

# SWAT+ AI

## Help Documentation



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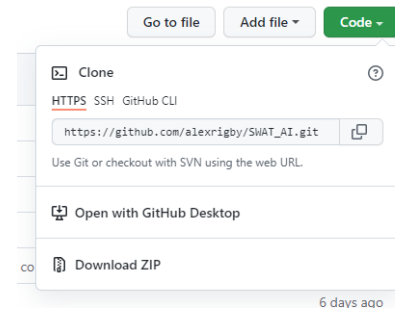
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# 1 Downloads

## 1.1 SWAT+ AI

Download: [https://github.com/alexrigby/SWAT\\_AI.git](https://github.com/alexrigby/SWAT_AI.git)

To download go to the GitHub link, click the green 'Code' button, and select 'Download ZIP'. Extract the zipped files in a safe location on your PC.

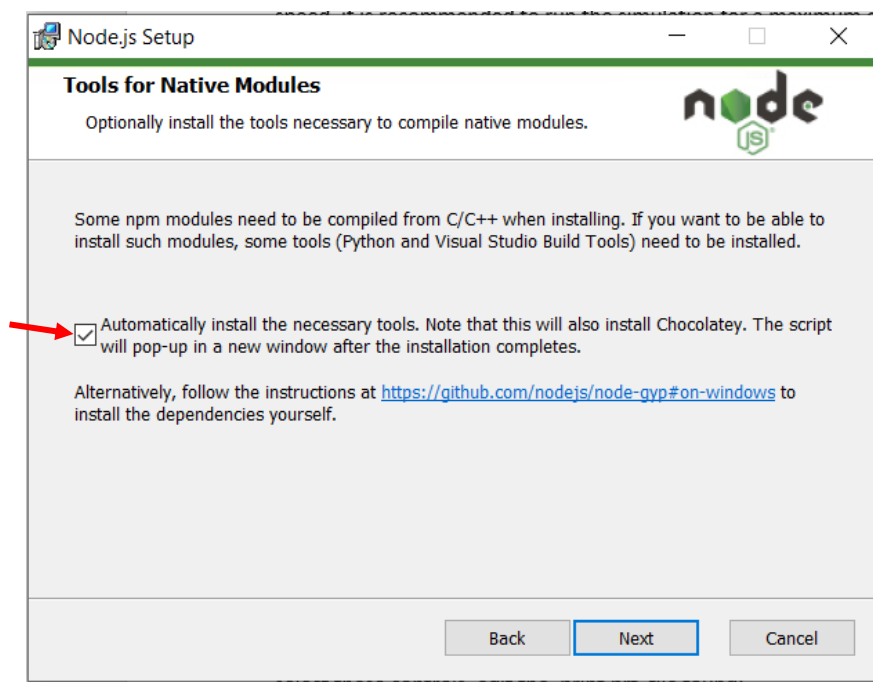


**IMPORTANT:** Depending on the number of catchments used to train the model, the folder can take up a lot of memory, to prevent complications it is best to save SWAT+ AI in a location not synced to any cloud storage service.

## 1.2 Node.js, npm, Python

Installed Node.js, npm and Python 3 as a package, choose the 64-bit download for windows (.msi) from: [Download | Node.js \(nodejs.org\)](#)

Follow the default installation process, **TICK** 'automatically install the necessary tools' in the 'Tools for Native Modules' window. Once node is installed a CMD (command line interpreter) window will appear displaying status of the 'necessary tools' installation (this will take a few minutes).



## 2 Set Up

### 2.1 SWAT+ Catchment Modelling

As its input data SWAT+ AI requires:

- **Uncalibrated** SWAT+ catchments
- Daily observed flow for the training catchments: [Search Data | National River Flow Archive \(ceh.ac.uk\)](#)

If you are not familiar with SWAT+ please visit the links below:

- SWAT+ download: [Installation - SWAT+ Documentation \(gitbook.io\)](#)
- A Useful short video series on getting started with SWAT+: <https://youtu.be/dBARTcejaPM>

**IMPORTANT:** Do **not** calibrate SWAT+ catchments before intended for training in SWAT+ AI.

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### 2.2 Importing Data for Dataset Preparation

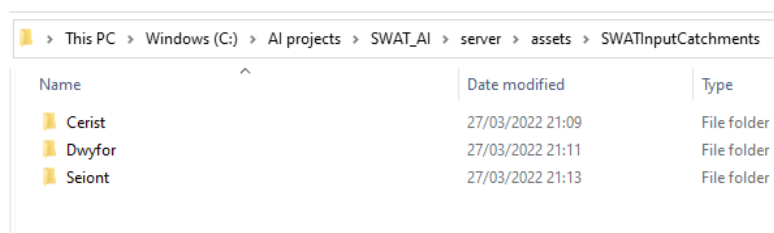
To prevent accidental corruption of local files the ability to navigate and connect to the local file systems was excluded from the SWAT+ AI interface.

SWAT+ AI requires full SWAT+ catchment directories as its input (the application extracts all relevant data at a later stage). To access the data, the catchments need to first be manually copied into the correct directories.

**IMPORTANT:** The SWAT+ simulation for both the training and prediction catchments must have been ran once with the output files: '**basin\_wb**', '**basin\_pw**' and '**channel\_sd**' printed at a **daily** timestep in CSV format ('./Scenarios/Default/TxtInOut/print.prt').

#### 2.2.1 Prediction Data

For catchment that flow predictions are to be made for, copy the entire SWAT+ catchment into the directory: '**./SWAT\_AI/server/assets/SWATInputCatchments/**'



Name	Date modified	Type
Cerist	27/03/2022 21:09	File folder
Dwyfor	27/03/2022 21:11	File folder
Seiont	27/03/2022 21:13	File folder

#### 2.2.2 Training Data

**\*\*\*To only make predictions and not define new AI models skip to section 2.3**


For training catchments (catchments where observed flow is available), copy the SWAT+ catchments into the directory: '**./SWAT\_AI/server/assets/SWATTrainingCatchments/**'

The AI model uses daily gauged flow as its ‘target’ variable (i.e., the value it is training to predict). Daily gauged flow is available to download from the NRFA website in CSV format (section 2.1). **Delete** the meta data in and **rename** the columns ‘date’ and ‘flow’. **Rename** the observed flow file the same name as its corresponding catchment + \_dly\_flo (e.g., ‘Dysynni\_dly\_flo.csv’).

Save the file in the directory ‘./SWAT\_AI/server/assets/reference/flowObservations/’

*\*\*\*some North Wales flows are already included in this directory, please check and name catchments accordingly*

	A	B	C	D	E	F
1	file	timestamp	2022-03-29T08:40:31			
2	database	id	nrfa-public-21			
3	database	name	UK National River Flow Archive			
4	station	id	64002			
5	station	name	Dysynni at Pont-y-Garth			
6	station	gridRefer	SH6311706604			
7	station	descriptio	Velocity area station with informal flat-v sty			
8	station	descriptio	Velocity area station with informal flat-v sty			
9	station	descriptio	Insensitive at low flows. Suffers from weed			
10	station	descriptio	Pre-1997 peak flow data from the old station			
11	station	descriptio	Impermeable Ordovician sediments with vo			
12	station	descriptio	Natural to within 10% at Q95.			
13	dataType	id	gdf			
14	dataType	name	Gauged Daily Flow			
15	dataType	paramete	Flow			
16	dataType	units	m3/s			
17	dataType	period	day (P1D)			
18	dataType	measuren	Mean			
19	data	first	#####			
20	data	last	#####			
21	01/01/1966		7.56			
22	02/01/1966		7.36			
23	03/01/1966		5.72			
24	04/01/1966		5.26			
25	05/01/1966		4.7			



	A	B	C	D
1	date	flow		
2	01/01/1966	7.56		
3	02/01/1966	7.36		
4	03/01/1966	5.72		
5	04/01/1966	5.26		
6	05/01/1966	4.7		
7	06/01/1966	4.19		
8	07/01/1966	3.76		
9	08/01/1966	3.39		
10	09/01/1966	3.05		
11	10/01/1966	2.74		
12	11/01/1966	2.48		
13	12/01/1966	2.27		
14	13/01/1966	2.15		
15	14/01/1966	2.01		
16	15/01/1966	1.84		
17	16/01/1966	1.78		
18	17/01/1966	1.72		
19	18/01/1966	1.38		
20	19/01/1966	0.78		
21	20/01/1966	1.38		
22	21/01/1966	1.55		
23	22/01/1966	1.5		
24	23/01/1966	1.4		
25	24/01/1966	1.49		

**IMPORTANT:** SWAT+ AI is a preliminary development and is set up to accept catchments with the land uses and soil types found in North Wales therefore may not work correctly for catchments containing different land uses and soil types.

## 2.3 Server Set Up

**IMPORTANT:** If this is the first time the SWAT+ AI application has been ran on this machine then in CMD (Command Prompt) navigate the location of SWAT+ AI by typing ‘cd [file location]\SWAT\_AI’ and pressing enter. From here type the command ‘**npm install**’ to install all relevant packages. **DO NOT** follow this step if you have previously installed the relevant packages.

```

Command Prompt
Microsoft Windows [Version 10.0.19042.1526]
(c) Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32>cd C:\AI projects\SWAT_AI
C:\AI projects\SWAT_AI> npm install
  
```

Launch the “data server” (back end): Open CMD and navigate to the toolkit location by typing ‘*cd [file location]\SWAT\_AI*’ and pressing enter. Launch the server by typing ‘*npm run swat-ai-server*’ and pressing enter on the keyboard.

```
npm run swat-ai-server
Microsoft Windows [Version 10.0.19042.1526]
(c) Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32> cd C:\AI projects\SWAT_AI
C:\AI projects\SWAT_AI> npm run swat-ai-server
> tensorflow-tutorial11.1@1.0.0 swat-ai-server
> node .\server

SWAT Server Listening on Port 8000
```

Launch the front-end server: In a new CMD window navigate to the file location again. Launch the Python server by typing ‘*npm run swat-ai*’ and hitting enter on the keyboard.

```
npm run swat-ai
Microsoft Windows [Version 10.0.19042.1526]
(c) Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32>cd C:\AI projects\SWAT_AI
C:\AI projects\SWAT_AI> npm run swat-ai
> tensorflow-tutorial11.1@1.0.0 swat-ai
> python serve.py

serving at port 8001
```

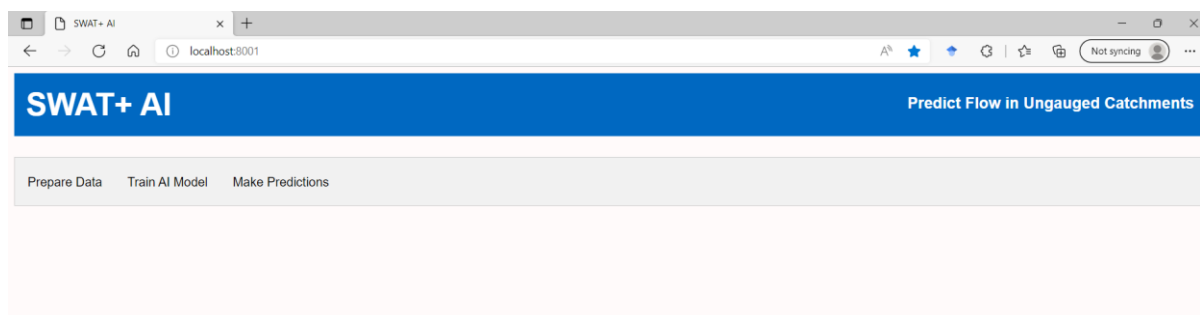
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## 3 Using the Toolkit

### 3.1 Opening SWAT+ AI

Navigate to the URL in your chosen browser: <http://localhost:8001/>

SWAT+ AI should now be running on the server port 8001 from the local PC (step 2.3). The browser window will display the blank opening page with the tab options ‘Prepare Data’, ‘Train AI Model’ and ‘Make Predictions’.



## 3.2 Prepare Data

Before training or predictions can take place the correct data needs to be extracted from the relevant SWAT+ files and compiled into a single dataset (CSV file). This can be done through the application.

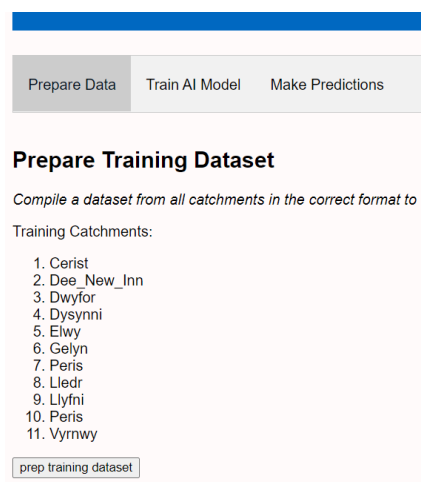
**IMPORTANT:** At the current stage of development SWAT+ AI data preparation cannot accept SWAT+ catchments larger than around 550MB. It is advised to make a copy of catchments larger than this then run one of the copies for the first half of the simulation period and the other copy for the second half of the simulation period.

### 3.2.1 Prepare Training Dataset

**\*\*\*skip to 3.2.2 if not training a new model**

The catchments present in './SWAT\_AI/server/assets/SWATTrainingCatchments/' are displayed on the screen. Click the 'prep training dataset' button to compile the training dataset. A loading spinner will appear and then disappear when the dataset is prepared.

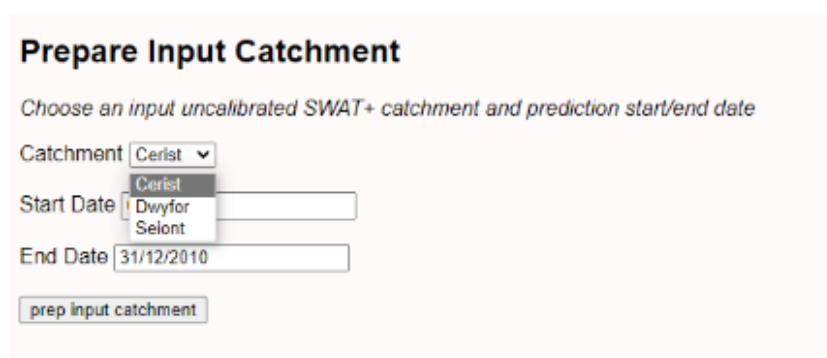
Training datasets are saved to: './SWAT\_AI/server/assets/trainingDatasets/'



The screenshot shows a web interface with a blue header bar. Below it is a navigation bar with three tabs: 'Prepare Data' (active), 'Train AI Model', and 'Make Predictions'. The main content area is titled 'Prepare Training Dataset' and contains the instruction 'Compile a dataset from all catchments in the correct format to train the model'. Below this, it says 'Training Catchments:' followed by a numbered list of 11 catchments: 1. Cerist, 2. Dee\_New\_Inn, 3. Dwyfor, 4. Dysynni, 5. Elwy, 6. Gelyn, 7. Peris, 8. Lledr, 9. Llyfni, 10. Peris, and 11. Vyrnwy. At the bottom of the list is a button labeled 'prep training dataset'.

### 3.2.2 Prepare Input Data

Choose the catchment that flow predictions are going to be made for. Choose the start and end date of the prediction period (bear in mind the simulation period of your original SWAT+ model). Click 'prep input catchment' to prepare the data, when the loading spinner has disappeared the data is prepared.



The screenshot shows a web interface titled 'Prepare Input Catchment' with the instruction 'Choose an input uncalibrated SWAT+ catchment and prediction start/end date'. It features three input fields: 'Catchment' with a dropdown menu showing 'Cerist' and a list of other options (Cerist, Dwyfor, Selont); 'Start Date' with a text input field; and 'End Date' with a text input field containing '31/12/2010'. At the bottom is a button labeled 'prep input catchment'.

The catchment data is saved in a CSV file named: 'catchment name\_start year\_end year'

Input catchment data is save to: './SWAT\_AI/server/assets/inputData/'

**IMPORTANT:** Predictions should not be made for a catchment that has been included in the training data.

### 3.3 Train AI Model

\*\*\*skip to 3.4 if not training a new model

#### 3.3.3 Model Architecture

A shallow (one hidden layer) ANN (Artificial Neural Network) was identified as an adequate model for this type of non-linear regression. In this tab some of the models architecture can be edited to try and optimize model performance.

**Epochs:** Number training iterations

**Nodes:** Number of inputs passed to next layer

**Activation:** Activation function of the layer

**Validation Split:** Fraction of the dataset to use in validation (i.e., 0.1 = 10% of the dataset used for validation)

Prepare Data	Train AI Model	Make Predictions
<p>The model is an ANN with one hidden layer (also known as a Multilayer Perceptron). Train a new model or go to 'Make Predictions' to predict flow using an existing model</p> <h3>Model Architecture</h3> <p>Control model paramaters to optimize prediction Accuracy</p> <p>Epochs <input type="text" value="50"/></p> <p>Input Layer: Nodes <input type="text" value="22"/> Activation <input type="text" value="ReLU"/></p> <p>Hidden Layer: Nodes <input type="text" value="14"/> Activation <input type="text" value="ReLU"/></p> <p>Validation Split (fraction of dataset) <input type="text" value="0.1"/></p>		

#### 3.3.4 Train The Model

Choose one of the training datasets prepared in the 'Prepare Data' tab (section 3.2.1). Click 'train' to train the model.

### Train The Model

Choose a dataset prepared in 'Prepare Data' to train the ANN

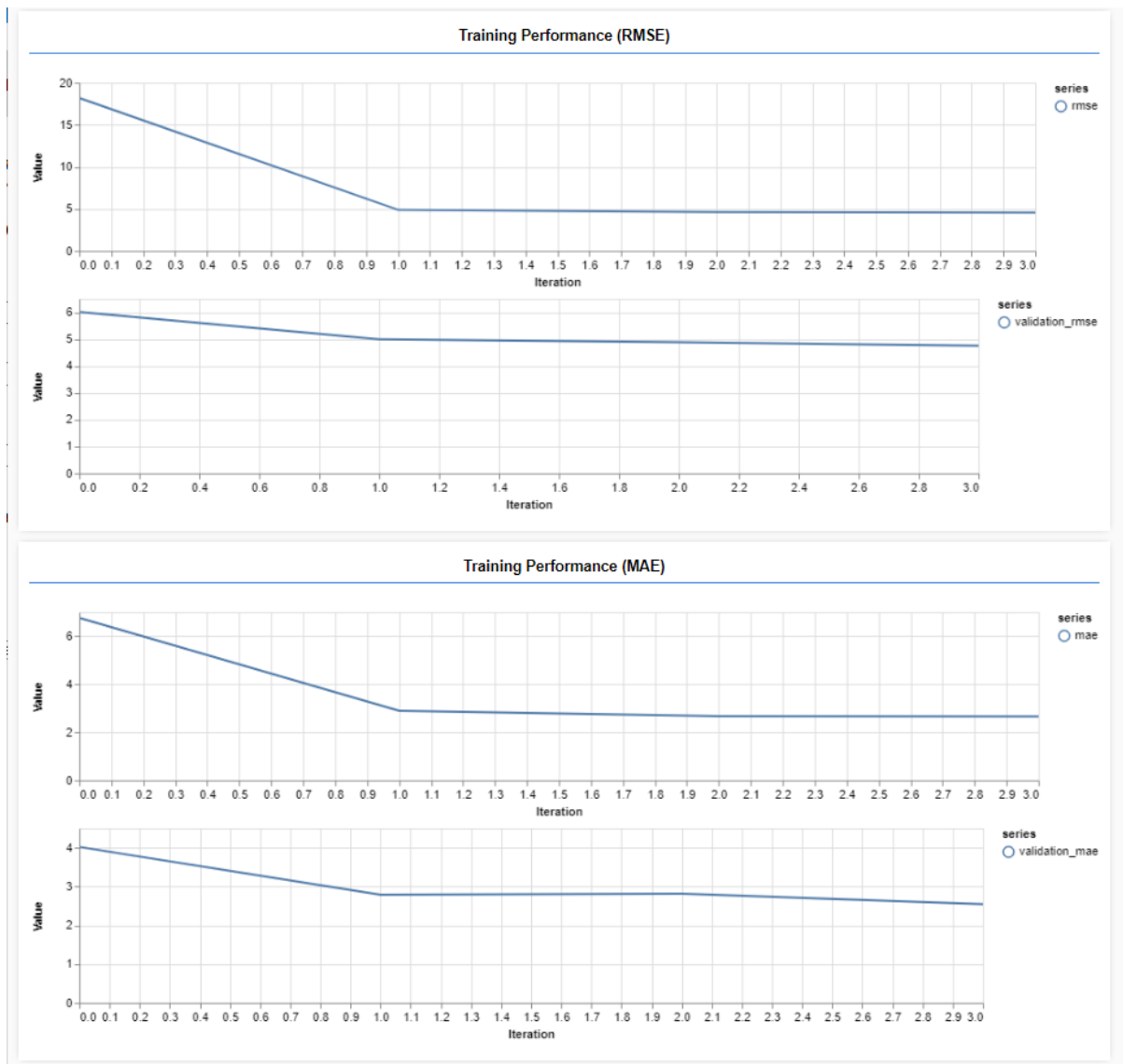
Training Dataset

11catchments\_10yrs.csv

3catchments\_10yrs.csv



A window will pop up on right of the screen with plots of the RMSE (Root Mean Squared Error) and MAE (Mean Absolut Error) per epoch (iteration) indicating how well the model is 'learning'.



When the model finishes training, minimize the training plots in the top left of the window. Final accuracy metrics are displayed on the screen. Save the model by clicking the 'save trained model' button. The model is given an automatic name:

*'number of catchments\_epochs\_input nodes and activation\_hidden layer nodes and activation'*

Saved models are downloaded to the 'downloads' directory. Copy both the .bin and .json files to:  
`"/SWAT_AI/server/assets/models/"`

## 3.4 Make Predictions

### 3.4.5 Choose prediction files

Select a trained model to use to make predictions. Unless a custom model has been trained, ‘\_main.json’ as the prediction model for North Wales. Select the catchment to make predictions on (prepared in section 3.2.2) from the drop-down menu. Click the ‘predict’ button.

Prepare Data

Train AI Model

Make Predictions

Select a trained ANN (*\_main is the default*) and an uncalibrated SWAT+ catchment to make flow predictions

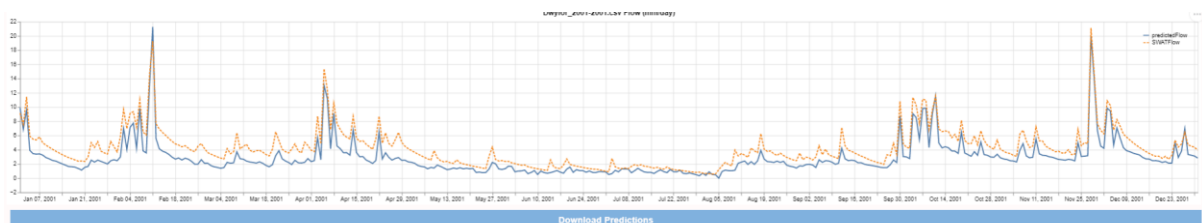
### Predict Flow

Select Model

Select Catchment

### 3.4.6 Predict and Download Flow

Once the model has predicted the flow a plot will pop up with the predicted flow (blue line) and the uncalibrated SWAT+ flow (orange dotted line) in mm/day. The data can then be downloaded as a CSV file by clicking the blue ‘Download Predictions’ Button.



## IMPORTANT

SWAT+ AI was developed as a showcase of how AI can be implemented to help hydrological investigation in ungauged catchments as an alternative to traditional methods of regionalisation. Although the AI model and techniques used in SWAT+ AI have shown promising preliminary results, further trialling and testing is needed to confirm that the algorithm works as expected on a range of catchments.

It is hypothesised by the developers that an increase in catchments used for training will improve the model’s accuracy and ability to predict flows in a wider variety of catchments.

