ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09-11 December 2025 | Online

MDPI

Numerical Simulation of Water Table Dynamics for Construction Planning

David Beltrán-Vargas [1*], Fernando García-Páez [1], Manuel Martínez-Morales [2]

[1] Department of Civil Engineering, Autonomous University of Sinaloa, 80013, Culiacán, Sinaloa, México

[2] Groundwater Hydrology Division, Mexican Institute of Water Technology, 62550, Juitepec Morelos, México

INTRODUCTION & AIM

Context

Groundwater flow in coastal urban areas is influenced by different factors such as tides, precipitation, lagoon–aquifer interactions, regional flow, and urban constructions that modify subsurface conditions.

Problem Statement

Buildings founded below the phreatic surface require an accurate estimation of groundwater level variations to prevent potential problems during the construction process.

Aim

To simulate and analyze short-term groundwater level variations in a coastal area of Mazatlán, using MODFLOW 6 and ModelMuse, as a tool for optimizing construction planning below the water table.

METHOD

The following section summarizes the modeling approach, boundary conditions, and calibration process applied to simulate groundwater dynamics

Data collection → **Model setup** → **Boundary assignment** → **Calibration and validation** → **Transient simulation**

Figure 1. Workflow diagram.

Data	DEM Piezometric level Tidal fluctuation Urban infrastructure
Software	QGIS, MODFLOW (v.6.6.3) and ModelMuse (v5.4.0.0)
Aquifer type	Unconfined coastal aquifer influenced by the Pacific Ocean and Laguna del Camarón
Model domain	1.39 × 0.74 km, 5 × 5 m cell size (DEM from QGIS)
Boundary conditions – MODFLOW Package	Ocean (tidal fluctuation) – GHB Lagoon – LAK Regional groundwater flow – GHB Barriers – HFB
Simulations	Six transient models (Nov 2023–Apr 2024) representing critical conditions (highest piezometric level measured in situ)
Calibration	Three daily piezometric records (09:00, 12:00, 15:00 h) used to adjust hydraulic parameters

Table 1. Overview of modeling methodology

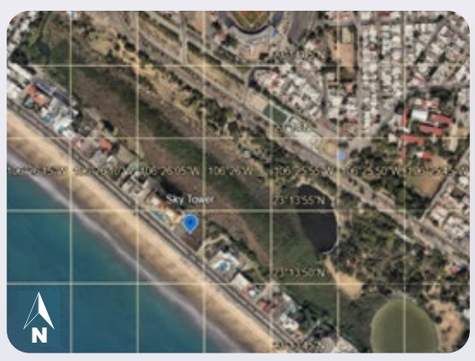


Figure 2. Study case location.

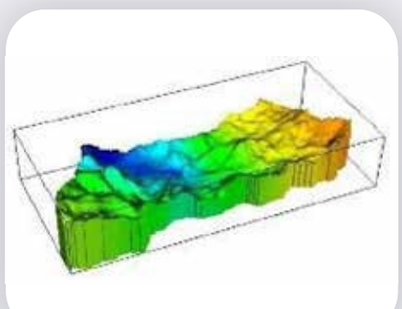
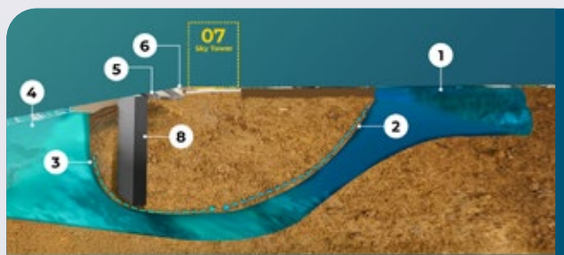


Figure 3. Numerical model conceptualization.



1. Laguna del Camarón (Lagoon)
2. Lagoonal groundwater flow network
3. Tidal groundwater flow network
4. Ocean influenced by tidal fluctuation
5. Malecón (seawall)
6. Urban construction
7. New construction project (Sky Tower)
8. Impermeable barrier

Figure 4. Representative Groundwater Flow Network

RESULTS

The following figures and tables present the comparison between observed and simulated groundwater levels, as well as the model's performance metrics for each critical scenario.

Day	Hour	Observed level (m.a.s.l.)	Simulated level (m.a.s.l.)
11/14/2023	09:00	0.24	0.315866
11/14/2023	12:00	0.36	0.398107
11/14/2023	15:00	0.53	0.501742
12/13/2023	09:00	0.17	0.230834
12/13/2023	12:00	0.29	0.348725
12/13/2023	15:00	0.46	0.477942
01/11/2024	09:00	0.14	0.196723
01/11/2024	12:00	0.26	0.320904
01/11/2024	15:00	0.41	0.46821
02/09/2024	09:00	0.1	0.015872
02/09/2024	12:00	0.25	0.20532
02/09/2024	15:00	0.38	0.381399
03/09/2024	09:00	-0.06	0.018105
03/09/2024	12:00	0.14	0.182957
03/09/2024	15:00	0.35	0.350492
04/09/2024	09:00	-0.12	-0.06316
04/09/2024	12:00	0.01	-0.082544
04/09/2024	15:00	0.31	0.219072

Table 2. Observed level vs simulated level.

Date	MAE (m)	RMSE (m)
2023-11-14	0.047	0.052
2023-12-13	0.046	0.050
2024-01-11	0.049	0.051
2024-02-09	0.032	0.038
2024-03-09	0.041	0.051
2024-04-09	0.080	0.082

Table 3. MAE and RMSE per month.

Period	MAE (m)	RMSE (m)
Nov 2023 – Apr 2024	0.049	0.056

Table 4. MAE and RMSE global.

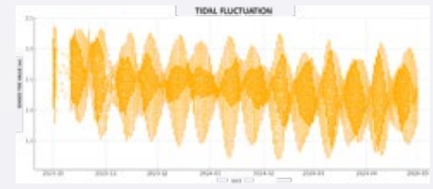


Figure 5. Tidal observations.

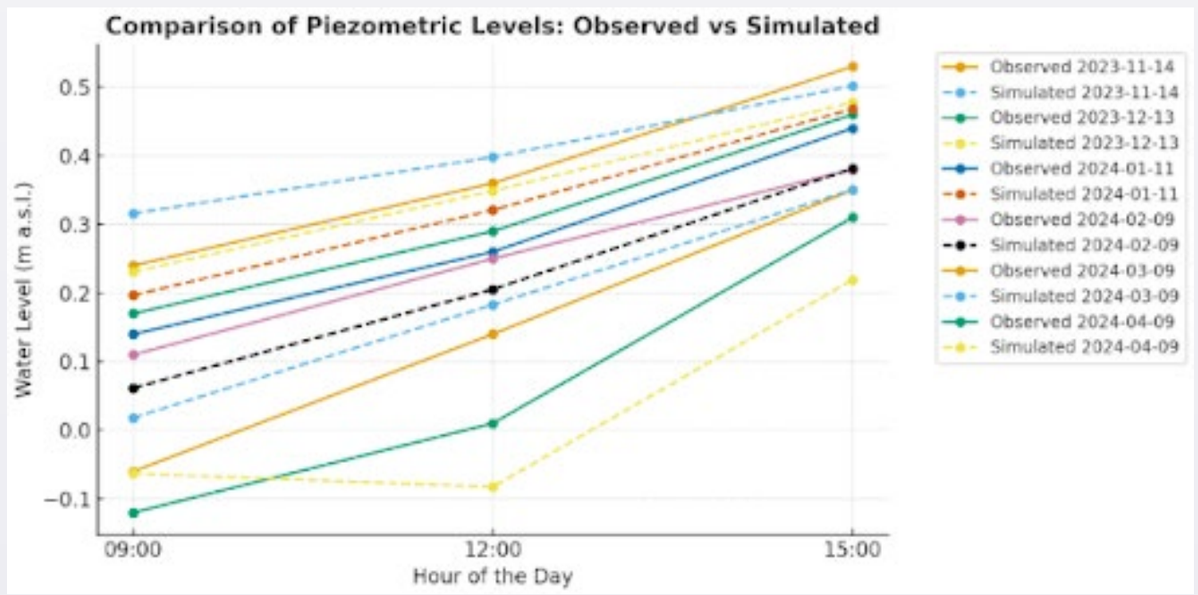


Figure 6. Observed level vs simulated level.

CONCLUSIONS

- The numerical model accurately reproduced groundwater fluctuations under tidal influence, with deviations of only a few centimeters.
- Tides are the main factor controlling short-term groundwater dynamics in this project.
- The model proves to be a reliable tool for planning constructions below the water table, such as the new project founded at approximately –2 m.a.s.l., helping anticipate dewatering needs and ensure safer, more sustainable construction.

FURTHER WORKS

- The integration of numerical modeling with structural design tools is also planned to optimize foundation and groundwater control strategies in coastal construction projects.
- Additional monitoring data will be incorporated to evaluate the performance of dewatering systems during excavation.
- These advances aim to promote more sustainable construction practices, improving groundwater management and minimizing environmental impacts in urban coastal areas.

"Sustainable construction begins with understanding the natural dynamics of groundwater systems."

David Beltrán-Vargas

davidbeltranvargas.fic@uas.edu.mx