HYDRAULIC ANALYSIS REPORT

Rosarito Desalination Plant

Pump Operation Scenarios Report — Seawater Intake System

CONFIDENTIAL

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1 Executive Summary

This report presents the hydraulic analysis of the seawater intake pumping system for the Rosarito Desalination Plant (Baja California, México). The system comprises five Ruhrpumpen 35WX vertical centrifugal pumps (4 duty + 1 standby) operating in parallel, controlled by a VAG RIKO DN1800 plunger valve that modulates headloss to maintain stable operating points across all staging scenarios.

Key findings:

- All four staging scenarios (4-pump down to 1-pump) converge to stable operating points within the pump's recommended operating envelope.
- Validation against hand-calculated reference values shows deviations well below the 5% acceptance threshold.
- The rule-based control system successfully manages pump trip/restore events during the 24-hour extended period simulation, with automatic standby pump activation and valve position adjustment.
- The 1-pump scenario operates below the VAG minimum flow recommendation (4,500 m³/h), which is a known system characteristic.

2 System Overview

2.1 Topology

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SEA (H=0m) → P_INTAKE → J_SUCTION → PUMP_1..5 (parallel) → J_MANIFOLD
→ P_US → J_RIKO_IN → RIKO valve (GPV) → J_RIKO_OUT
→ P_DS → PLANT (H=18.17m)
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2.2 Equipment

Equipment	Specification
Pumps	5× Ruhrpumpen 35WX vertical centrifugal (4 duty + 1 standby)
Control valve	VAG RIKO DN1800 plunger valve
Configuration	N+1 redundancy, rule-based staging per Georgescu et al. (CCWI 2015)
Intake pipe	DN2500, Darcy-Weisbach friction
Upstream/downstream	DN1800, Darcy-Weisbach friction

2.3 Operating Principle

The RIKO plunger valve adjusts its opening (22%–44%) to match the number of active pumps, providing sufficient throttling headloss to keep each pump near its best efficiency point. Four parallel GPV links in EPANET model different valve openings; rule-based controls activate the correct GPV when pump count changes.

3 Steady-State Staging Scenarios

Four scenarios model the system from full capacity (4 duty pumps) down to minimum capacity (1 pump). Each scenario uses the corresponding RIKO valve opening determined by the control rules.

Pumps	RIKO (%)	Kv (m³/h)	Q_total (l/s)	Q_total (m³/h)	Q/pump (l/s)	H_pump (m)	dH_RIKO (m)	v_DS (m/s)	hf_INTAKE (m)	hf_US (m)	hf_DS (m)
4	44	21,038.45	5012.2	18044	1253.1	26.14	7.5	1.97	0.029	0.094	0.345
3	38	14,444.21	3660.9	13179	1220.3	26.93	8.5	1.439	0.016	0.052	0.19
2	30	7,621.47	2218.6	7987	1109.3	29.51	11.24	0.872	0.006	0.02	0.074
1	22	3,179.78	1012.3	3644	1012.3	31.66	13.47	0.398	0.001	0.005	0.017

Table 1: Steady-state operating points for all staging scenarios

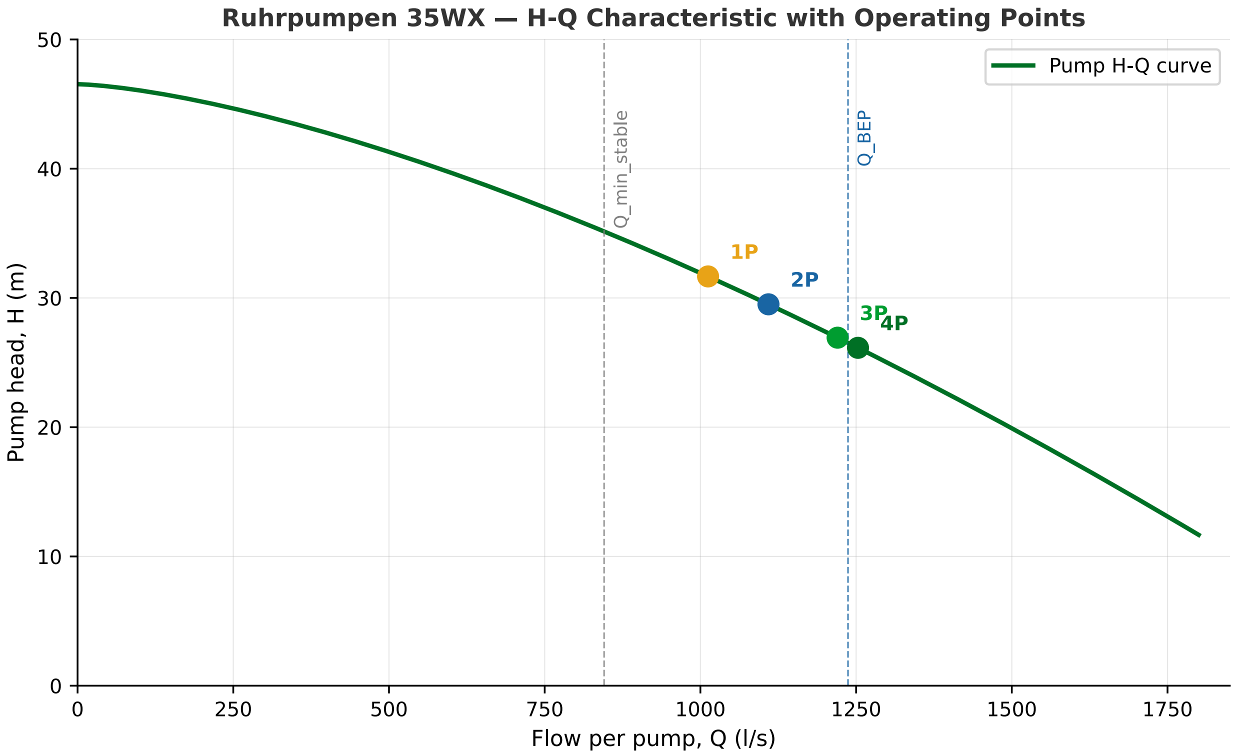

Figure 1: Ruhrpumpen 35WX H-Q characteristic curve with computed operating points for each staging scenario

4 Energy Summary

Pump power calculations use the ISO 5167 Kv-based headloss method. Efficiency is fixed at the duty-point value (η = 88%) for all scenarios. Actual efficiency varies slightly with operating point.

Pumps	Q/pump (l/s)	H_pump (m)	η (%)	P_hyd (kW)	P_shaft (kW)	Motor load (%)	P_total (kW)	E_24h (kWh)
4	1253.1	26.14	88	329.4	374.3	83.7	1497.1	35,931
3	1220.3	26.93	88	330.4	375.4	84	1126.3	27,031
2	1109.3	29.51	88	329.1	374	83.7	748	17,953
1	1012.3	31.66	88	322.3	366.3	81.9	366.3	8,790

Table 2: Pump power and 24-hour energy consumption per staging scenario

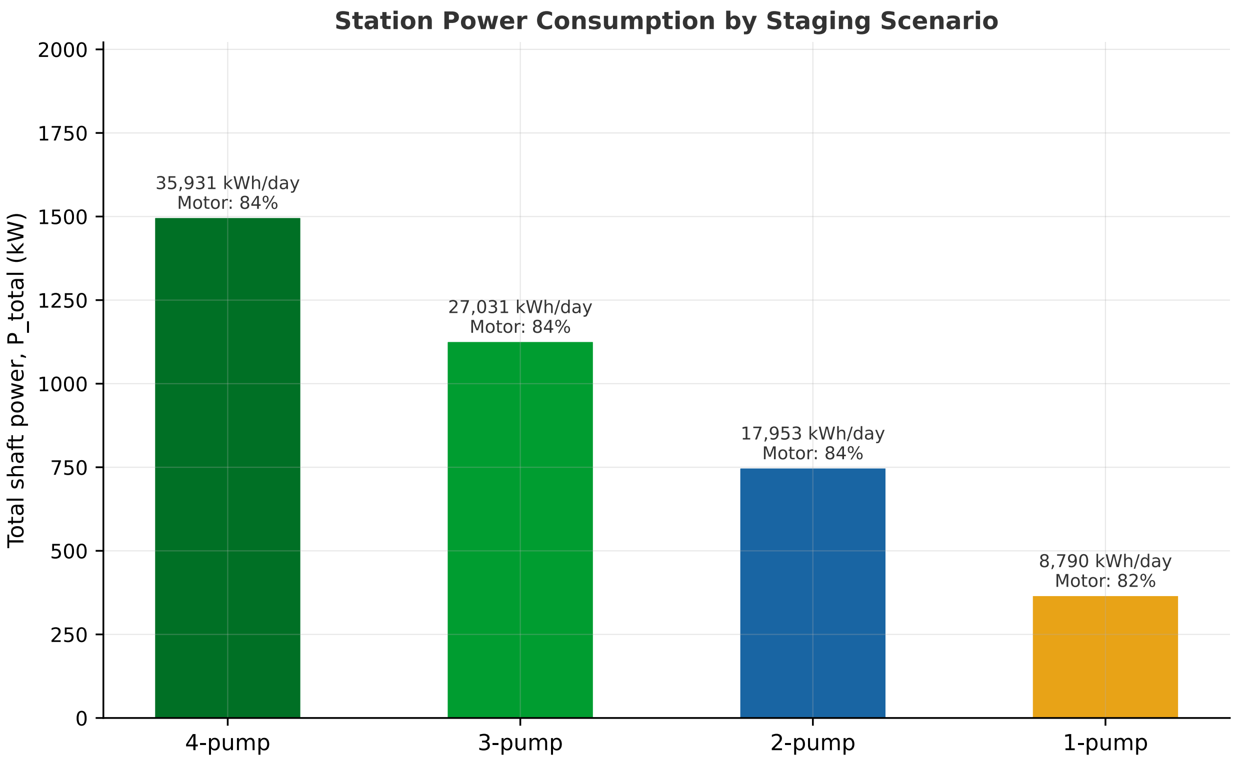

Figure 2: Total station shaft power and daily energy consumption by staging scenario

5 Validation

Computed EPANET results are compared against hand-calculated reference values from Section 5 of the Project Instructions. The acceptance threshold is 5% deviation.

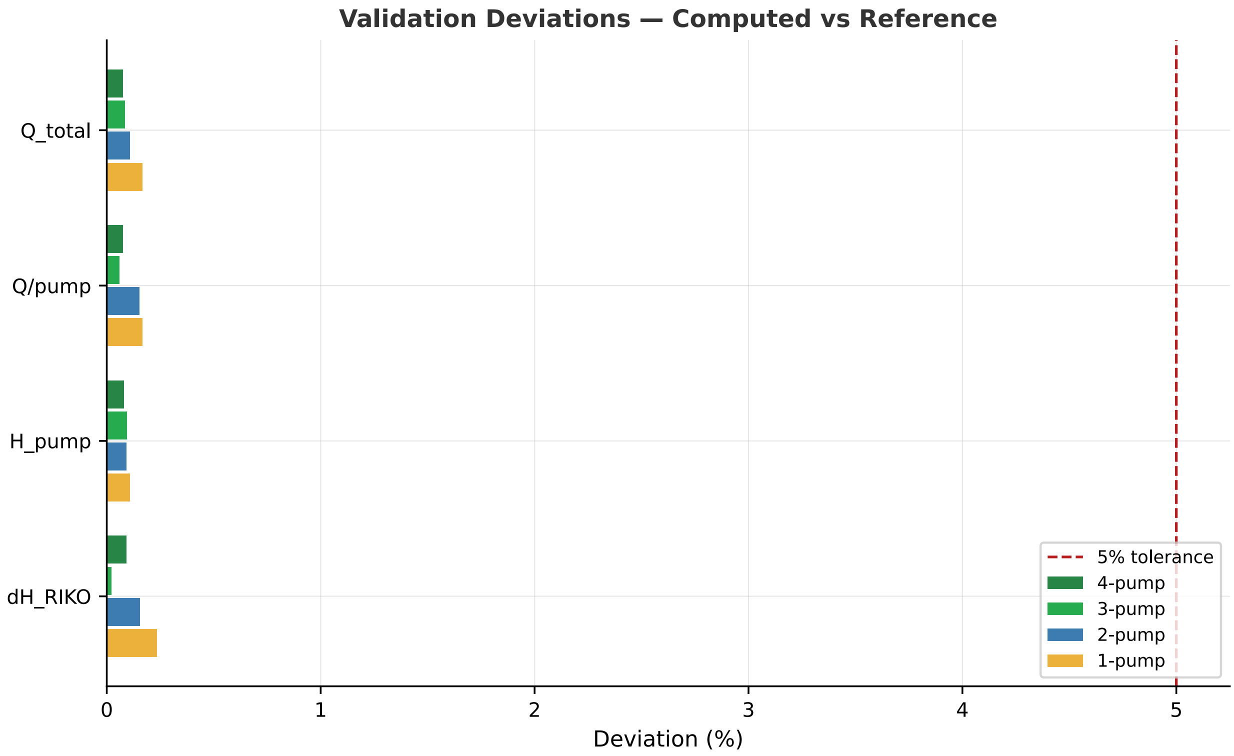

Figure 3: Parameter deviations across all scenarios — all within the 5% acceptance threshold

5.1 4-Pump Scenario (φ = 44%) — PASS

Parameter	Computed	Reference	Deviation (%)	Result
Q_total	5012.21	5016	0.08	OK
Q/pump	1253.05	1254	0.08	OK
H_pump	26.14	26.12	0.08	OK
dH_RIKO	7.5	7.51	0.09	OK

5.2 3-Pump Scenario (φ = 38%) — PASS

Parameter	Computed	Reference	Deviation (%)	Result
Q_total	3660.85	3664	0.09	OK
Q/pump	1220.28	1221	0.06	OK
H_pump	26.93	26.9	0.1	OK
dH_RIKO	8.5	8.5	0.02	OK

5.3 2-Pump Scenario (φ = 30%) — PASS

Parameter	Computed	Reference	Deviation (%)	Result
Q_total	2218.6	2221	0.11	OK
Q/pump	1109.3	1111	0.15	OK
H_pump	29.51	29.48	0.09	OK

Parameter	Computed	Reference	Deviation (%)	Result
dH_RIKO	11.24	11.22	0.15	OK

5.4 1-Pump Scenario (φ = 22%) — PASS

Parameter	Computed	Reference	Deviation (%)	Result
Q_total	1012.32	1014	0.17	OK
Q/pump	1012.32	1014	0.17	OK
H_pump	31.66	31.63	0.11	OK
dH_RIKO	13.47	13.44	0.23	OK

Warning: Q_total = 3644 m3/h < VAG Qmin (4500 m3/h) — known system characteristic for 1-pump

6 24-Hour Extended Period Simulation

The EPS models a full 24-hour operating cycle with scheduled pump trips to test the rule-based control system response. The standby pump (PUMP_5) activates automatically when a duty pump trips, and the RIKO valve adjusts its opening to match the new pump configuration.

6.1 Pump Trip Schedule

- **PUMP_4**: trip at hour 6, restore at hour 8
- **PUMP_3**: trip at hour 12, restore at hour 14
- **PUMP_2**: trip at hour 18, restore at hour 20

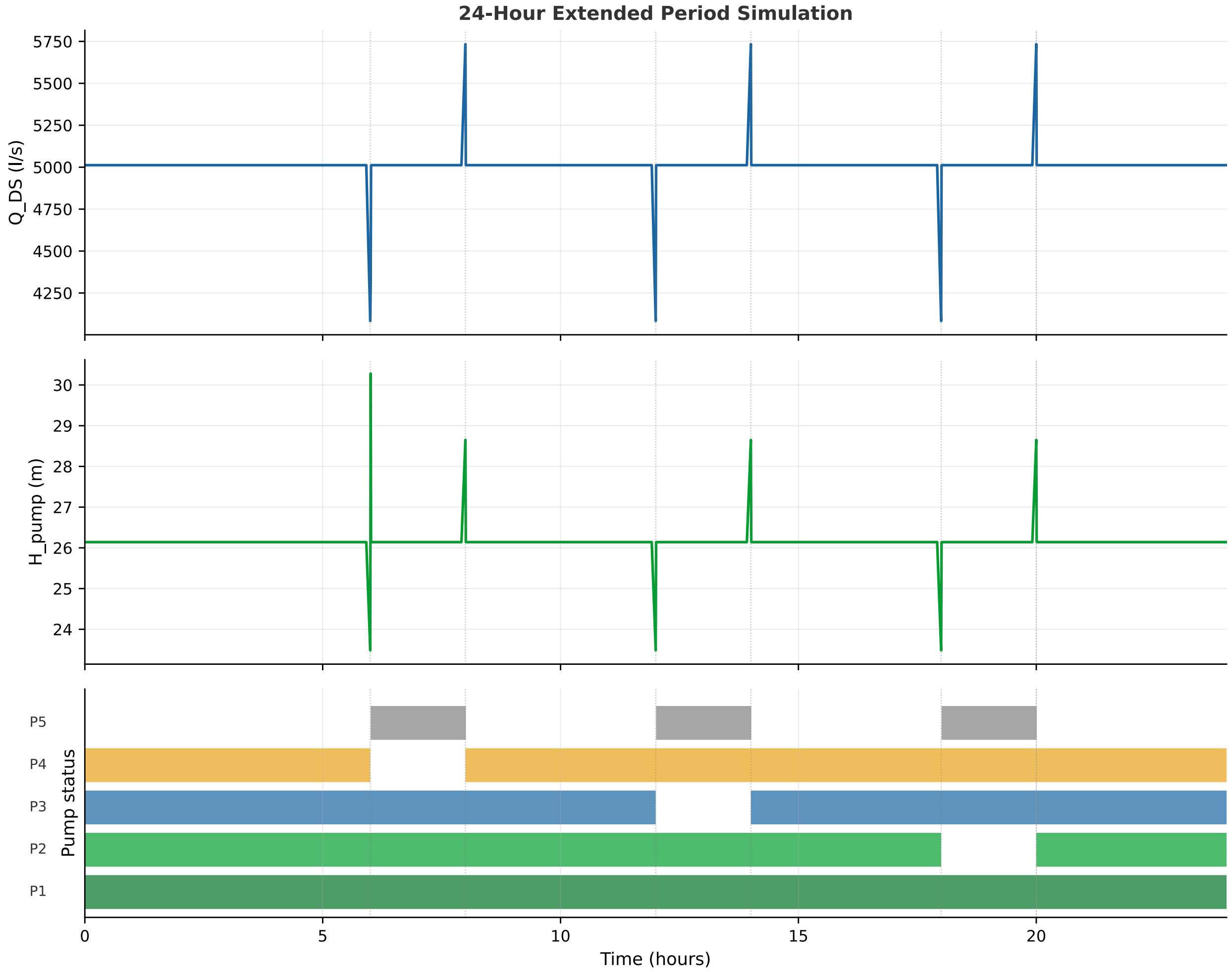

Figure 4: 24-hour EPS time series — flow, pump head, and pump ON/OFF status

6.2 Event Log

The table below shows only timesteps where pump status or RIKO valve position changes.

Time	P1	P2	P3	P4	P5	Active	RIKO	Q_DS (l/s)	Q_DS (m³/h)	H_pump (m)
0:00	ON	ON	ON	ON	OFF	4	44%	5012.2	18044	26.14
6:00	ON	ON	ON	OFF	OFF	3	44%	4083.4	14700	23.48
6:00	ON	ON	ON	OFF	ON	4	38%	4300.1	15481	30.28
6:00	ON	ON	ON	OFF	ON	4	44%	5012.2	18044	26.14
8:00	ON	ON	ON	ON	ON	5	44%	5733.4	20640	28.65
8:00	ON	ON	ON	ON	OFF	4	44%	5012.2	18044	26.14
12:00	ON	ON	OFF	ON	OFF	3	44%	4083.4	14700	23.48
12:00	ON	ON	OFF	ON	ON	4	44%	5012.2	18044	26.14
14:00	ON	ON	ON	ON	ON	5	44%	5733.4	20640	28.65
14:00	ON	ON	ON	ON	OFF	4	44%	5012.2	18044	26.14
18:00	ON	OFF	ON	ON	OFF	3	44%	4083.4	14700	23.48
18:00	ON	OFF	ON	ON	ON	4	44%	5012.2	18044	26.14
20:00	ON	ON	ON	ON	ON	5	44%	5733.4	20640	28.65
20:00	ON	ON	ON	ON	OFF	4	44%	5012.2	18044	26.14
24:00	ON	ON	ON	ON	OFF	4	44%	5012.2	18044	26.14

Table 3: EPS event log — state transitions during pump trip/restore sequence

7 Notes and Warnings

1. **H_PLANT = 18.17 m** is back-calculated from system data, not field-measured. All operating points shift if this value changes.
2. **1-pump scenario** produces Q_total below the VAG minimum operating flow (4,500 m^3/h). This is a known system characteristic, not a modeling error.
3. **Valve headloss** uses the ISO 5167 Kv method: $\Delta H = Q^2 \times 132.15 / Kv^2$. VAG's internal ζ (zeta) values are *not* used.
4. **Pump efficiency** is fixed at the duty-point value ($\eta = 88\%$) for energy calculations. Actual efficiency varies with the operating point along the pump curve.
5. **EPS rule-based controls** handle standby pump activation (PUMP_5) and RIKO valve position changes automatically, following the priority-based control strategy described by Georgescu et al. (CCWI 2015).
6. **Friction model:** Darcy-Weisbach throughout, appropriate for large-diameter pipes at $Re > 10^6$.