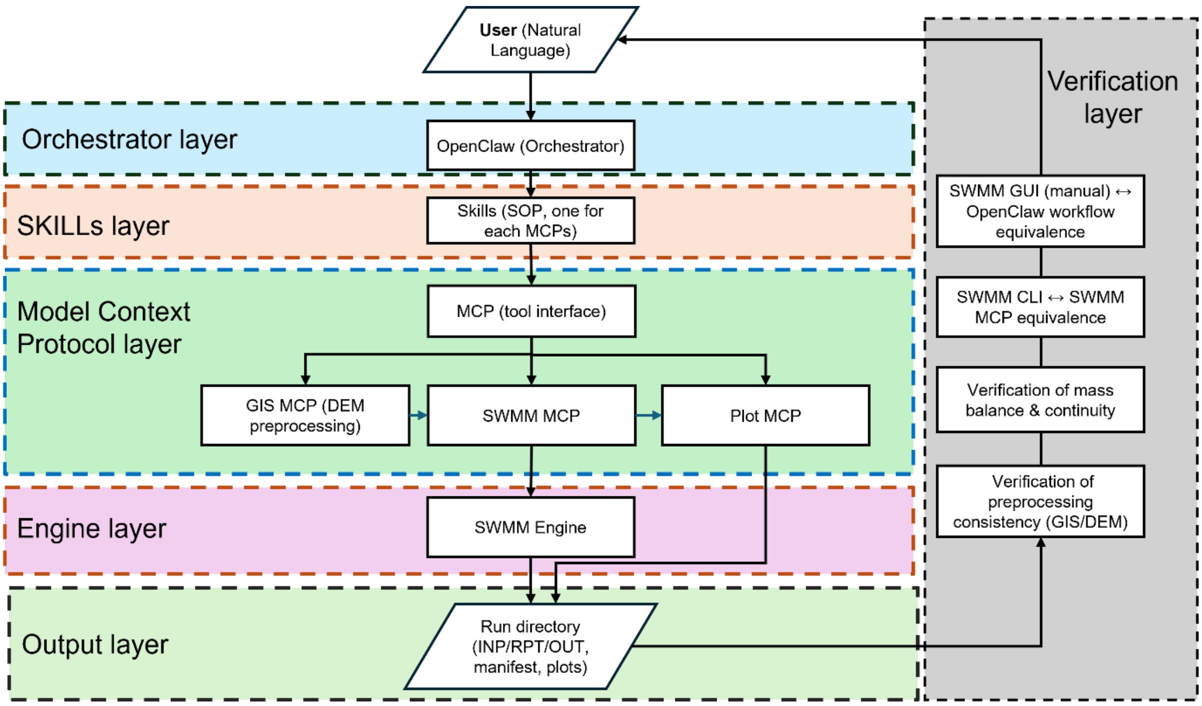


Figure 1: Methodology Flowchart for the whole proposed pipeline.

2.1 Study Site

The Todd Creek watershed, which spans about 17 km^2, is situated on Vancouver Island's Saanich Peninsula in British Columbia, Canada. The covered region is mostly rural with a few tiny residential villages scattered throughout the watershed's undulating terrain (see Figure

2a in the digital elevation model). The 1000–1200 mm of annual precipitation is mostly concentrated between October and March of the following year. The soil types range from poorly draining clays to well-drained soils that are rich in organic matter (see Figure 2b). The resolution of the digital elevation model is 27 meters.

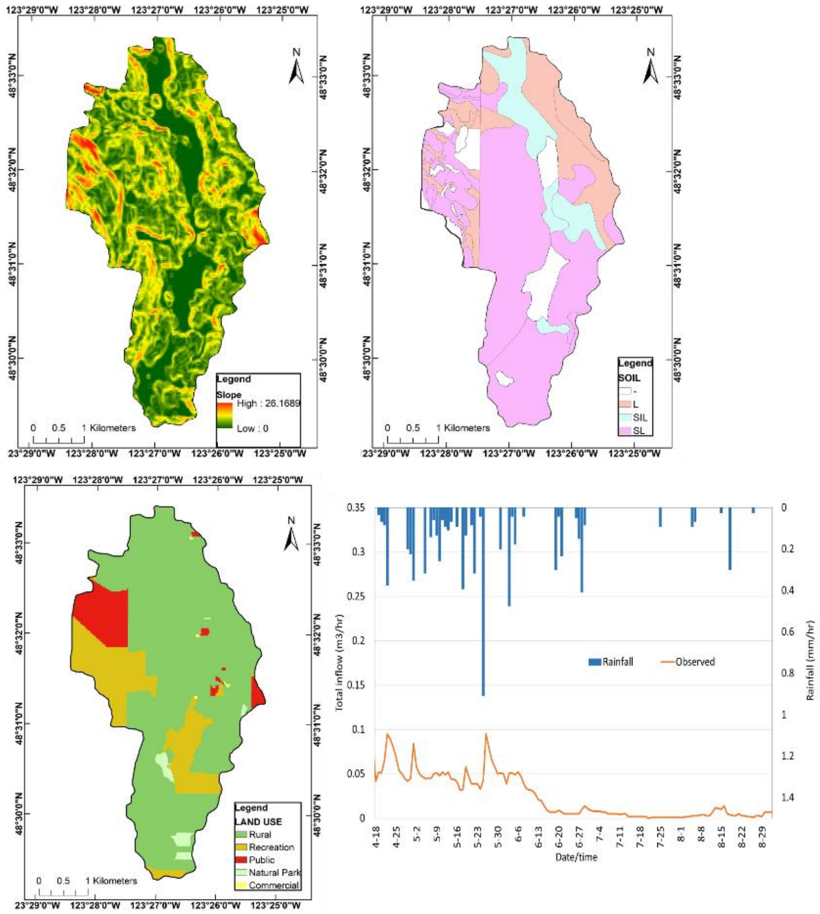


Figure 2: Slope, landuse and soil as well as timeseries rainfall in 1984.

The Tod Creek database contained a) digital elevation model (DEM); b) soil type polygons with texture attributes; c) land use polygons (zoning-style categories; used as a land-use proxy); and d) 1984 rainfall records (daily totals in units of mm). For demonstration purposes, a lumped model representation of Saanich was used to validate the end-to-end workflow. The outlet location was selected algorithmically on the DEM boundary (minimum elevation candidate) to obtain a consistent reference outfall point for the stormwater simulation.

2.2 Methodology of Agentic SWMM System

Our research compiles the SWMM command-line program (v5.2.4) from the EPA SWMM source code on macOS and executes simulations using the standard command “swmm5 <inp> <rpt> <out>”. Our SWMM Skill workflow automatically creates a separate run directory for each run, uniformly saving the input file (INP), report file (RPT), and binary output (OUT), and additionally generating a manifest file as shown in the Supplementary file Section S1. The biggest difference from the traditional UI approach is that while users can see the modifications made in a UI, this manifest, based on OpenClaw (Version 2026.2.17), is mandatory and written into the Skill. This log records the software version, key user configurations and parameter mappings, rainfall event information, and a summary of key results (such as continuity error, peak flow, etc.), thus, achieving transparency, reverse tracing, and auditability for each experiment. In addition, the same INP file is run synchronously in the SWMM GUI, and the consistency of key indicators and resulting statistics is used as the basis for equivalence verification to ensure that the automated command line process and the GUI run in terms of numerical behavior are consistent. After establishing this equivalence, we invoke the SWMM MCP via natural-language instructions that specify the original locations of the required datasets to trigger automated execution and subsequently call the plot Skill to generate the runoff comparison results shown in Section 3 of this paper.

2.2.1 OpenClaw

OpenClaw is used as an orchestration environment that executes commands, reads and writes artifacts, and invokes external programs. Within this work, OpenClaw does not replace SWMM; it standardizes the execution and bookkeeping around it. It is currently compatible with most large language models through the application programming interface (API) for analysis complex tasks. In our case study, we are using GPT 5.2 as the primary model of OpenClaw. In practice, OpenClaw workflow is triggered by a natural language prompt. This will invoke the available Skills and orchestrates the MCP service to run the SWMM engine automatically and generates the model outputs. The natural language prompt input format we recommend is:

"*Run the full Agentic SWMM workflow using your GIS, SWMM runner, and plotting skills. My input data folder is located at <PROJECT_ROOT>:*

1. *Use swmm-gis to select an outlet (document the method) and export the outlet (GeoJSON + preview).*
2. *Use swmm-runner to build and run a baseline SWMM simulation from the provided inputs and assumptions and save a self-contained run folder with all artifacts and a manifest.json.*
3. *Use swmm-plot to generate figures for the QoIs on dd-MM-YYYY.*
4. *Return: the output folder path, the manifest.json path, and a short list of assumptions (if you have).*"

Note that, swmm-gis, swmm-runner, and swmm-plot in the prompts are Skill modules (tool bundles). The Skills we used hav been standardized as Standard Operating Procedures (SOP); therefore, the workflow does not require high quality user prompts. The dependence on the overall prompting process is significantly reduced because the capability boundaries, parameter structure, and output formats are all "well designed" by the Skill/MCP interfaces. As a result, the Agentic AI does not need to guess the user's meaning, which maximizes portability and reproducibility as well as minimizes the LLM hallucination.

2.2.2 MCP

MCP provides a consistent protocol for exposing local capabilities as callable tools. In the proposed design, three MCP servers are used: a) swmm-gis-mcp for DEM data preprocessing; b) swmm-runner-mcp: generates inputs, runs swmm5, extracts quantities of interest (QoIs) and continuity metrics; and c) swmm-plot-mcp: reads INP/OUT artifacts and produces figures that conform to a fixed user's specification. Moreover, OpenClaw can automatically configure MCP services after configuring the API of any Large Language model. Therefore, users can use OpenClaw to configure the required MCP services for different analysis scenarios, such as pollutant diffusion or water quality modules. In this study, we only encapsulated the peak flows we were interested in to demonstrate the overall effect of Agentic SWMM. Table 1 shows an interface catalogue for a SWMM-focused MCP toolchain. Table 1 lists six MCP servers, which are designed for the entire Agentic AI workflow.

Table 1. MCP tool interface specification for the Agentic SWMM workflow

MCP Server	Tool name	Required inputs	Outputs	Units / assumptions	Failure modes
swmm-gis-mcp	gis_find_pour_point	dem (path); outGeojson (path); outPng (path)	JSON: x,y,row,col,crs,score; GeoJSON; PNG preview	Coordinates in DEM CRS; score=min elev or max accum index	DEM unreadable/NoData boundary; pysheds missing (maxAccum); output path not writable
swmm-runner-mcp	swmm_run	inp (path); runDir (path)	JSON manifest; writes rpt/out/log/manifest	Flow units follow INP FLOW_UNITS (CMS → m^3/s)	swmm5 missing; INP errors; runDir not writable; nonzero return code
swmm-runner-mcp	swmm_peak	rpt (path)	JSON: node, peak, timeHHMM, source	peak in SWMM flow units; time in report timebase	RPT parse mismatch; node not found and return null; encoding issues
swmm-runner-mcp	swmm_continuity	rpt (path)	JSON: runoff table; routing table; continuityErrorPct	SWMM report units; continuity in percent	Continuity blocks missing; parser mismatch across SWMM versions

swmm-runner-mcp	swmm_compare	rpt (path); rpt2 (path)	JSON: aErr, bErr (headline continuity)	percent (%)	Same as continuity; different INPs/steps and return expected differences
swmm-plot-mcp	plot_rain_runoff_si	inp (path); out (path); outPng (path)	writes PNG; JSON: ok,outPng	Rain as mm/Δt (default 5 min); flow m^3/s if CMS	OUT missing/corrupt; TS_RAIN missing; swmmtoolbox missing; font fallback

2.2.3 Skills

Beyond MCP, Skills package scripts, configuration, and conventions for specific tasks or workflow (e.g., generating INP files Via MCP, running SWMM, extracting outputs, and producing figures). This packaging ensures the workflow can be repeated and shared with minimal manual setup. The shortcoming to MCP is that it only addresses the interface issue of "how the tools are called" (encapsulating SWMM execution, result extraction, and plotting capabilities into callable tools), thus failing to accurately implement the Standard Operating Procedure (SOP) process. We adopt Skill to render commands of "what to call, in what order, using what specifications; how to implement quality gates; and how to produce reproducible workpieces" into a reusable methodology. This is shown in Table 2.

Table 2. OpenClaw SWMM Capability Skill CatLog

Skill name	Purpose	Key scripts	MCP server	Main tools	Outputs
swmm-gis	GIS/DEM preprocessing (pour point/outlet selection) for reproducible SWMM workflows	scripts/find_pour_point.py	scripts/mcp/server.js (swmm-gis-mcp)	gis_find_pour_point	GeoJSON pour point + DEM preview PNG
swmm-runner	Run swmm5 reproducibly and extract peak/continuity + write manifest.json	scripts/swmm_runner.py	scripts/mcp/server.js (swmm-runner-mcp)	swmm_run, swmm_peak, swmm_continuity, swmm_compare	run directory: rpt/out/stdout/stderr/manifest.json; metrics JSON

swmm-plot	Publication-grade plotting	scripts/plot_rain_runoff_si.py	scripts/mcp/server.js (swmm-plot-mcp)	plot_rain_runoff_si	figure PNG/PDF

In the Agentic SWMM scenario, Skill orchestrates the corresponding MCP to autogenerate the INPs file; runs the swmm engine, extracts indicators such as peaks and continuity; performs conservation/continuity checks and GUI-CLI equivalence comparisons; includes built-in plotting specifications (units, axes, fonts, and window clipping, etc.) and automatic repair rules for common pitfalls; and enforces standardized run directories and manifests (version, hash, parameter mapping, key results, plots, etc.). Therefore, simply relying on MCP can easily degenerate into a set of "bare tools", which can be called but are difficult to manage and reproduce stably over a long period of time. This also makes it difficult to quickly port the entire workflow. Skill, however, organizes interface capabilities into reproducible experimental packages that are auditable, shareable, and maintainable; thus, enabling workflows to run repeatedly and be reliably reused with minimal manual setup. As well, in the data preprocessing part, because DEM-based preprocessing is often required for hydrologic model setup (e.g., identifying a pour point and delineating subcatchments) and EPA SWMM does not provide these GIS functions, we implemented a dedicated swmm-gis Skill to automate this step. We use two methods from the DEM to find candidate outlets: one is the lowest point on the boundary, and the other is the point with the largest flow accumulation. This skill saves the pour point with coordinate system as a reproducible geographic file, which can be directly used for SWMM model configuration.

2.3 Verification, Reproducibility and Repeatability

2.3.1 Verification of DEM-based Preprocessing (Automatic Pour Point Detection)

Because EPA SWMM does not provide necessary GIS pre-processing utilities, we implemented an automated pour-point detection routine as an independent SWMM–GIS MCP and Skill (as shown in Table 1 and Table 2) to reproduce key preprocessing steps in a traceable, script-driven workflow, and to verify consistency against a conventional GUI-based approach (PCSWMM). Its pseudocode implementation logic has been included in Section S3 of the Supporting file.

2.3.2 Repeatability: equivalence validation between CLI and MCP

In this section, we tested whether the results produced by the packaged MCP service are numerically consistent with a direct command-line interface (CLI) SWMM execution under identical model inputs. Our baseline model is a lumped model with a timestep of 5 minutes, representing the Chicago storm (which is the same INP structure and parameters for hydrology/hydraulics). Two types of tests were performed. In Test 1, a total of 30 runs is conducted where the Chicago storm-shape parameter r (time to peak $r \in [0.30, 0.50]$ f) is increased from 0.30 by an increment of (0.50-0.30)/30 in each run while holding all other model settings constant. Test 2 is similarly 30 runs where the percentage of imperviousness (I) is varied by a factor ranging from $[0.9, 1.1]$ while holding all other model settings constant. Note that there are 30 samples in each test, but we run the test in two different ways (CLI and MCP), resulting in a total of 120 runs. We then compare the degree of agreement of the computed peak flow at the outlet for each run using R^2 and the Nash and Sutcliffe Efficiency (NSE). Theoretically, if CLI and MCP are equivalent, then R^2 and NSE should both be exactly 1.

2.3.3 Reproducibility: SWMM GUI vs Agentic SWMM

To verify cross-system consistency, we manually recreated the baseline model in the SWMM GUI and note that the baseline model is generated by the Agentic SWMM from the user prompt. After the manual configuration, we ran the SWMM GUI and compared the results with the Agentic AI generated baseline model to verify whether its ability to automate configuration using natural language was consistent with manual configuration.

RESULTS

3.1 Verification of data preprocessing tools

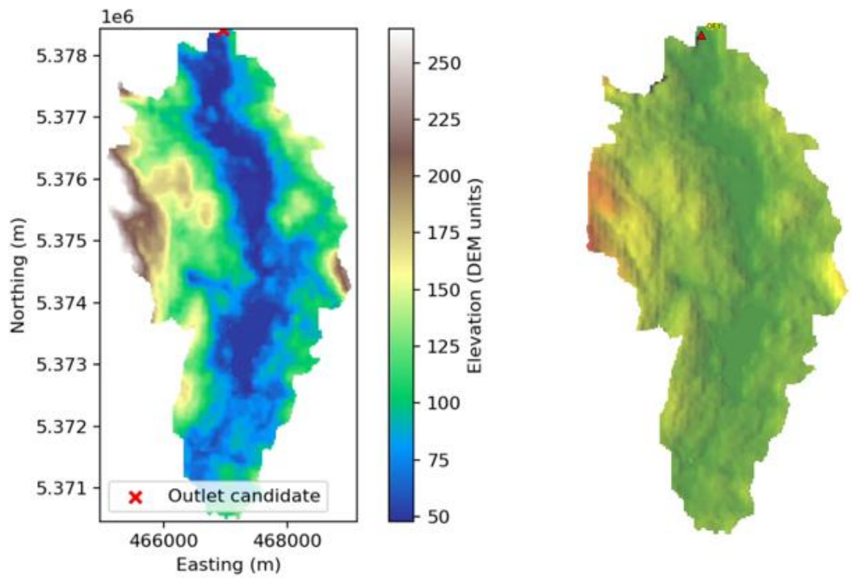
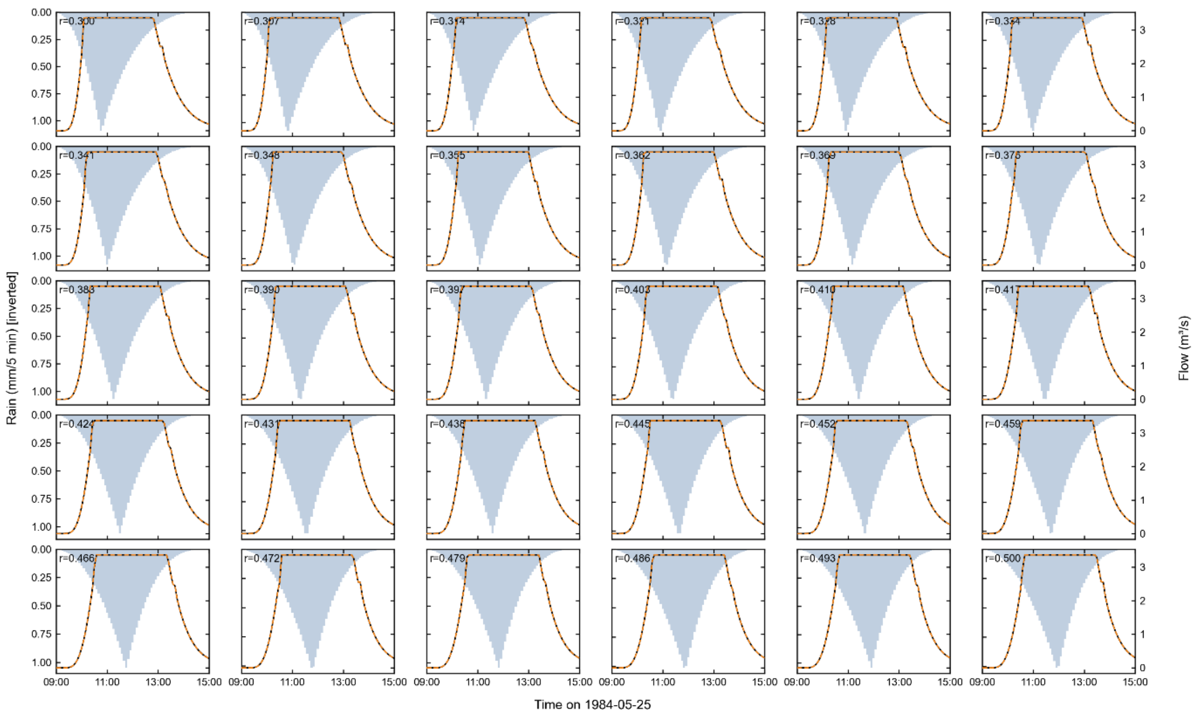


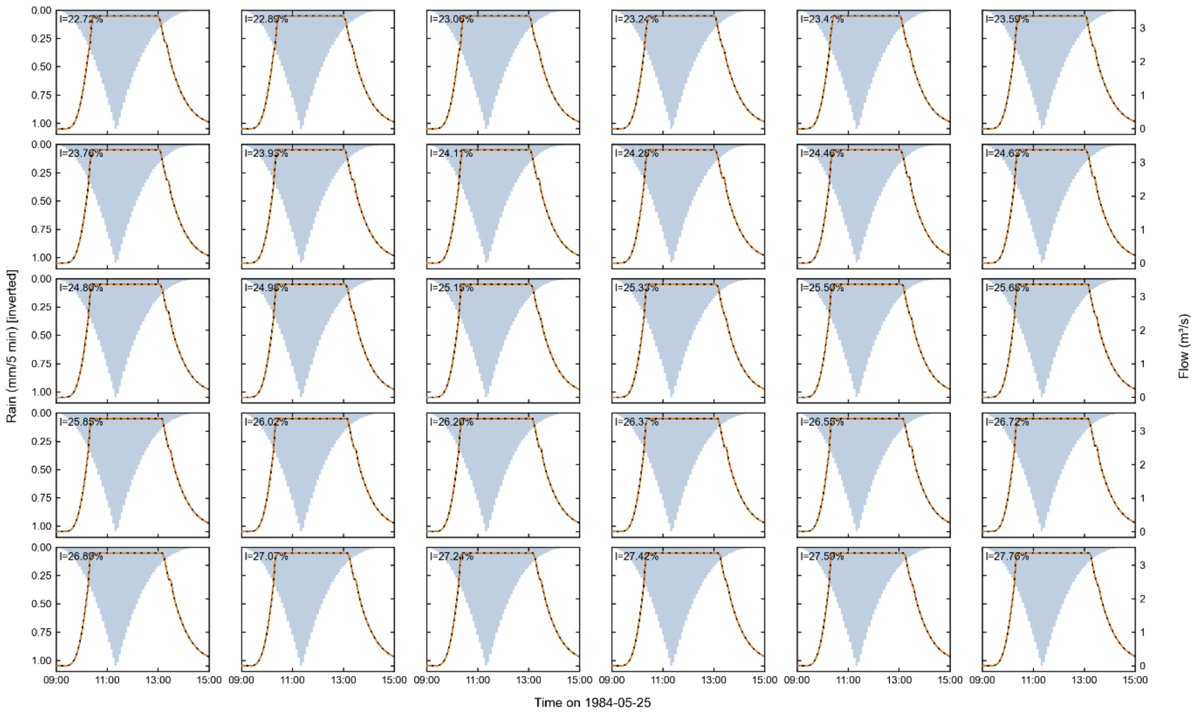
Figure 3**:** The comparison of boundary minimum-elevation outlet detection. Left panel shows the pour-point and watershed boundary generated via and the right panel is the corresponding watershed and pour-point generated with the PCSWMM GUI.

Because SWMM itself does not integrate DEM-related GIS preprocessing functions, we implemented "automatic pour point identification" as an independent script logic SWMM-GIS Skill to extract key spatial features before modeling. Specifically, we used rasterio/numpy generated by OpenClaw to search for the lowest elevation point on the study area boundary as a candidate pour point and automatically output it as a point. In Figure 3, the left panel shows the DEM visualization generated by the OpenClaw SWMM–GIS Skill. The automatically identified candidate pour point is shown as a red mark. The right panel visualization of the pour point location in the same area was generated in PCSWMM using manually identified pour points from (Zhang and Valeo, 2022). The results show that the two methods exhibit high consistency in spatial location and topographical consistency, indicating that Skill can stably produce pour point results similar to those of the traditional GUI workflow.

3.2 Repeatability: SWMM CLI and SWMM MCP



(a)



(b)

Figure 4: Computed hydrographs at the outlet for all 30 runs with hyetograph shown in blue on the left axis (inverted) for (a) Test 1; and (b) Test 2. CLI results are shown as black solid lines and MCP results are orange dashed lines overlaid on top.

Figure 4 a and b, and Figure S2 in the Supplementary file show that the evaluation metrics, R2 and NSE are all identically 1.0, demonstrating consistent predictions across all 30 simulations. Therefore, we can reasonably conclude that the model called by the MCP server, and the model used via the command line through the CLI port are consistent, and that the core hydrological computation based on Openclaw is entirely based on the SWMM engine rather than the large language model itself. Furthermore, the secure hash algorithm 256-bit (SHA256) hashes of the manifest.json files for both tests are all identical; the return code is all 0, and max|ΔQpeak|=0.0, proving that the CLI and MCP have completely identical INPs (same hash). Further indications of the robustness of the MCP service in shown in Table S2 and S4 in the Supplementary file.

3.3 Reproducibility: Agentic SWMM and SWMM GUI

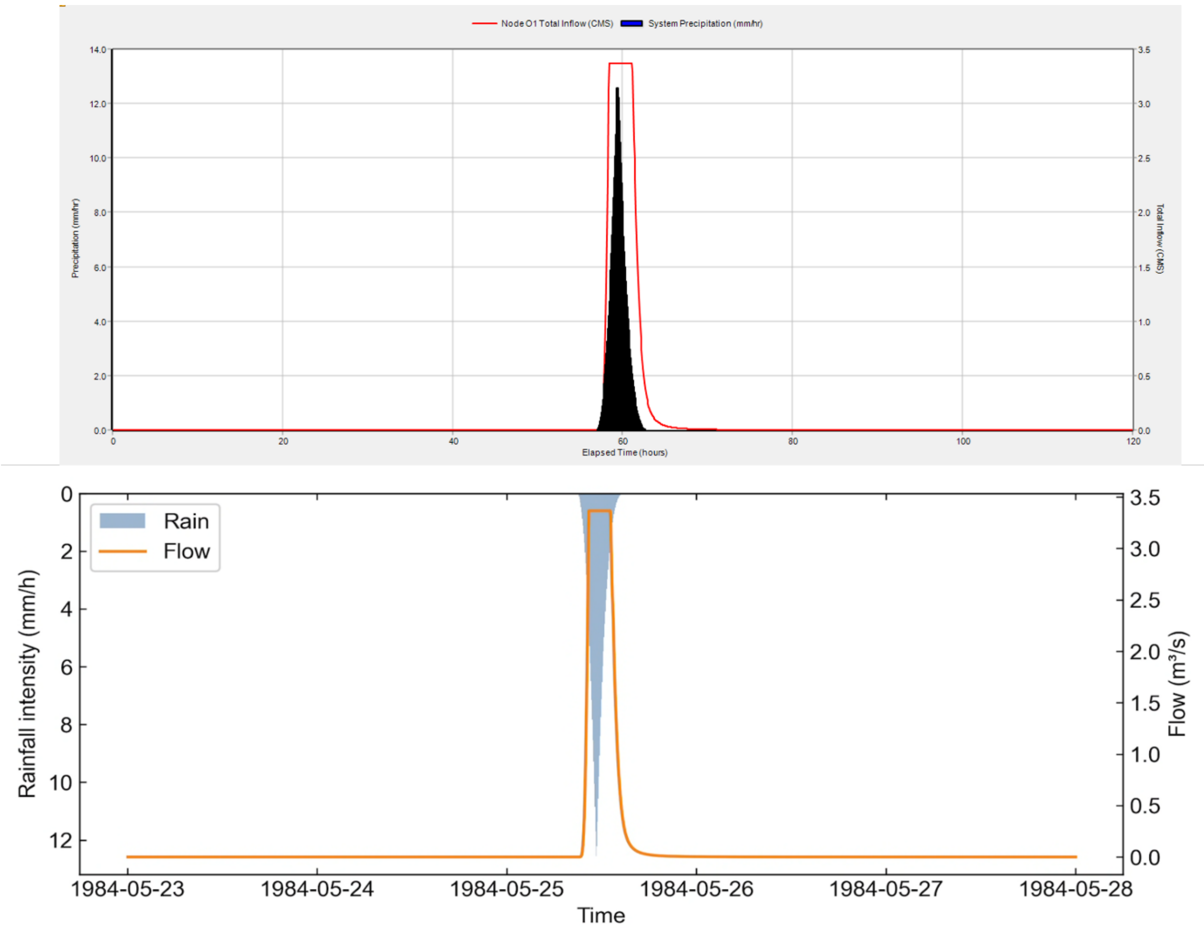


Figure 5: Equivalence between OpenClaw workflow (bottom panel) results and SWMM GUI generated results (top panel).

Using identical INP files we conducted equivalence verification on two execution paths. Figure 5 top panel shows the GUI interface display obtained through manual parameter configuration and execution using the traditional SWMM GUI. Figure 5's bottom panel shows the workflow from Figure 1, entirely driven by OpenClaw through natural language dialogue, utilizing the SWMM Skill and MCP toolchain. Agentic AI automatically generates/verifies inputs from the original dataset, calls swmm5 to execute simulations, and extracts key outputs. As the comparison in Figure 5 shows, the peak flow results obtained from both paths are completely identical, indicating that the OpenClaw driven SWMM modeling approach is practically consistent with GUI execution. This demonstrates that, given the current level of AI development, OpenClaw orchestrated end-to-end workflows can produce event response results are identical to manual GUI operations, greatly expanding the model's usability.

DISCUSSION AND CONCLUSIONS

The MCP and Skills described in this paper suggest that Agentic AI offers a highly effective real-time prediction capability for hydrological modeling in place of traditional GUI modes of parameter modification. OpenClaw is an Agentic AI runtime that orchestrates tool-based workflows (via Skills and MCP) to execute, verify, and reproduce domain tasks beyond conversational responses. This paper details how the OpenClaw architecture, leveraging mainstream MCP services and Skills, can completely replicate the previously manually driven GUI operation process. This application-level implementation greatly facilitates subsequent researchers or users unfamiliar with model deployment and operation to configure their own hydrological models in a very short time. This enables hydrological analysis and modelling, and to the authors' knowledge, this is the first time Agentic AI (OpenClaw) has been applied to peak runoff prediction. In this study, our MCP servers and Skills are primarily prototyped and iterated rapidly through a dialogue-driven workflow, rather than being implemented from scratch with extensive engineering code, enabling a high degree of flexibility and adaptability across different tasks. This offers a high degree of freedom and flexibility, distinguishing it from traditional large language models like GPT in terms of task-specific capabilities. It excels at "act" rather than "answer." Furthermore, OpenClaw is completely open source, allowing it to use local Ollama® models (open-weights LLMs) for inference. This largely ensures data privacy, which is why we chose it as one of our core frameworks.

The interpretability of our results does not arise from Agentic AI itself or from the underlying LLM. Rather, interpretability is grounded in the physical model and its explicit, inspectable input/output files. In our framework, SWMM constitutes the computational core: all hydrologic calculations are executed by SWMM, while the Agentic layer is responsible for orchestration, tracking, and standardized output generation. To mitigate LLM hallucinations, we first established the full end-to-end workflow and then performed manual checks to confirm consistency between automated and reference runs. Moreover, after exposing the MCP interfaces, we packaged the workflow as a standardized Skill (SOP) with mandatory artifacts and quality gates (e.g., continuity diagnostics and consistent QoI definitions), improving portability and substantially reducing the risk of hallucination errors. In practice, while poor prompting can lead to variability in how non-expert users specify tasks, the Skill constrains execution to validated procedures and specifications, thereby shielding the workflow from failures caused by ambiguous or low-quality prompts.

The MCP services or Skills in this paper can be recreated and adjusted according to the needs of end users (such as adjusting quantity of interests like water quality or any function available in SWMM, for example). Future researchers can consider building QGIS MCP as the QGIS is an open-source software, which naturally makes function calls easier compared to commercial software like ArcGIS.

ABBREVIATIONS

EPA	United States Environmental Protection Agency

SWMM®	Storm Water Management Model
MCP	Model Context Protocol
CLI	command-line interface
GUI	graphical user interface
QoI	quantity(ies) of interest
DEM	digital elevation model
GIS	geographic information system
INP / RPT / OUT	SWMM input / report / binary output files
SOP	standard operating procedure
API	application programming interface
LLM	large language model
NSE	Nash − Sutcliffe efficiency
SHA-256	Secure Hash Algorithm 256-bit

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DATA AVAILABILITY STATEMENT

The source codes are available for downloading at the link:
https://github.com/Zhonghao1995/agentic-swmm-workflow

CONFLICT OF INTEREST

The authors declare there exist no financial interests/personal relationships which may be considered as potential competing interests.

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Section S1 Manifest Schema

Table S1. Run Manifest Schema for Reproducible SWMM Execution

Field	Type	Required	Description
manifest_version	string	YES	Manifest schema version.
created_at	string (ISO-8601)	YES	Timestamp when the run record was created.
swmm5.cmd	string	YES	Command used to invoke SWMM engine (e.g., swmm5).
swmm5.version	string|null	RECOMMEND	SWMM engine version if detectable (e.g., 5.2.4).
inp	string (path)	YES	Path to the SWMM input file (.inp).
inp_sha256	string	YES	SHA256 hash of the input INP to guarantee input equivalence (GUI vs CLI).
files.rpt	string (path)	YES	Path to SWMM report file (.rpt).
files.out	string (path)	YES	Path to SWMM binary output (.out).
files.stdout	string (path)	YES	Captured stdout from swmm5 execution.
files.stderr	string (path)	YES	Captured stderr from swmm5 execution.
metrics.peak.node	string	YES	Node/outfall identifier used for peak extraction (e.g., O1).
metrics.peak.peak	number|null	YES	Peak flow value parsed from SWMM report; unit follows INP FLOW_UNITS (paper uses m^3/s).
metrics.peak.time_hhmm	string|null	YES	Time of peak in HH:MM if available in report summary.
metrics.peak.source	string|null	YES	Which SWMM report section provided the peak (e.g., Node Inflow Summary).
metrics.continuity	object	YES	Parsed continuity blocks including continuity_error_percent and underlying tables.
return_code	integer	YES	Return code from swmm5 (0 indicates success).

This table defines the required and recommended fields of the run-level manifest used to record provenance and key metrics for each SWMM simulation by using OpenClaw. The manifest captures execution metadata (timestamp, engine command/version), input identity (INP path and SHA256 hash), generated artifacts (RPT/OUT and logs), extracted peak-flow metrics, continuity check results, and return status, enabling auditable reproduction and GUI–CLI equivalence verification. As well, the Json file are provided as following:

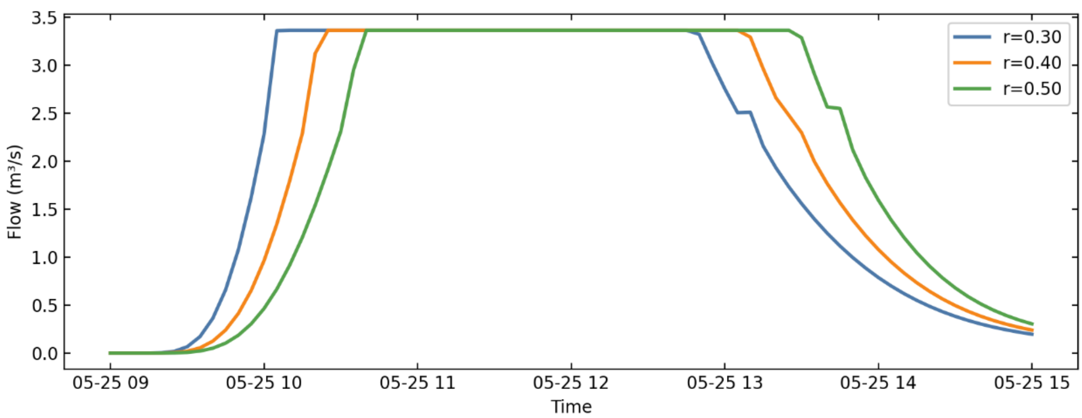
```
{
   "manifest_version": "1.0",
   "created_at": "2026-02-25T09:40:12",
   "swmm5": {
      "cmd": "swmm5",
      "version": "5.2.4"
   },
   "inp": "/path/to/model_chicago5min.inp",
   "inp_sha256": "…",
```

"files": {
    "rpt": "/path/to/model.rpt",
    "out": "/path/to/model.out",
    "stdout": "/path/to/stdout.txt",
    "stderr": "/path/to/stderr.txt"
},
"metrics": {
    "peak": {
        "node": "O1",
        "peak_m3s": 3.366,
        "time_hhmm": "10:31",
        "source": "Node Inflow Summary"
    },
    "continuity_error_percent": {
        "runoff_quantity": 0.003,
        "flow_routing": 0.003
    }
},
"return_code": 0
}

Section S2 Sensitivity analysis to Chicago peak-time ratio (r)

To demonstrate how the agentic workflow supports controlled experimentation, we conducted a supplementary sensitivity test in which only the Chicago hyetograph peak-time ratio *r* was changed while holding constant: (i) total rainfall depth (21.8 mm), (ii) lookup-table parameterization, (iii) outlet selection method, (iv) SWMM version and time stepping, and (v) extraction procedures.

Three cases were evaluated: *r* = 0.30, 0.40 (baseline), and 0.50. Across these runs, the peak flow magnitude at the outfall remained unchanged in this simplified v0 configuration (3.366 m^3/s), while the time of peak shifted systematically (10:11, 10:28, and 10:45, respectively). SWMM-reported continuity errors remained small ($\leq 0.003\%$). This experiment illustrates that the proposed pipeline can generate, run, verify, and summarize controlled scenario variants with minimal manual effort and with complete provenance.



Section S3 Automatic Pour Point Detection Algorithm

Algorithm: FindPourPoint_BoundaryMinElev_ImageFrame(Z, M, T)

Input : Z[H,W], M[H,W] (True=valid), affine transform T

Output: (r*, c*), (x*, y*), z*

B ← {(r,c) | r∈{0,H−1} OR c∈{0,W−1}}

V ← {(r,c) ∈ B | M[r,c]=True AND isfinite(Z[r,c])}

if V = ∅:

raise "No valid boundary cells"

(r*, c*) ← argmin_{(r,c)∈V} Z[r,c]   (optional: tie-break by first / min r / etc.)

z* ← Z[r*,c*]

(x*, y*) ← CellCenter(T, r*, c*)

return (r*, c*), (x*, y*), z*

Section 4 Validation

Table S2. the SHA256 hashes of the manifest.json files for Scenario A

scenario	case	np_sha25	_inp_sha	_inp_sha	a256_mat	return_(	return_(	urn_code	_version	_version	peak_cl	peak_mc	peak_cl	peak_mc	dQpeak	eak_mat	cli_vs_	cli_vs_	runoff_	routing_	i_run_di	p_run_di	r
A_r	r0p3000	d90e998c6	d90e998c6	d90e998c6	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:10	10:10	0	TRUE	1	1	0	0	/Users/zh	/Users/zh	0.3
A_r	r0p3069	873ed9e59	873ed9e59	873ed9e59	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:10	10:10	0	TRUE	1	1	-0.002	-0.002	/Users/zh	/Users/zh	0.306897
A_r	r0p3138	7bee80f63	7bee80f63	7bee80f63	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:15	10:15	0	TRUE	1	1	-0.001	-0.001	/Users/zh	/Users/zh	0.313793
A_r	r0p3207	8806e8213	8806e8213	8806e8213	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:15	10:15	0	TRUE	1	1	0	0	/Users/zh	/Users/zh	0.32069
A_r	r0p3276	b4a7dca52	b4a7dca52	b4a7dca52	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:15	10:15	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.327586
A_r	r0p3345	e4b5df0c3	e4b5df0c3	e4b5df0c3	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:15	10:15	0	TRUE	1	1	0.001	0.001	/Users/zh	/Users/zh	0.334483
A_r	r0p3414	ba53fd2b7	ba53fd2b7	ba53fd2b7	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:20	10:20	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.341379
A_r	r0p3483	4475d09a5	4475d09a5	4475d09a5	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:20	10:20	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.348276
A_r	r0p3552	14e3ca170	14e3ca170	14e3ca170	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:20	10:20	0	TRUE	1	1	0.001	0.001	/Users/zh	/Users/zh	0.355172
A_r	r0p3621	15279d286	15279d286	15279d286	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:20	10:20	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.362069
A_r	r0p3690	1eee5966b	1eee5966b	1eee5966b	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.002	0.002	/Users/zh	/Users/zh	0.368966
A_r	r0p3759	e31edbf28	e31edbf28	e31edbf28	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.375862
A_r	r0p3828	e0254cc83	e0254cc83	e0254cc83	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.382759
A_r	r0p3897	7aa5b0022	7aa5b0022	7aa5b0022	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.389655
A_r	r0p3966	1b699644e	1b699644e	1b699644e	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.001	0.001	/Users/zh	/Users/zh	0.396552
A_r	r0p4034	cca05715e	cca05715e	cca05715e	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.403448
A_r	r0p4103	647122b7b	647122b7b	647122b7b	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.004	0.004	/Users/zh	/Users/zh	0.410345
A_r	r0p4172	5bc9ca6ef	5bc9ca6ef	5bc9ca6ef	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.002	0.002	/Users/zh	/Users/zh	0.417241
A_r	r0p4241	c2086d0b6	c2086d0b6	c2086d0b6	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.004	0.004	/Users/zh	/Users/zh	0.424138
A_r	r0p4310	1b17e9c19	1b17e9c19	1b17e9c19	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:35	10:35	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.431034
A_r	r0p4379	237b95eb2	237b95eb2	237b95eb2	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:35	10:35	0	TRUE	1	1	0.004	0.004	/Users/zh	/Users/zh	0.437931
A_r	r0p4448	2c3770f25	2c3770f25	2c3770f25	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:35	10:35	0	TRUE	1	1	0.002	0.002	/Users/zh	/Users/zh	0.444828
A_r	r0p4517	20f7b0fcc	20f7b0fcc	20f7b0fcc	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:35	10:35	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.451724
A_r	r0p4586	834bca04f	834bca04f	834bca04f	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:40	10:40	0	TRUE	1	1	0.002	0.002	/Users/zh	/Users/zh	0.458621
A_r	r0p4655	7418ae7be	7418ae7be	7418ae7be	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:40	10:40	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.465517
A_r	r0p4724	7d42120f3	7d42120f3	7d42120f3	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:40	10:40	0	TRUE	1	1	0.002	0.002	/Users/zh	/Users/zh	0.472414
A_r	r0p4793	507005be0	507005be0	507005be0	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:40	10:40	0	TRUE	1	1	0.002	0.002	/Users/zh	/Users/zh	0.47931
A_r	r0p4862	030ed1bd2	030ed1bd2	030ed1bd2	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:45	10:45	0	TRUE	1	1	0.001	0.001	/Users/zh	/Users/zh	0.486207
A_r	r0p4931	2134ce64c	2134ce64c	2134ce64c	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:45	10:45	0	TRUE	1	1	0.003	0.003	/Users/zh	/Users/zh	0.493103
A_r	r0p5000	c9580ba3e	c9580ba3e	c9580ba3e	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:45	10:45	0	TRUE	1	1	0.001	0.001	/Users/zh	/Users/zh	0.5

Table S2. the SHA256 hashes of the manifest.json files for Scenario B

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	scenario	case	np_sha25	_inp_sha	_inp_sha	a256_mat	return_	return_	urn_code	_version	_version	peak_cl	peak_mc	peak_cl	peak_mc	dQpeak	eak_mat	cli_vs_	_cli_vs_	runoff_	routing_	i_run_d	p_run_d	perv_pct	
2	B_imperv	imperv22	35fef0401	35fef0401	35fef0401	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	22.716	
3	B_imperv	imperv22	68700533	68700533	68700533	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.004	0.004	/Users/z	/Users/z	22.89007	
4	B_imperv	imperv23	0cec6354	0cec6354	0cec6354	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	23.06414	
5	B_imperv	imperv23	70568e99	70568e99	70568e99	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	23.23821	
6	B_imperv	imperv23	075f2242	075f2242	075f2242	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.004	0.004	/Users/z	/Users/z	23.41228	
7	B_imperv	imperv23	5278df76	5278df76	5278df76	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.002	0.002	/Users/z	/Users/z	23.58634	
8	B_imperv	imperv23	d99593aa	d99593aa	d99593aa	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	23.76041	
9	B_imperv	imperv23	cb337ad5	cb337ad5	cb337ad5	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	23.93448	
10	B_imperv	imperv24	88e8267b	88e8267b	88e8267b	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	24.10855	
11	B_imperv	imperv24	39fbe13e	39fbe13e	39fbe13e	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.004	0.004	/Users/z	/Users/z	24.28262	
12	B_imperv	imperv24	cc48439b	cc48439b	cc48439b	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.002	0.002	/Users/z	/Users/z	24.45669	
13	B_imperv	imperv24	24bb18fb	24bb18fb	24bb18fb	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0	0	/Users/z	/Users/z	24.63076	
14	B_imperv	imperv24	7b845e22	7b845e22	7b845e22	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	24.80483	
15	B_imperv	imperv24	554124e0	554124e0	554124e0	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	24.9789	
16	B_imperv	imperv25	227a6972	227a6972	227a6972	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	25.15297	
17	B_imperv	imperv25	0bff6b3d	0bff6b3d	0bff6b3d	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.002	0.002	/Users/z	/Users/z	25.32703	
18	B_imperv	imperv25	8a4837e9	8a4837e9	8a4837e9	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	25.5011	
19	B_imperv	imperv25	277f8c8f	277f8c8f	277f8c8f	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:30	10:30	0	TRUE	1	1	0.002	0.002	/Users/z	/Users/z	25.67517	
20	B_imperv	imperv25	8c2f0bc4	8c2f0bc4	8c2f0bc4	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	25.84924	
21	B_imperv	imperv26	7215ea69	7215ea69	7215ea69	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	26.02331	
22	B_imperv	imperv26	dc6ce071	dc6ce071	dc6ce071	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	26.19738	
23	B_imperv	imperv26	cd508750	cd508750	cd508750	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	26.37145	
24	B_imperv	imperv26	f9636e78	f9636e78	f9636e78	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	26.54552	
25	B_imperv	imperv26	ea7d39c3	ea7d39c3	ea7d39c3	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.001	0.001	/Users/z	/Users/z	26.71959	
26	B_imperv	imperv26	865c6396	865c6396	865c6396	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	26.89366	
27	B_imperv	imperv27	6ae034fd	6ae034fd	6ae034fd	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0	0	/Users/z	/Users/z	27.06772	
28	B_imperv	imperv27	6c0152bb	6c0152bb	6c0152bb	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.002	0.002	/Users/z	/Users/z	27.24179	
29	B_imperv	imperv27	558a9416	558a9416	558a9416	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	27.41586	
30	B_imperv	imperv27	e4d3edec	e4d3edec	e4d3edec	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.002	0.002	/Users/z	/Users/z	27.58993	
31	B_imperv	imperv27	a7d6367d	a7d6367d	a7d6367d	TRUE	0	0	TRUE	5.2.4	5.2.4	3.365671	3.365671	10:25	10:25	0	TRUE	1	1	0.003	0.003	/Users/z	/Users/z	27.764	
32																									
33																									