

Westland Mineral Sands Company Limited

Report No: Z22025_03

Mananui Mineral Sands Project

Hydrological and Water Quality Impact Assessment Model Results Update

Kōmanawa:

1. ***(verb) spring, well up (of water)***
2. ***(verb) to spring, well up (of thoughts, ideas)***

Kōmanawa Solutions Limited (KSL) is a water resource consultancy and research company specialising in water resource investigation and modelling, environmental limit setting and water resource impact assessment. Our goal is to provide excellent science to facilitate the robust management of natural resources in our changing climate. Clients include New Zealand enterprises in the private sector, central and local government agencies and community groups.

Our vision

KSL delivers high quality science and research. We aspire to be at the forefront of creativity and innovation to address our increasingly complex water resource challenges; mō tatou, ā, mō kā uri ā muri ake nei (for us and our children after us).

Our mission

Our mission is to develop solutions to the increasingly challenging water resource management issues we now face by providing a clear vision of the pathway from problem to solution. We work closely with our partners, communities, and stakeholders, deploying state-of-the-art scientific methods and building trust through knowledge and honest science communication.

Limitations

Kōmanawa Solution Ltd (KSL) has prepared this Report in accordance with the usual care and thoroughness of the consulting profession for the use of Westland Minerals Company Limited.

This Report has been prepared in accordance with the scope of work and for the purpose outlined at the start of this report and is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

Where this Report indicates that information has been provided to KSL by third parties, KSL has made no independent verification of this information except as expressly stated in the Report. KSL assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between 7/12/2023 and 22/12/2023 and is based on the conditions encountered and information reviewed at the time of preparation. KSL disclaims responsibility for any changes that may have occurred after this time.

This Report should be read in full. No responsibility is accepted for use of any part of this Report in any other context or for any other purpose. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This Report has been prepared for the exclusive use of Westland Minerals Company Limited and their authorised agents. Except as required by law, no third party may use or rely on this Report unless otherwise agreed in writing by KSL.

To the extent permitted by law, KSL expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. KSL does not admit that any action, liability or claim may exist or be available to any third party.

Version control

Date	Report no	Issue notes
22/12/2023	Z22025_03	Issue 1

Authors

Zeb Etheridge

Director & Principal Water Resource Scientist, Kōmanawa Solutions Ltd

Matt Hanson Dumont

Computational Hydrogeologist, Kōmanawa Solutions Ltd

Suggested citation

Etheridge, Z. and Dumont, M. (2023). *Mananui Mineral Sands Project Hydrological and Water Quality Impact Assessment Model Results Update*

Contents

Figures

Tables

1 Background

Wallbridge Gilbert Aztec (WGA) undertook a review of the technical documents lodged in support of the application by Westland Minerals Company Limited (WMSC) for resource consents authorising the development of a mineral sands mining operation at Mananui, Hokitika. The review prompted further interrogation and revision of the configuration of the numerical model used to evaluate key aspects of the impact assessment. Further water quality data have also now become available from lab analysis which were scheduled at the time of the original hydrological impact assessment but were incomplete at the time of the report issue. This report provides updated water quality data together with a revised set of model results using the improved configuration and new data. The main aspects of the model configuration and parameterisation are described in Etheridge & Rekker (2023) and in the accompanying *S92 information request response: Hydrological impact assessment memo*.

2 Water quality update

2.1 Updated slimes and ROMs sample results

The original hydrological and water quality impact assessment was based on testing of five mineral sand samples (referred to as ROM) and one slimes sample. An additional set of eight ROM samples and three slimes samples were collected on 11th October 2023 to improve characterisation of the likely dredge pond water quality. Results from the original and more recent sampling are summarised in Table 2-3 and Table 2-2 respectively. The original water quality impact assessment provided synthetic dredge pond water samples to account for the proportions of coarse sediment (>90%) and fine sediment (slimes, <10%) in the dredge pond:

- A best estimate sample was derived as follows: Average concentration in all ROM samples x 0.9 + Slimes sample concentrations x 0.1.
- A max concentration (worst case) sample was derived as follows: Max concentration in all ROM samples x 0.9 + Slimes sample concentrations x 0.1.

Table 2-1 provides the original data and the revised dredge pond water quality, the latter being based on all available water quality data (i.e. 13 ROM samples and four slimes samples). The expected dredge pond water quality using the additional data collected in October is significantly better than the original results for the average and the same as the original results for the maximum (i.e. the maximum concentrations were recorded in the original set of samples).

Table 2-1: Synthetic dredge pond water quality

Updated	Parameter	mg/L	Original	Parameter	mg/L
Composite sample - average	Dissolved Aluminium	0.2685	Composite sample - average	Dissolved Aluminium	0.4887
	Dissolved Chromium	0.0019		Dissolved Chromium	0.002214
	Dissolved Copper	0.0045		Dissolved Copper	0.007254
	Dissolved Zinc	0.0074		Dissolved Zinc	0.01278
	Dissolved Nickel	0.0024		Dissolved Nickel	0.003699
Composite sample - max					
	Dissolved Aluminium	0.9243	Composite sample - max	Dissolved Aluminium	0.9243
	Dissolved Chromium	0.0045		Dissolved Chromium	0.00486
	Dissolved Copper	0.0099		Dissolved Copper	0.0099
	Dissolved Zinc	0.0253		Dissolved Zinc	0.0252
	Dissolved Nickel	0.00558		Dissolved Nickel	0.00558

Table 2-2: October 2023 Slimes & ROM test results

Analyte	Units	HSAC 109	HSAC 179	HSAC 177	HSAC 181	HSAC 107 Slime	HSAC 100 Slime	HSAC 108	HSAC 108 Slime	HSAC 107	HSAC 100 R/O	HSAC 100	DWSNZ (health)	DWSNZ (aesthetic)	ANZG 99th percentile DGV (2023)
Sum of Anions	*meq/L*	0.98	1.11	0.98	0.96	1.19	1.36	0.63	1.23	0.59	0.12	0.64	_	_	_
Sum of Cations	*meq/L*	0.64	0.65	0.67	0.65	0.97	1.11	0.67	0.91	0.67	0.11	0.67	_	_	_
Turbidity	*NTU*	390	280	630	470	2900	3900	250	5700	172	105	146	_	≤ 5	_
pH	*pH Units*	7.2	7.2	7.3	7.3	6.5	6.5	7.3	6.5	7.2	6.6	7.3	_	7 - 8.5	_
Total Alkalinity	*g/m^3 as $CaCO_3$*	31	36	31	31	35	37	13.2	35	12.0	4.0	13.4	_	_	_
Bicarbonate	*g/m^3 at 25°C*	38	44	37	37	42	45	16.0	43	14.6	4.8	16.3	_	_	_
Total Hardness	*g/m^3 as $CaCO_3$*	18.7	19.4	19.8	19.7	31	38	19.7	30	19.2	2.2	20	_	≤ 200	_
Electrical Conductivity	*(EC) mS/m*	7.5	7.5	7.5	7.6	9.8	11.8	7.3	9.7	7.0	0.9	7.2	_	_	_
Total Suspended Solids	*g/m^3*	-	-	-	-	-	-	-	-	-	-	-	_	≤ 1000	__
Total Dissolved Solids	*(TDS) g/m^3*	-	-	-	-	-	-	-	-	-	-	-	_	_	_
Dissolved Calcium	*g/m^3*	6.2	6.4	6.6	6.6	10.5	12.9	6.7	10.2	6.5	0.64	6.9	_	_	_
Total Iron	*g/m^3*	-	-	-	-	-	-	-	-	-	-	-	_	_	_
Dissolved Lithium	*g/m^3*	-	-	-	-	-	-	-	-	-	-	-	_	_	_
Dissolved Magnesium	*g/m^3*	0.77	0.81	0.82	0.74	1.18	1.28	0.75	1.18	0.72	0.15	0.74	_	_	_
Dissolved Mercury	*g/m^3*	-	-	-	-	-	-	-	-	-	-	-	_	_	0.00006

Analyte	Units	HSAC 109	HSAC 179	HSAC 177	HSAC 181	HSAC 107 Slime	HSAC 100 Slime	HSAC 108	HSAC 108 Slime	HSAC 107	HSAC 100 R/O	HSAC 100	DWSNZ (health)	DWSNZ (aesthetic)	ANZG 99th percentile DGV (2023)
Total Mercury	g/m^3	-	-	-	-	-	-	-	-	-	-	-	0.007	_	_
Dissolved Molybdenum	g/m^3	-	-	-	-	-	-	-	-	-	-	-	_	_	_
Dissolved Potassium	g/m^3	1.89	1.72	2.1	2.0	1.02	1.59	2.1	1.23	1.87	0.33	1.96	_	_	_
Dissolved Silver	g/m^3	-	-	-	-	-	-	-	-	-	-	-	_	_	0.00002
Dissolved Sodium	g/m^3	4.5	4.5	4.5	4.4	5.4	5.9	4.6	5.2	4.6	0.88	4.4	_	≤200	_
Chloride	g/m^3	3.5	3.8	3.7	3.4	6.9	11.6	3.8	8.7	3.5	0.6	4.0	_	≤250	_
Total Ammoniacal-N	g/m^3	-	-	-	-	-	-	-	-	-	-	-	_	_	_
Nitrite-N	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	0.012	0.011	< 0.002	0.006	< 0.002	< 0.002	< 0.002	0.92	_	_
Nitrate-N	g/m^3	0.77	0.84	0.78	0.75	0.74	0.79	0.76	0.77	0.78	0.060	0.79	11.3	_	_
Nitrate-N + Nitrite-N	g/m^3	0.77	0.84	0.78	0.75	0.75	0.80	0.76	0.78	0.79	0.061	0.79	11.3	_	_
Total Kjeldahl Nitrogen	(TKN) g/m^3	-	-	-	-	-	-	-	-	-	-	-	_	_	_
Diss. Reactive Phosphorus	(DRP) g/m^3	-	-	-	-	-	-	-	-	-	-	-	_	_	_
Sulphate	g/m^3	9.9	10.2	9.6	9.4	11.9	11.3	9.8	10.7	9.5	0.7	9.9	_	≤ 250	_
Total Organic Carbon	(TOC) g/m^3	18	10	11	6	71	48	5	61	6	< 5	6	_	_	_
Dissolved Aluminium	g/m^3	**0.090**	**0.101**	**0.101**	**0.076**	**0.46**	**0.31**	**0.114**	**0.25**	**0.20**	**0.118**	**0.131**	1	**≤ 0.1**	**0.027**
Dissolved Arsenic	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.01	_	0.0008
Dissolved Boron	g/m^3	0.009	0.009	0.009	0.008	0.027	0.022	0.009	0.020	0.009	0.008	0.009	2.4	_	0.34
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.004	_	0.00006

Analyte	Units	HSAC 109	HSAC 179	HSAC 177	HSAC 181	HSAC 107 Slime	HSAC 100 Slime	HSAC 108	HSAC 108 Slime	HSAC 107	HSAC 100 R/O	HSAC 100	DWSNZ (health)	DWSNZ (aesthetic)	ANZG 99th percentile DGV (2023)
Dissolved Chromium	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	**0.0011**	**0.0012**	< 0.0005	**0.0007**	< 0.0005	< 0.0005	< 0.0005	0.05	–	**0.00001**
Dissolved Cobalt	g/m^3	-	-	-	-	-	-	-	-	-	-	-	–	–	–
Dissolved Copper	g/m^3	0.0010	**0.0013**	**0.0019**	**0.0015**	**0.0161**	**0.026**	**0.0016**	**0.0154**	**0.0020**	**0.0015**	**0.0017**	2	≤ 1	**0.001**
Dissolved Iron	g/m^3	0.11	0.11	0.14	0.07	0.50	0.29	0.13	0.20	0.26	0.12	0.13	–	≤ 0.3	–
Dissolved Lead	g/m^3	0.00014	0.00015	0.00030	0.00012	0.00078	0.00081	0.00027	0.00043	0.00046	0.00026	0.00029	0.01	–	0.001
Dissolved Manganese	g/m^3	0.147	0.179	0.166	0.131	0.58	0.46	0.078	0.32	0.080	0.049	0.094	0.4	≤ 0.04	1.2
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0030	0.0006	0.0017	0.0010	< 0.0005	0.0009	0.08	–	0.008
Dissolved Zinc	g/m^3	< 0.0010	0.0016	< 0.0010	0.0040	0.0019	0.0116	< 0.0010	0.0016	0.0014	0.0014	0.0013	–	≤ 1.5	0.024

Note: values highlighted in red are those that exceed the ANZG (2023) 99% protection of species DGV, values underlined exceed the DWSNZ aesthetic threshold and values in *italics* exceed the DWSNZ health standards.

Table 2-3: June 2023 Slimes & ROM sample results

Analyte	Units	Slimes Compy Shanks Test 26/06/2023	HSAC 013 14/06/23	HSAC 053 14/06/23	HSAC 006 14/06/23	HSAC 101 14/06/23	HSAC 180 14/06/23	DWSNZ (health)	DWSNZ (aesthetic)	ANZG 99th percentile DGV (2023)
Sum of Anions	*meq/L*	2.5	0.12	0.16	0.15	0.12	0.11	–	–	–
Sum of Cations	*meq/L*	1.58	0.14	0.19	0.15	0.2	0.25	–	–	–
Turbidity	*NTU*		320	880	70	176	173	–	≤ 5	–
pH	*pH Units*	6.3	6.3	6.3	6.2	6.2	6.1	–	7 - 8.5	–
Total Alkalinity	*g/m^3 as $CaCO_3$*	100	4.5	6	6	4.5	4	–	–	–
Bicarbonate	*g/m^3 at 25°C*	122	5.5	7.3	7.3	5.5	4.9	–	–	–
Total Hardness	*g/m^3 as $CaCO_3$*	54	< 3	4	< 3	3	3	–	≤ 200	–
Electrical Conductivity	*(EC) mS/m*	14.9	0.8	1.2	1	0.9	0.9	–	–	–

Analyte	Units	Slimes Compy Shanks Test 26/06/2023	HSAC 013 14/06/23	HSAC 053 14/06/23	HSAC 006 14/06/23	HSAC 101 14/06/23	HSAC 180 14/06/23	DWSNZ (health)	DWSNZ (aesthetic)	ANZG 99th percentile DGV (2023)
Total Suspended Solids	*g/m^3*	-	175	360	56	93	108	_	≤ 1000	__
Total Dissolved Solids	*(TDS) g/m^3*	480	25	52	21	32	28	_	_	_
Dissolved Calcium	*g/m^3*	17.8	< 1	1.1	< 1	< 1	< 1	_	_	_
Total Iron	*g/m^3*	1240	14.5	37	6	10.7	9	_	_	_
Dissolved Lithium	*g/m^3*		0.0006	0.0005	0.0008	0.0008	0.0012	_	_	_
Dissolved Magnesium	*g/m^3*	2.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	_	_	_
Dissolved Mercury	*g/m^3*	< 0.0002	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	_	_	0.00006
Total Mercury	*g/m^3*	< 0.00021	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008	0.007	_	_
Dissolved Molybdenum	*g/m^3*	< 0.0004	< 0.0002	0.0004	< 0.0002	0.0002	0.0005	_	_	_
Dissolved Potassium	*g/m^3*	2	< 1	< 1	< 1	< 1	< 1	_	_	_
Dissolved Silver	*g/m^3*	< 0.002	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	_	_	0.00002
Dissolved Sodium	*g/m^3*	6.4	0.8	0.9	1	0.8	0.8	_	≤200	_
Chloride	*g/m^3*	9	< 0.5	< 0.5	0.8	< 0.5	< 0.5	_	≤250	_
Total Ammoniacal-N	*g/m^3*	0.6	< 0.010	0.033	< 0.010	0.015	< 0.010	_	_	_
Nitrite-N	*g/m^3*	< 0.10	< 0.002	0.006	< 0.002	0.002	< 0.002	0.92	_	_
Nitrate-N	*g/m^3*	0.15	0.041	0.047	0.041	0.047	0.059	11.3	_	_
Nitrate-N + Nitrite-N	*g/m^3*	0.15	0.043	0.053	0.042	0.049	0.06	11.3	_	_
Total Kjeldahl Nitrogen	*(TKN) g/m^3*	40	0.37	2.3	0.29	0.57	0.52	_	_	_
Diss. Reactive Phosphorus	*(DRP) g/m^3*	< 0.2	0.01	0.015	0.011	0.011	0.011	_	_	_
Sulphate	*g/m^3*	9	0.7	0.9	< 0.5	0.8	< 0.5	_	≤ 250	_
Total Organic Carbon	*(TOC) g/m^3*	240	0.6	18	3.8	6.8	7	_	_	_
Dissolved Aluminium	*g/m^3*	**0.57**	**0.31**	**0.37**	**0.22**	**0.56**	**0.97**	1	≤ 0.1	0.027
Dissolved Arsenic	*g/m^3*	< 0.02	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.01	_	0.0008

Analyte	Units	Slimes Compy Shanks Test 26/06/2023	HSAC 013 14/06/23	HSAC 053 14/06/23	HSAC 006 14/06/23	HSAC 101 14/06/23	HSAC 180 14/06/23	DWSNZ (health)	DWSNZ (aesthetic)	ANZG 99th percentile DGV (2023)
Dissolved Boron	*g/m³*	0.15	0.015	0.012	0.011	0.008	0.008	2.4	_	0.34
Dissolved Cadmium	*g/m³*	< 0.0010	< 0.00005	0.00009	< 0.00005	< 0.00005	< 0.00005	0.004	_	0.00006
Dissolved Chromium	*g/m³*	< 0.010	**0.0007**	**0.0012**	**0.0012**	**0.0018**	**0.0049**	0.05	_	0.00001
Dissolved Cobalt	*g/m³*	< 0.004	0.0004	0.0004	0.0005	0.0006	0.0036	_	_	_
Dissolved Copper	*g/m³*	**0.041**	**0.0038**	**0.0021**	**0.0069**	**0.0029**	**0.0041**	2	≤ 1	0.001
Dissolved Iron	*g/m³*	0.4	0.45	0.55	0.31	0.71	1	_	≤ 0.3	_
Dissolved Lead	*g/m³*	< 0.0002	0.00039	0.00035	0.00041	0.00064	**0.00142**	0.01	_	0.001
Dissolved Manganese	*g/m³*	1.03	0.061	0.107	0.085	0.077	0.043	0.4	≤ 0.04	1.2
Dissolved Nickel	*g/m³*	**0.021**	< 0.0005	0.0041	0.0012	0.0011	0.0034	0.08	_	0.008
Dissolved Zinc	*g/m³*	< 0.02	0.0045	0.0036	**0.027**	0.0039	**0.027**	_	≤ 1.5	0.024

Note: values highlighted in red are those that exceed the ANZG (2023) 99% protection of species DGV, values underlined exceed the DWSNZ aesthetic threshold and values in *italics* exceed the DWSNZ health standards.

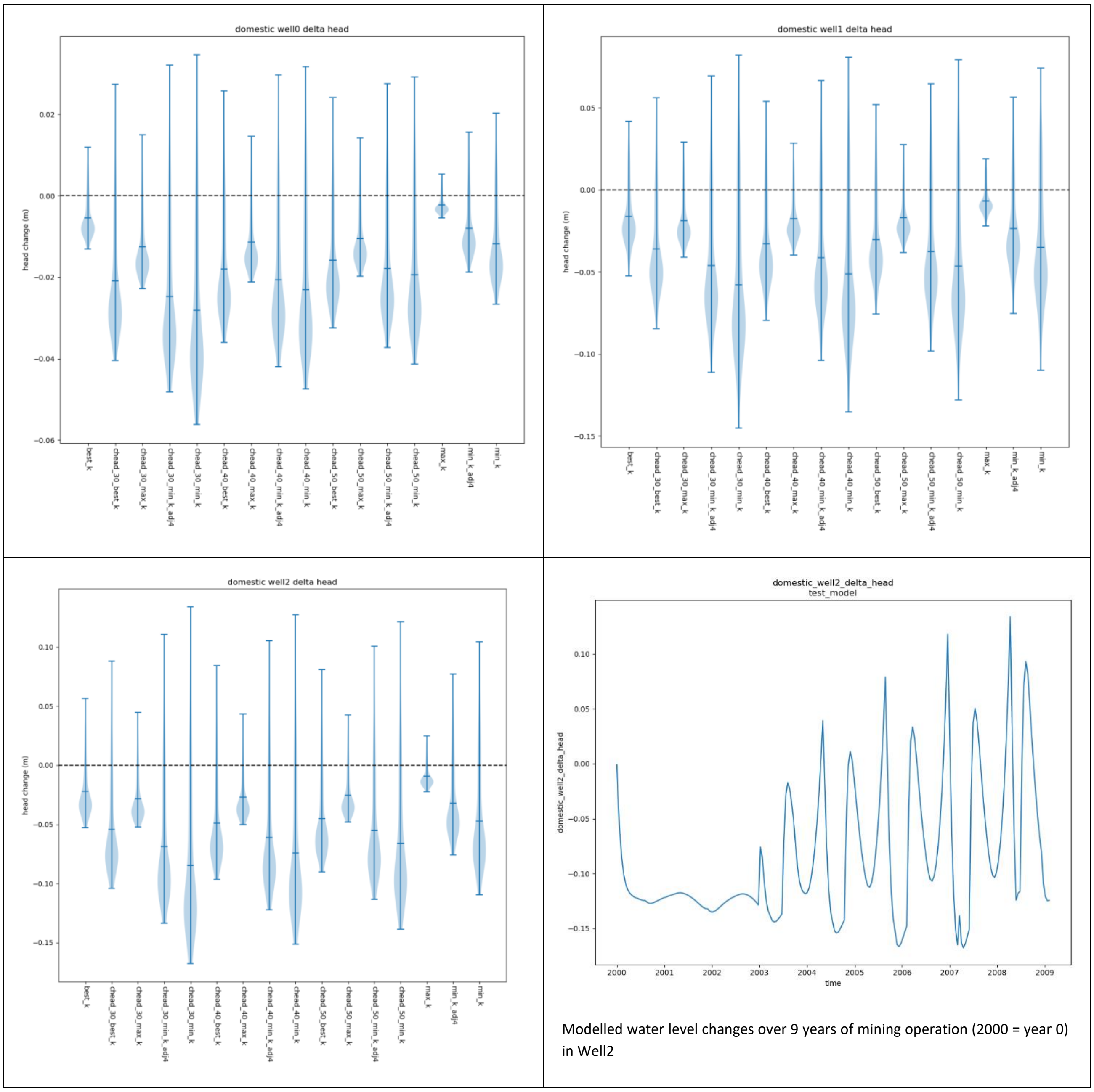
3 Water quantity modelling

3.1 Hydraulic impacts on local wells

Modelled water level changes in the three local water supply wells are presented as violin plots in Figure 3-1 for the array of model parameterisations summarised in Table 3-1. The results distributions presented in the violin plots summarise the range of modelled water level changes over the duration of mining, as the dredge pond traverses the site. A time series plot of drawdown (negative values) and mounding (positive values) is also provided for Well 2 for the chead_30_min_k scenario. Results are discussed below. Well locations are shown in Etheridge & Rekker (2023).

Table 3-1: Model parameterisation and nomenclature summary

Model name	Parameter details
best_k	Best estimate hydraulic conductivity values (55 m/d mineral sand, 214 m/d gravels) applied to full model domain (no low K zone at coast)
chead_30_best_k	30 m/d K assigned to coastal low k zone, best estimate hydraulic conductivity values applied to rest of model
chead_30_max_k	30 m/d K assigned to coastal low k zone, max hydraulic conductivity values (137 m/d mineral sand, 518 m/d gravels) applied to rest of model
chead_30_min_k_adj4	30 m/d K assigned to coastal low k zone, low estimate hydraulic conductivity values (20 m/d mineral sand, 150 m/d gravels) applied to rest of model
chead_30_min_k	30 m/d K assigned to coastal low k zone, minimum hydraulic conductivity values (14 m/d mineral sand, 101 m/d gravels) applied to rest of model
chead_40_best_k	40 m/d K assigned to coastal low k zone, best estimate hydraulic conductivity values applied to rest of model
chead_40_max_k	40 m/d K assigned to coastal low k zone, max hydraulic conductivity values applied to rest of model
chead_40_min_k_adj4	40 m/d K assigned to coastal low k zone, low estimate hydraulic conductivity values applied to rest of model
chead_40_min_k	40 m/d K assigned to coastal low k zone, minimum hydraulic conductivity values applied to rest of model
chead_50_best_k	50 m/d K assigned to coastal low k zone, best estimate hydraulic conductivity values applied to rest of model
chead_50_max_k	50 m/d K assigned to coastal low k zone, max hydraulic conductivity values applied to rest of model
chead_50_min_k_adj4	50 m/d K assigned to coastal low k zone, low estimate hydraulic conductivity values applied to rest of model
chead_50_min_k	50 m/d K assigned to coastal low k zone, minimum hydraulic conductivity values applied to rest of model
max_k	Max hydraulic conductivity values applied to full model domain (no low K zone at coast)
min_k_adj4	Low hydraulic conductivity values applied to full model domain (no low K zone at coast)
min_k	Min hydraulic conductivity values applied to full model domain (no low K zone at coast)



Modelled water level changes over 9 years of mining operation (2000 = year 0) in Well2

Figure 3-1: Modelled water level changes in local water supply wells

The updated results are broadly consistent with the original outputs, although the peak drawdown in Well 1 and Well 2 is slightly higher (0.15 m new versus 0.1 m old) and the peak mounding is also slightly higher (~ 0.15 m new versus 0.075 m old). The results overall equate to neutral well interference effects, with relatively short periods of both slightly higher and slightly lower water levels. We consider that these minor potential water level variations will not adversely affect the reliability of supply from the local domestic wells.

3.2 Hydraulic impacts on Tūwharewhare

Figure 3-2 presents modelled augmentation and depletion of Tūwharewhare across the suite of model realisations over the life of the mine. Results from one model realisation (chead_30_best_k) are also plotted as a time series in Figure 3-3. Key findings are as follows:

- The proposed activity is expected to increase flows in Tūwharewhare for most of the mine life across all realisations.

- A peak depletion of ~ 180 m³/d (2 L/s) is projected for the chead_30_max_k model. This equates to <2% of the mean annual low flow (MALF) of the creek. This is much less than the widely accepted 10% MALF reduction effects threshold.
- The previous model results showed a peak depletion of 3 L/s, which also equates to <2% of the mean annual low flow (MALF) of the creek.
- The peak modelled augmentation of 1,000 m³/d (11.5 L/s) equates to <10% of the mean annual low flow (MALF) of the creek and ~ 1% of the median flow.
- The proposed activity is therefore very unlikely to cause more than minor effects on flows in the creek.

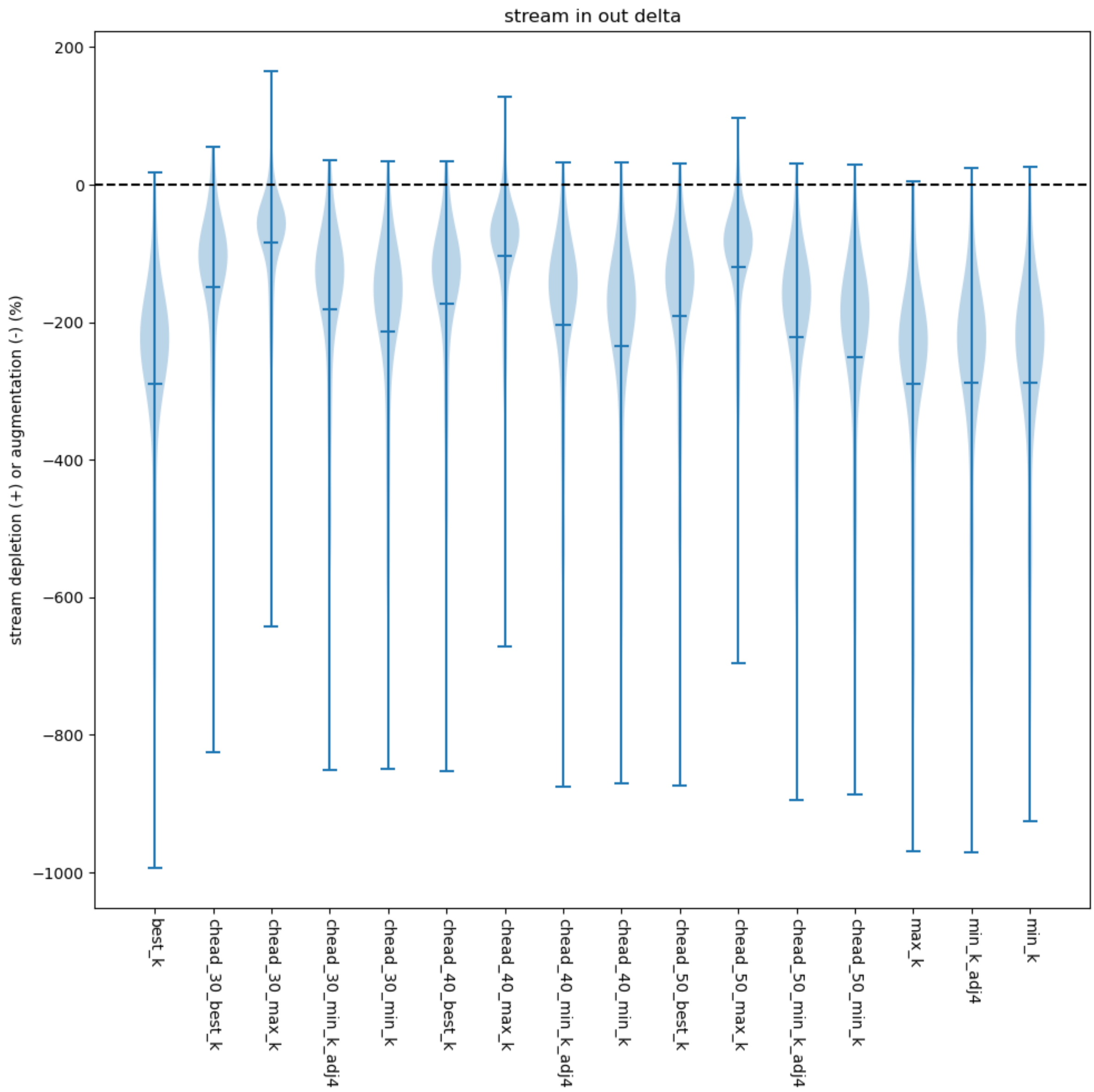


Figure 3-2 Modelled depletion (positive) and augmentation (negative) of Tūwharewhare

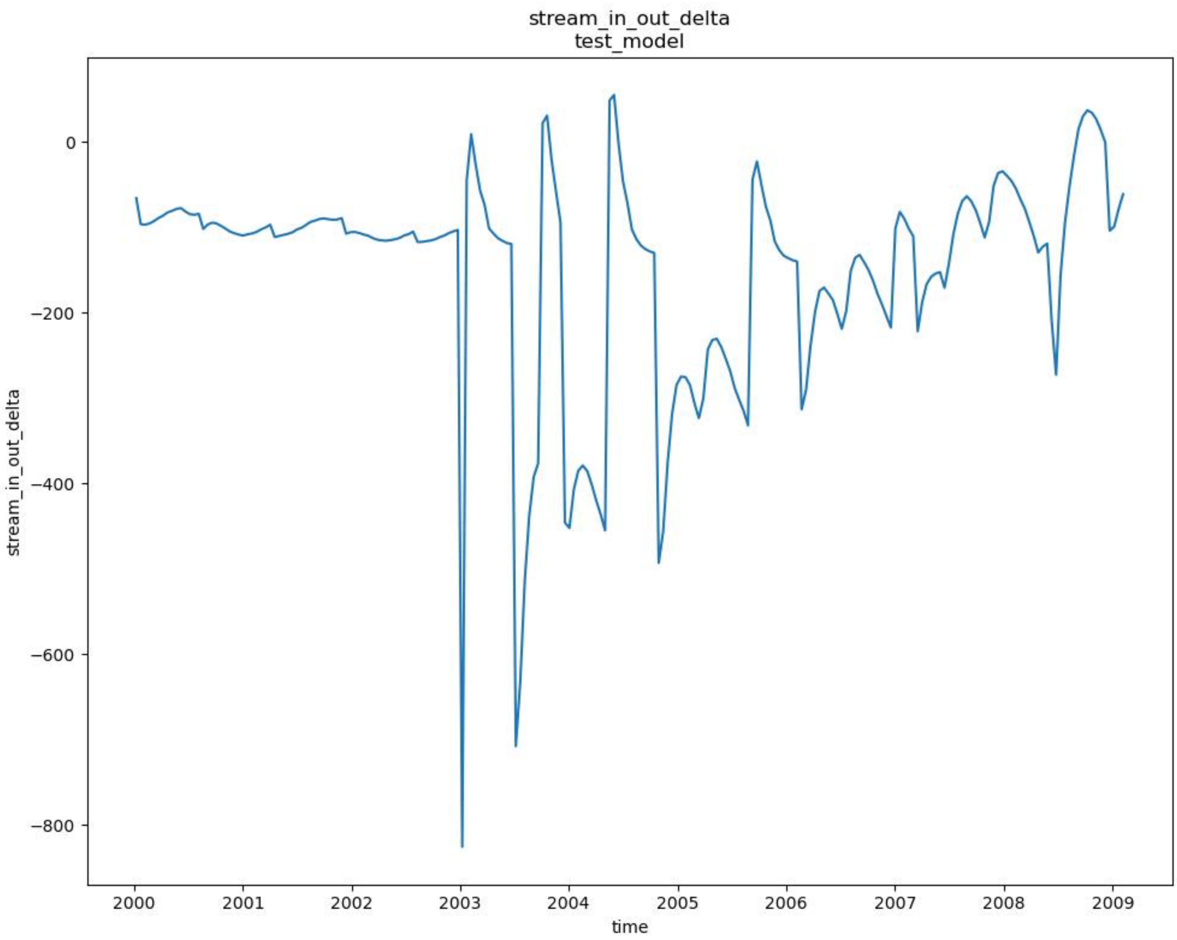


Figure 3-3 Modelled time series of stream depletion and augmentation for chead_30_best_k model

3.3 Hydraulic effects on riparian wetland

Figure 3-4 presents modelled groundwater level changes at the edge of the Tūwharewhare riparian wetland across the suite of model realisations over the life of the mine. Results show a peak mounding of ~ 5 cm and a peak decline of <1 cm. These results are similar to the previous results, which showed a peak mounding of 5 cm and a peak decline of 2 cm. The conclusions of the *Mananui Mineral Sands Project Hydrological and Water Quality Impact Assessment* report therefore remain valid: the potential for wetland water balance changes is negligible and hence hydrological effects on the wetland will be less than minor.

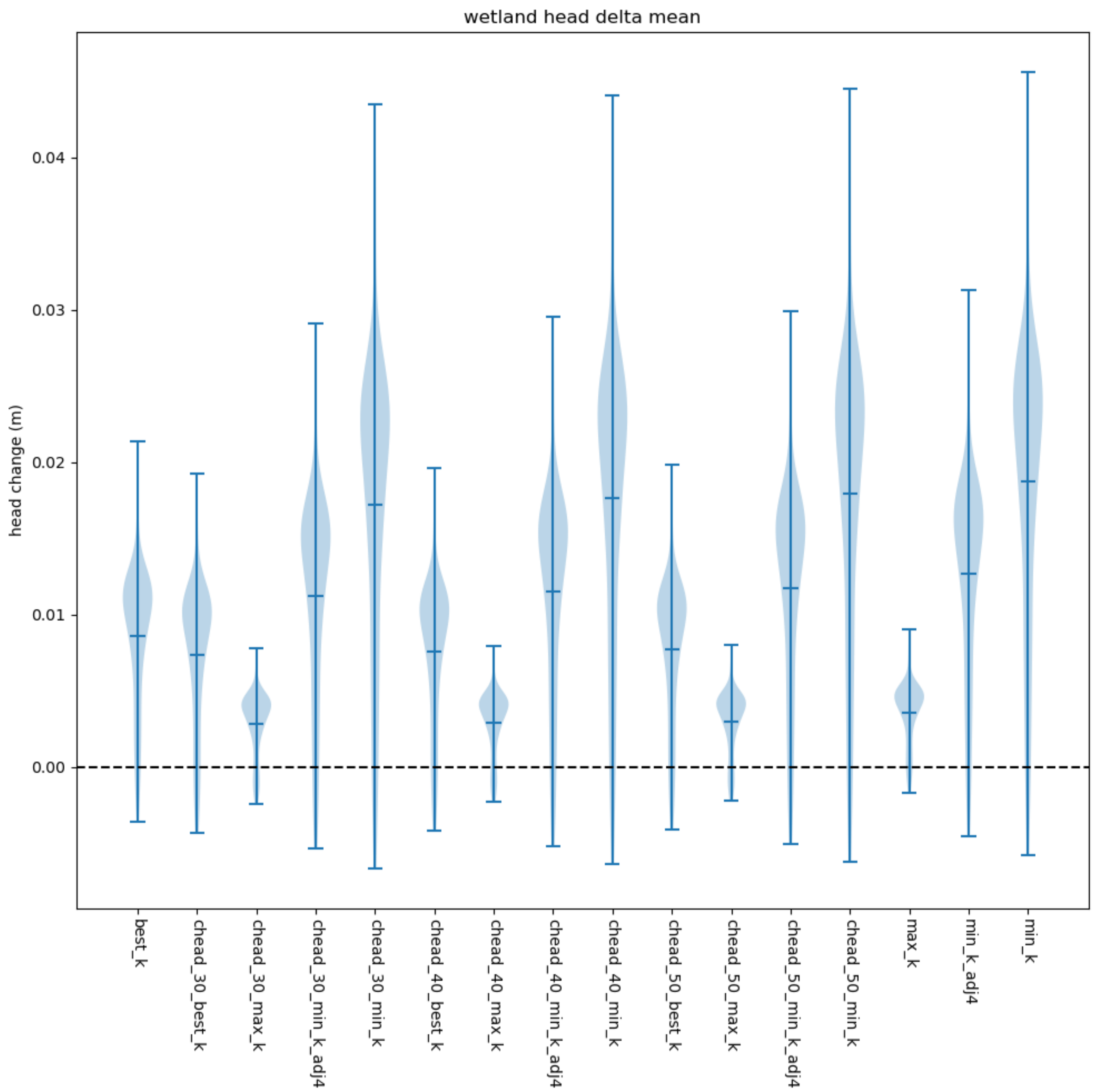


Figure 3-4: Modelled groundwater level changes at edge of riparian wetland

4 Water quality modelling

4.1 Water quality impacts on local wells

Figure 4-1 plots the modelled dredge pond water fraction (as percentages) in the local domestic wells across the suite of model realisations over the life of the mine. The results show a peak concentration of 13% in Well 1 for the most conservative model (chead_30_max_k: these results also shown as a time series plot in the lower left figure), with concentrations being less than 10% for the majority of the time across all model realisations and all 3 wells. The water quality screening assessment data presented in Section 2 show that the dredge pond water quality is expected to meet the drinking water standards for all parameters bar aluminium, which could exceed the aesthetic limit of 0.1 mg/L. Groundwater sampling results presented in the *Mananui Mineral Sands Project Hydrological and Water Quality Impact Assessment* report show that dissolved aluminium is naturally elevated above the aesthetic limit in this area, with a maximum concentration of 0.4 mg/L recorded in monitoring well HSSC-018. Monitoring wells HSSC-025, HSSC-030, HSSC-032 and HSSC-033 are located upgradient of the domestic wells and were sampled in September 2023 as described in the *Hydrological and Water Quality Impact Assessment* report. Dissolved aluminium concentrations in these wells range from <0.003 to 0.049 mg/L with an average of 0.025 mg/L, assuming that the concentration of the <0.003 sample = 0.0015 mg/L. The available information therefore suggest that dissolved aluminium concentrations are likely to be below the aesthetic limit for aluminium at present. We have therefore modelled dissolved aluminium concentrations in the domestic wells as follows:

- Current/background concentration upgradient of domestic wells = 0.025 mg/L
- Average dredge pond concentration= 0.27 mg/L (Table 2-2)
- Maximum percentage pond water flowing to Well 1 = 13%
- Maximum dissolved aluminium concentration in Well 1 = (0.025 x 87%) + (0.27 x 13%) = 0.056 mg/L

The proposed activity is therefore unlikely to cause dissolved aluminium concentrations to exceed the aesthetic drinking water limit.

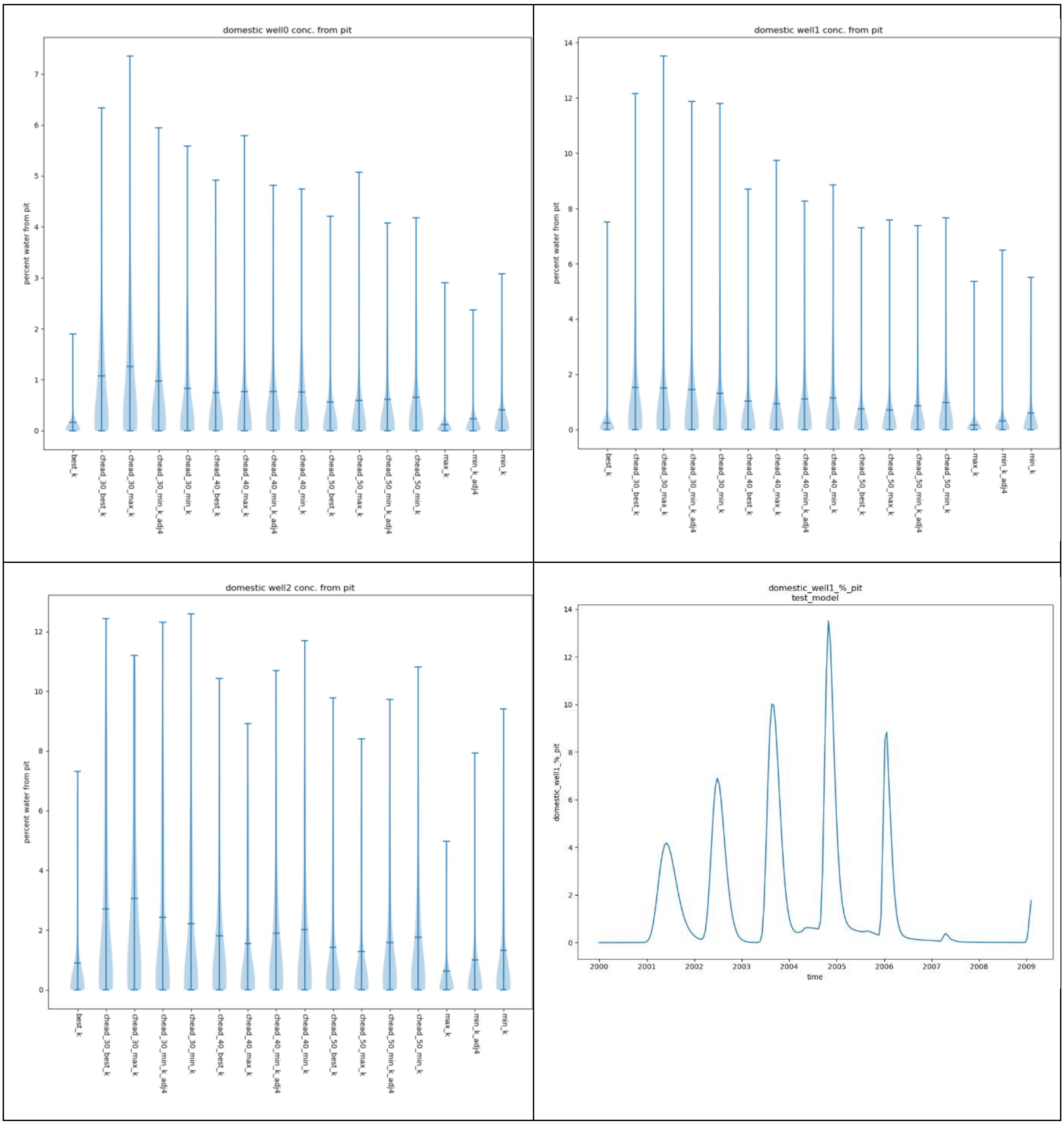


Figure 4-1: **Modelled domestic well concentrations**

We have tested the sensitivity of the above results to the range of possible outcomes shown in the water quality data and model results using the highest dissolved aluminium concentration recorded in all slimes and ROM samples as follows:

- Current/background concentration upgradient of domestic wells = 0.025 mg/L
- Maximum dredge pond concentration= 0.92 mg/L (Table 2-2)
- Average percentage pond water flowing to wells = 2%
- Average dissolved aluminium concentration in wells = (0.025 x 98%) + (0.92 x 2%) = 0.043 mg/L

We used the average percentage of pond water flowing to the wells in this sensitivity assessment to evaluate potential exposure to higher aluminium concentrations over the life of the mine. The results show that changes are expected to be negligible and well below the aesthetic limit. We have also undertaken a highly conservative assessment which assumes that the dissolved aluminium concentration in the pond water is equal to the highest value recorded in all slimes and ROM samples and that this maximum concentration coincides with the brief period for which the maximum concentration of pond water (13%) flows to Well 1:

- Current/background concentration upgradient of domestic wells = 0.025 mg/L
- Maximum dredge pond concentration= 0.92 mg/L (Table 2-2)
- Maximum percentage pond water flowing to Well 1 = 13% (0.13)
- Maximum dissolved aluminium concentration in Well 1 = (0.025 x 0.87) + (0.92 x 0.13) = 0.14 mg/L

A brief and minor exceedance of the aesthetic limit occurs under this very low probability scenario. Given the low probability of this scenario, it's short duration and the low consequences of the results if they were to eventuate (a brief period of very slight discolouration of the water), our model results show that the risk of adverse water quality effects on the local domestic wells is very low.

4.2 Water quality impacts on Tūwharewhare

Figure 4-1 plots the modelled rate of seepage to Tūwharewhare based on MT3D simulations across the suite of model realisations over the life of the mine. The results show an average seepage of 500 m^3/d (5.8 L/s) under the most conservative model (chead_30_min_k). This equates to ~ 3% of the Tūwharewhare MALF and 1% of the median flow at the lake outlet (see Table 4-6 of the *Hydrological and Water Quality Impact Assessment* report).

Table 4-1 provides water quality modelling results for Tūwharewhare under low (MALF) and median flows using the expected dredge pond water quality (Average ROM) and the worst-case water quality (Max ROM). The results are based on the following assumptions:

- Where the laboratory limit of detection is higher than the ANZG99 DGV we have used the limit of detection as a threshold value to screen for potential adverse effects, as discussed in the accompanying *S92 information request response: Hydrological impact assessment* memo.
- For the baseline creek water quality we have taken the average of all samples collected to date. For samples below the limit of detection, we have assumed that concentrations are equal to the limit of detection.
- Model results are based on a mass balance approach, assuming no retardation or attenuation of contaminants on the flow path to the creek or within the creek. Full mixing has been assumed, which is reasonable given the dynamic nature of the discharge (dredge pond traversing the site).
- The creek and mineral sand aquifer are directly connected, with no clogging material on the riverbed or banks. This is a conservative/worst case scenario.

The model results show no exceedances of the threshold values for the expected dredge pond water quality under either median or low flows. Two minor exceedances occur under the worst-case water quality (Max ROM) scenario under low flows; no exceedances occur under median flows.

It should be noted that, in addition to the conservative assumptions noted above, the model results are likely to significantly overestimate the rate of seepage from the dredge pond and backfill material to Tūwharewhare because the modelled groundwater flow divide is located much further to the west than interpolation of measured groundwater levels at the sites suggest (see Figure 4-3 below). The westerly bias in the divide position means that mine-affected water from a much larger area of the site seeps towards the creek than is likely. Taking this into account, our model results indicate that the proposed activity is unlikely to cause adverse water quality effects in Tūwharewhare and our conclusion remains unchanged: water quality effects in Tūwharewhare are expected to be no more than minor.

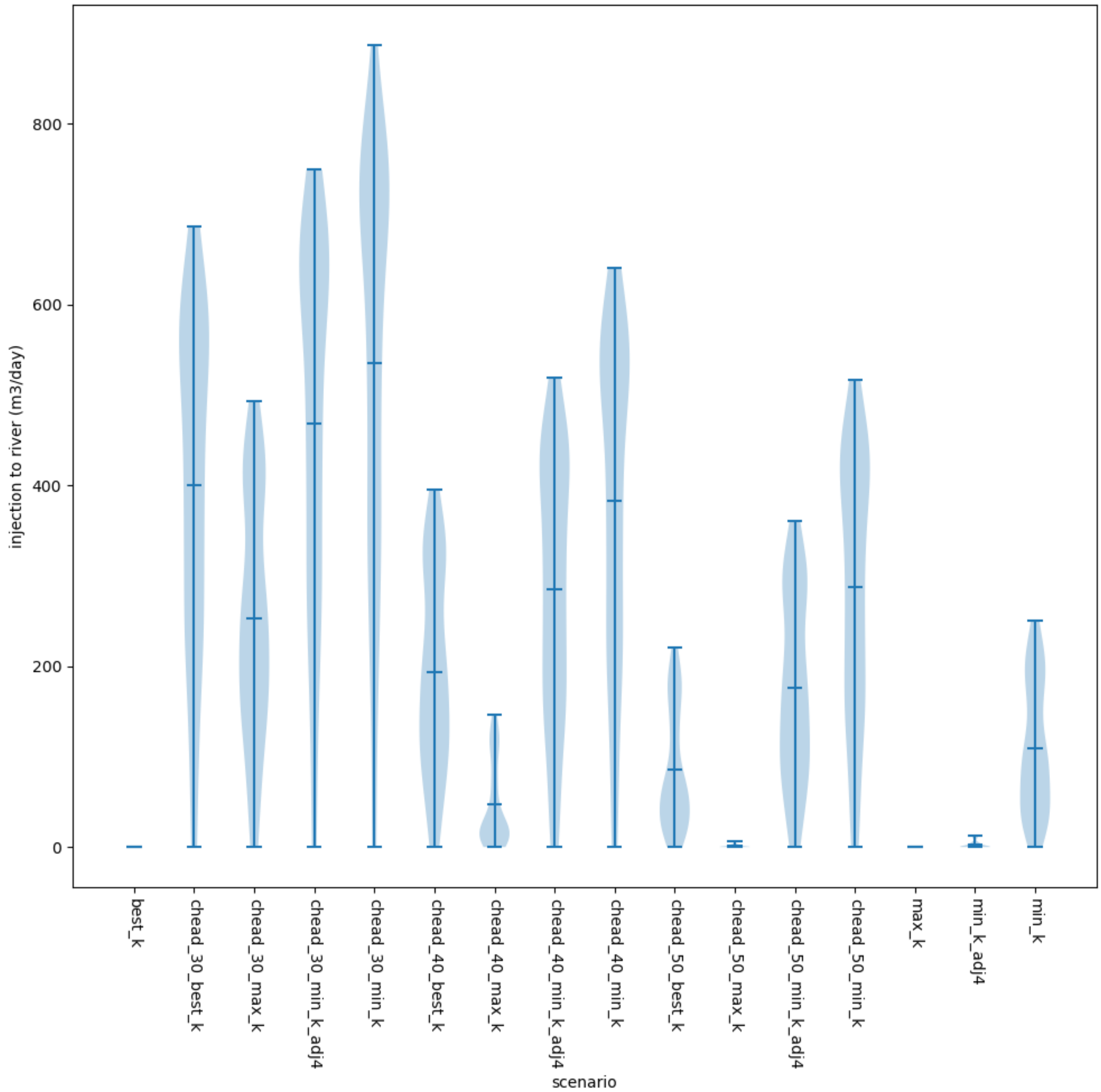


Figure 4-2: Modelled water seepages to Tūwharewhare

Table 4-1: Modelled water quality in Tūwharewhare

Synthetic dredge pond sample name	Determinant	Concentration in pond (g/m³)	Mass flux in creek MALF (g/d)	Mass flux in creek med (g/d)	Total concentration in creek under MALF (g/m³)	Total concentration in creek under median flow (g/m³)	ANZG 95th percentile (g/m³)	ANZG 99th percentile (g/m³)	Background creek concentration (g/m³)	Threshold value (g/m³)
Average ROM	Aluminium	0.268	4,263	18,190	0.27	0.27	0.055	0.027	0.27	0.27
Average ROM	Chromium	0.002	9	34	0.0005	0.0005	0.001	0.00001	0.0005	0.0005
Average ROM	Copper	0.004	17	69	0.001	0.001	0.0014	0.001	0.001	0.001
Average ROM	Zinc	0.007	65	271	0.004	0.004	0.008	0.0024	0.004	0.004
Average ROM	Nickel	0.002	7	28	0.0005	0.0004	0.011	0.008	0.0004	0.008
Max ROM	Aluminium	0.924	4,592	18,519	0.29	0.27	0.055	0.027	0.27	**0.27**
Max ROM	Chromium	0.005	10	36	0.0006	0.0005	0.001	0.00001	0.0005	0.0005
Max ROM	Copper	0.01	20	72	0.001	0.001	0.0014	0.001	0.001	0.001
Max ROM	Zinc	0.025	74	280	0.005	0.004	0.008	0.0024	0.004	**0.004**
Max ROM	Nickel	0.006	9	30	0.0006	0.000	0.011	0.008	0.0004	0.008

Note: values highlighted in red are those that are above the comparison value, where the comparison value is the largest value out of the 99% protection of species ANZG DGV & the background concentration in the creek. All concentrations are dissolved values. See details above regarding average and max ROM samples.

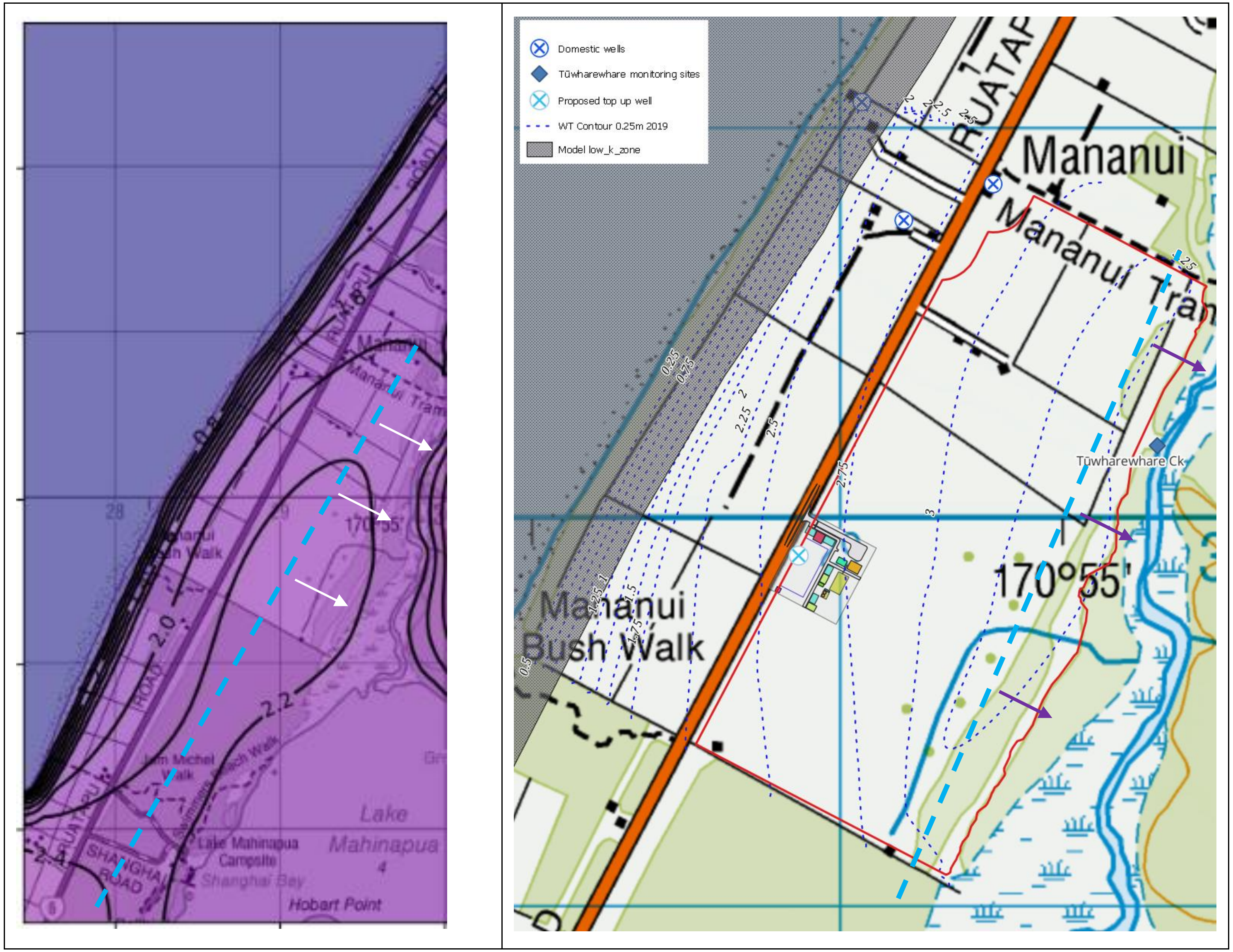


Figure 4-3: **Modelled (left) and measurement-based (right) groundwater contours and flow divide**

5 References

Etheridge, Z. and Rekker, J. (2023). *Mananui Mineral Sands Project Hydrological and Water Quality Impact Assessment*