Issues related to groundwater and surface water takes in the MDC Speeds Road well field area

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Executive Summary

Marlborough District Council invited Pattle Delamore Partners Limited to analyse recently gathered data from the Tuamarina River catchment in order to clarify the relationships between groundwater levels, surface water flows, and consented and proposed abstractions, and to comments upon their potential effects on the municipal water supply for Picton at Speeds Road.

The Tuamarina River in the vicinity of the Speeds Road area is a gaining stream, one that increases its flow downstream as a result of seepage from groundwater into the river channel.

Groundwater level data has been gathered from wells in the Speeds Road well field and, for this report, matched with corresponding flow data from the Tuamarina River. There is a strong positive correlation between groundwater levels in the Speeds Road wells and the flow of water in the adjacent Tuamarina River. In addition, there is a strong negative correlation between the rate of groundwater abstraction from Speeds Road and the corresponding flows in the Tuamarina River at Para Road Bridge. This correlation is due to stream depletion effects resulting from the pumping at Speeds Road wells. Similar relationships between groundwater abstraction and flow in the Tuamarina River have been monitored or modelled for other wells in this catchment. Most, if not all shallow groundwater abstractions within the Tuamarina Catchment are likely to have an impact on Tuamarina River flows, or those of its tributaries. Recent hydrological and groundwater level monitoring data indicate that the stream depletion effect vary from 40% to 95% of the abstraction rate. Groundwater takes are expected to divert groundwater from entering the surface water, they do not, under normal circumstances, actually abstract river water.

Surface water takes do not produce short-term effects on the groundwater. However, in the long-term, a take from a river will slightly reduce the amount of groundwater stored in the aquifer system by increasing the seepage rate to the river.

A catchment management plan involving the ‘stacking’ of abstractions, with progressively more severe restrictions based on measured river flows, has been proposed for abstractions in the Tuamarina Catchment as a practical method of minimising the adverse effects of takes on the ecological health of a river, especially during low flows. The stacking of proposed new abstractions with their proposed restriction and cessation flows indicates that the abstractions, though they will not affect the river at low flows, they will increase the frequency and duration of them.

The following recommendations are made as a result of the conclusions reached in this report:

- That precise surface water elevations of the Tuamarina River are measured as part of the monitoring process at Speeds Road, particularly during low flow situations;

- That stacking of future consent holders be replaced by a grouping of users who would share a common cut-off flow on their consents. This will allow rostering of abstractions within each water user group;
- The minimum operating groundwater levels below which the Speeds Road wells #1, #2 and #3 will struggle to meet their peak demand are 11.4, 10.3 m, 12.2 m (PBD) respectively. The river flows that corresponds to these levels are estimated to be below 30 L/s for wells #1 and #2, and about 30 L/s for well #3. Therefore, Well #3 cannot be used at more than a small fraction of its maximum pumping rate during times of low water level. In the interests of protecting the Picton water supply it is desirable that no nearby abstractions should occur below this river flow or groundwater level.

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Appendix A: Figures

1.0 Introduction

In the management of water abstractions, a balance needs to be achieved between the demand for water and the available resource supply. Demand is seasonally variable. During times of water shortage, there is a special need for clear-cut guidelines for effective and sustainable management of the resource, balancing the needs of abstractors with the available supply, and with in-stream and other environmental requirements (Sustainable Flow Regime or SFR). Marlborough District Council (MDC) is concerned about the sustainability of current takes and the potential effects of future takes in the Tuamarina Catchment , not only on the resource as a whole and associated in-stream values, but also on the ability of MDC to supply drinking water to Picton.

Marlborough District Council invited Pattle Delamore Partners Limited (PDP) to investigate the relationships between the groundwater and surface water resources in the Speeds Road well field area (Figure 1) and relate actual and potential effects to current and proposed abstractions.

A number of topics are covered in this report:

- Results of flow monitoring of the Tuamarina River;
- Relationship between groundwater levels and flows in the Tuamarina River;
- Effects of current and proposed abstractions from groundwater;
- Effects of current and proposed abstractions from surface water;
- Stream depletion effects by current and potential abstractors;
- Proposed management regime;
- Likely effects of proposed consents on the surface water regime.

Two earlier documents prepared by PDP and submitted to MDC are used in the production of this report:

- Security of Groundwater at Speeds Road – August 2002;
- Tuamarina Aquifer Management – October 2001.

2.0 River Flow and Groundwater Level Monitoring

Flows have been monitored at Para Road bridge on the Tuamarina River since November 1971. Between that date and April 2004, flows were measured only sporadically, or at times when floods or low flows were evident. However, since April 2004, continuous monitoring of flows has been undertaken Data plotted at 30 minute intervals is presented in Figure 2, representing data from April 2004 to February 2005.

There is also a small data set of low and medium flows measured simultaneously at Para Road Bridge, and at Speeds Road Bridge. These data are used to create a correlation between the monitored flows at the two sites (Figure 3) for low flows. The correlation relationship for low flows only is:

Speed Road flow = 0.60 * (Para Road flow) - 35.77 (L/s);

with a strong correlation coefficient (R^2) of 0.96. This correlation for low flows is useful in predicting the flow at Speeds Road, and the effects of takes on the flow at Speeds Road at times when irrigation restrictions are being considered. Synthetic Tuamarina River low flow data for Speeds Road are generated from this correlation and shown, with Para Road flow in Figure 4. These Para Road and Speeds Road data have been sorted in descending flow order to produce an exceedance plot, as shown in Figure 5.

If the entire flow data are used, including flood and high flows, then a somewhat different relationship between Para Road and Speeds Road flows exists that is not accurate at low flows and is not suitable for the purposes of setting consent conditions.

Groundwater levels are measured continuously at the three MDC Speeds Road wells. Although most of these data are affected by active pumping within one or more of the wells, a clear pattern of levels is evident. The time series relationship between groundwater levels measured in inactive Well 2 at the Speeds Road well field, and the corresponding monitored Tuamarina River flows at Para Road, is presented at 30 minute intervals in Figure 6. High flows in the river correspond with high groundwater levels in the wells. This relationship is an example of strong hydraulic connection between the two water bodies.

These data may be plotted in a different way, as, for example by plotting river flow at 30 minute intervals directly against groundwater level at the same intervals, as in Figure 7.

The data in Figure 7 fall into clustered trend lines. This is because at any time, the well field may have: no; one; two; or all three wells actively pumping. The pumping rates corresponding to the four strands of data in Figure 7 are approximately: 0 (Hs); and three Hp at 27; 41; and 57 L/s respectively. When river flows at Para Road are greater than about 3000 L/s, then the relationship between river flow and groundwater level is approximately linear. At river flows of less than 3000 L/s the relationship presented in Figure 7 changes, and there is a smaller rate of reduction in river flows as groundwater levels decrease.

It is significant that the trend of data points when no pumping is occurring is also curved at flows below 3000 L/s. This means that there is a fundamental and variable relationship between the groundwater level and flow in the river. When groundwater levels (and flows towards the river) are very low, they have a lesser effect on the river to which they are contributing. That this observation can be made at all implies that flow in the river is not entirely driven by seepage from local groundwater, but includes a component of flow from upstream that is not related to local groundwater levels.

In practical terms, it has long been appreciated that the available drawdown at Speeds Road well field under low river flow conditions is smaller than under high flow conditions. When water level and water elevation data corresponding to low flow conditions become available, they may allow estimation of the lowest river flow (proxy for groundwater level) under which safe pumped abstraction can be undertaken from the well.

A modified version of Figure 7 is presented in Figure 8, where synthetic Speeds Road flows are plotted against the elevation of groundwater levels in Well 2. The bounding envelope of data under non-pumping conditions is also plotted. In addition, there are two additional data points: one representing conditions of river level (12.225 m PBD) and flow (32 L/s) at Speeds Road on 3rd and 7th May 2001 respectively (drought conditions); the other data point represents static groundwater level (Hs = 12.52 m PBD) in well #2 and the corresponding river flow. No wells were pumping at the time that these two data points were measured. Notice that the Hs for 3rd May 2001 is separated from the data points recorded during the period April 2004 to February 2005, and indicates the need for more information, especially for a range of low flows. It is possible that the non-pumping (Hs) envelope continues along the line as indicated on Figure 8. The slope of this line and the corresponding Hp lines drawn for the system during pumping (one, two and three wells), indicates a smaller change in river flows for changes in groundwater level under low groundwater level conditions.

Figure 15 shows the relationship between water levels within each pumping well, and the flow discharged from the well field. This figure allows estimation of the individual and combined drawdowns for each well, and therefore, the corresponding safe minimum standing water levels required for operation. Table 1 lists the drawdowns associated with each well, for different combined flow rates. Cumulative drawdown represents the total drawdown with all wells active and is used in Table 2 to estimate the safe water level. The step drawdowns in Table represent the decrease in water level as an additional pump (well) is used. No assessment of any relationship between drawdown and static groundwater level has been made. It may become evident that at low groundwater levels drawdowns in wells may increase.

Table 1: Drawdowns and corresponding pumping rates estimated from Figure 15

Wells active		Combined flow (L/s)	Incremental drawdowns (m)		
			Well #1	Well #2	Well #3
Step drawdown	2 *(1 well active)*	26.8	0.21	0.32	0.18
	1 to 2 *(2 wells active)*	45.1	0.34	0.12	0.10
	(1 + 2) to 3 *(all active)*	52	0.02	0.04	0.42
Cumulative drawdown		52	0.57	0.48	0.7

It is generally undesirable to pump from a well such that the top of the screen is exposed above the drawn down water surface. Currently, the minimum water level (determined by pump placement) in Well #3 is about 11.5 m relative to the Picton Borough Datum (PBD). Therefore, under river low flow conditions there is very little groundwater lying above the top of the screen under static water level conditions. Under pumping conditions, the water level in the well is likely to be below the top of the screen (Table 2). This effect is seen in Figure 8, where the maximum pumping rate data (57 L/s) appear to be absent under low groundwater level conditions.

Table 2: Well data derived from Plan P3/68. Elevations in metres relative to Picton Borough Datum.
(*) Includes drawdown interference plus a safety margin of 1 m;
(#) Well #3 is generally used at a rate of 7 L/s (no safety margin included).

	New Well #1 P27/0471	Well #2 (New well)	Well #3
Elevation of top of screen (m)	9.8	8.8	9.2
Elevation of top of pump (m)	6.5	5.9	11.5
Normal peak pumping rate (L/s)	27	18	~7
Maximum drawdown required to achieve maximum pumping rate (m)	0.6	0.5	0.7
Groundwater level required to achieve maximum pumping rate * (m)	11.4	10.3	12.2#
Approximate Speeds Road river flow at required groundwater elevation (L/s)	<30	<30	30

Elsewhere in the well field, for example, in the New Well #1, the top of the screen is deeper, about 9.8 m relative to the Picton Borough Datum (PBD). According to the data in Figure 8, the lowest static groundwater level, at, for example, a river flow of 10 L/s, is likely to be only 12.5 m PBD, estimated to be 2 m higher than the top of the screen during pumping. Therefore, for wells with pumps located in sumps, the screen top is comfortably below the lowest groundwater levels associated with drought conditions.

River stage elevation data on Plan P3/68 indicates that on the 3rd May 2001, the water level in the river at Speeds Road was 12.225 m PBD, with a flow of approximately 32 L/s (7th May 2001). Plotting of this datum point on Figure 9 shows that, even at the very low flows of autumn 2001, there is still a significant positive difference between the static water level in the wells (Hs) and the water level in the river.

However, whilst at low flows there may be sufficient water above the top of screen at Speeds Road for safe pumping for the new wells with pumps situated in sumps, this is not the case for Well #3. The dashed Hp lines presented in Figure 8 show that the elevation of groundwater and river flow during use of Well #3 is such that the pumping water level is likely to be below the top of the pump for all but small rates of abstraction from this well. Examination of the data spread in Figure 8 shows that there are data absent from the region (area with groundwater levels below 12.5 m, marked 'A' on plot) occupied by low river levels when all three wells are pumping. A plot of the change in pumping rate for each well in order to accommodate changes in background groundwater level is presented in Figure 16.

In addition, at very low river flows, the Hp lines indicate that the relative elevations of groundwater and surface water level can be reduced to approximately zero, such that there is a potential for actual river water to be drawn into the wells. This has significant ramifications for protecting the quality of groundwater in the aquifer from potential contamination by surface water in the river. This topic will be subject of a subsequent report.

In conclusion to this section, the minimum operating groundwater levels below which the Speeds Road wells #1 and #2 will struggle to meet their peak demand are 11.4 and 10.3 m (PBD) respectively; well #3 has an estimated minimum water level of 12.2 m (PBD). The river flows that corresponds to these levels are estimated to be below 30 L/s for wells #1 and #2, and about 30 L/s for well #3. Therefore, Well #3 cannot be used at more than a small fraction of its maximum pumping rate (7 L/s). In the interests of protecting the Picton water supply it is desirable that no nearby abstractions should occur below this river flow or groundwater level.

Configuration of wells #1 and #2 have meant that the minimum groundwater levels for safe operation of the pumps is so low that, provided there is some flow remaining in the Tuamarina River to form a constant head boundary to the aquifer, they should still achieve their desired rates.

3.0 Effects of current and proposed abstractions from the water resource

There are two kinds of water abstractions in the Tuamarina Catchment area: groundwater takes, and surface water takes. These are described separately in this section, and then their combined effect assessed. It is proposed that the effects of these two types of take have differing short and long-term effects on the entire water resource. The two types of water abstractions, and the corresponding effects on the entire water resource are now described and explained.

3.1 Abstractions from the Tuamarina River

It is important at the outset to understand that in the Speeds Road well field area, groundwater is contributing to stream flow (i.e. the river is gaining water from the groundwater). Therefore, surface water takes from the Tuamarina River do not immediately have an effect on the groundwater resource; there would have to be a significant drop in stage height in the river, as a result of the take, before there is a corresponding change in the hydraulic gradient driving an increased rate of groundwater flow towards and into the river. The change in stage height resulting from a surface water abstraction is governed by the width of the river and the ratio of the abstraction versus the flow in the river. The same argument holds for abstractions directly from tributaries of the Tuamarina River.

The effect of surface water takes on the storage of groundwater in the aquifer system is not significant except in the long-term, whereby there would be a small decrease in storage close to the river if the hydraulic gradient between the river and the groundwater is increased. Surface water takes, therefore, do affect the storage capacity of groundwater, but not markedly so.

3.2 Abstractions from groundwater

Abstractions directly from groundwater create an effect on groundwater pressures, and indirectly affect the surface water bodies that are in hydraulic connection with them, a process known as stream depletion. Monitoring of abstractions both during pumping tests and during water use, show that wells intercept groundwater that ultimately would enter the Tuamarina River. The interception and abstraction of groundwater originally destined to enter a surface water body is related to a number of factors: the distance between the abstraction point and the river; values for a number of aquifer parameters; and, the length of time over which the abstraction is occurring. In some cases a take from groundwater only depletes a stream, gradually increasing over a period of days. In others, the depletion mechanism may take only hours for it to develop to a maximum.

3.3 Groundwater takes and stream depletion

Analysis of two groundwater abstractions in the Speeds Road area, with corresponding measurements of surface water flow in the Tuamarina River indicate that these abstractions cause stream depletion to such a degree that much of the groundwater abstracted was originally destined to flow to the river, and additionally, the maximum degree of stream depletion is attained within hours for wells close to the Tuamarina River, but may take a few days for abstractions more distant from the river.

Not only does abstraction of groundwater have an effect on river flows, but by decreasing groundwater levels, abstraction also affects the long-term storage of water in the aquifer. Changes in groundwater storage are directly related to groundwater levels. As levels decline, there is less water in storage within the aquifer (much as the water level in a tank is a measure of water available). As groundwater levels decline, so does storage, and the ability of wells to remain efficient at abstracting water. In an extreme drought or low flow event, pumps may cease to operate when water levels are too low.

Groundwater abstractions affect the degree of groundwater storage, which in turn determines the flow within the Tuamarina River. As storage declines, so does the corresponding river flow. Consented flow restrictions in part govern the rate at which storage is allowed to decline. Surface water abstractions result in lower rates of storage decline than groundwater takes.

Proposed surface water takes, especially if the takes have high Tuamarina River flow restrictions on them such that the abstractions are restricted to times of high flow, should not measurably affect the magnitude of storage of the aquifer under low flow conditions.

4.0 Stream depletion effects by current and potential abstractors

Four separate investigations of two specific abstractions (MDC and Waitohi Farm Ltd) have indicated that the abstraction of groundwater from sites within 1 km of the Tuamarina River contribute to a process of stream depletion. The degree of stream depletion is variable, ranging from as low as 40% to as much as 95% of the abstraction rate. As such, each groundwater abstraction effectively amounts to being equivalent to a surface water take. This conclusion was made in the PDP report: "*Tuamarina Aquifer Management*". However, the conclusion is not new, it was reached over 30 years ago, during the original pumping test of the Speeds Road wells in 1971 (58% stream depletion within 24 hours). It has been confirmed, not only at a pumping test for the Waitohi well, but also, again, for the Speeds Road wells, in 2004.

Monitoring data are presented in this report in order to show the effects of stream depletion on river flows. The period 13th to 15th December 2004 was sufficiently wet that irrigation demand was at a minimum. Figure 9 presents Tuamarina River flow at Para Road and pumping monitoring data from the Speeds Road well field indicating the direct and rapid stream depletion effects corresponding with abstraction from the MDC Speeds Road well field.

In response to this conclusion, MDC has developed an interim management plan that recognises that groundwater abstractions have almost immediate and far-reaching effects on flows in the Tuamarina River. This management plan attempts to minimise the adverse effects of abstractions by controlling rates of abstractions at low flows. This management plan is described in the following section.

5.0 Proposed management regime

In 2001 Pattle Delamore Partners Limited was invited by MDC to make proposals for a management regime for the water resources of the Tuamarina catchment. The recommendations of that report are quoted below, and further recommendations made.

5.1 Tuamarina Aquifer Management Report

A quote from this 2001 report follows:

1. *"Whenever the flow in the Tuamarina River ceases at Speeds Road, or falls below 30 L/s at Para Road, then irrigation abstractions must cease, unless they can reliably demonstrate to MDC that their abstraction comes from a separate water source that does not affect either the Tuamarina River or the Picton water supply. For example, a confined aquifer that is distinct from the shallow groundwater and river system that exists in the Tuamarina River system does not affect surface flow in the Tuamarina River. This condition may be further constrained following an assessment of sustainable flow regime for in-stream values.*

2. *The allocation of water for irrigation will be based on the assessed effect that each abstraction will have on the surface flow in the Tuamarina River.*

   - *For a surface water abstraction this will be based on the maximum pumping rate, with an additional allowance of one-third of the pumping rate to protect in-stream values.*

   - *For a groundwater abstraction this will be based on the stream depletion effect that is proven by a pumping test. In the absence of a pumping test, the stream depletion effect will be assumed to be the average pumping rate from the well head.*

3. *Irrigation abstractions that affect the Tuamarina River shall be subject to a pro-rata restriction which commences when an upper flow level is reached at Speeds Road, with the abstraction ceasing when a lower flow level is reached. The lower flow rate at which abstraction must cease shall be calculated from the sum of all prior water allocations that have been made. The upper flow shall include the calculated stream depletion effect of the current allocation. These flow measurements will be made at both Speeds Road and Para Road.*

4. *All irrigation consents should include a clause which states that the conditions of the consent can be reviewed for the purposes of dealing with any adverse effects on the Picton water supply wells located at Speeds Road.*

5. *Recommendations 1 – 4 must be presented to existing water users (including in-stream interest groups and local iwi) and consent applicants in a draft form for their consideration. The recommendations should be reviewed and refined on an annual basis, taking into account the views of all interest groups and the latest monitoring data that has been gathered."*

The Tuamarina Aquifer Management report also contained a table (Table 3).

Table 3: Examples of Water Sharing Between Irrigators (GW = Groundwater; SW = Surface water)

Irrigation Abstractor	Average Daily Depletion Rate from the Tuamarina River (L/s)	Source of Water	Flow Monitoring at Speeds Road		Flow Monitoring at Para Road	
			Flow at which Abstraction Starts to be Restricted (L/s)	Flow at which Abstraction Must Cease (L/s)	Flow at which Abstraction Starts to be Restricted (L/s)	Flow at which Abstraction Must Cease (L/s)
1st Irrigator	*20*	*GW*	*20*	*0*	*50*	*30*
2nd Irrigator	*10*	*GW*	*30*	*20*	*60*	*50*
3rd Irrigator	*60*	*SW*	*90*	*30*	*120*	*60*
4th Irrigator	*25*	*GW*	*115*	*90*	*145*	*120*

These two quotes from the proposed management plan indicate how a process of ‘stacking’ of abstractors and their corresponding restriction and cessation flows can alleviate the adverse effects of groundwater and surface water takes on the Tuamarina River. The following section shows how the management plan could be updated to allow for new information, and new abstractors.

5.2 Tuamarina River Catchment Management Plan - Update

It can be seen from the quoted material and in Table 3 in the foregoing, that the proposed minimum flow at which takes must cease was zero at Speeds Road, equivalent to 30 L/s at Para Road. MDC has operated the management plan with a higher value for the minimum flow. This value may be inferred from consent conditions for current abstractions as set out in the Table 4.

Table 4: Relationships between Tuamarina River flow and abstractions. Proposed abstractions in italics. Correlation used as in Section 2 of this report.

Abstractor	Maximum daily depletion rate from Tuamarina River (L/s)	Water source	Flow Monitoring: Speeds		Flow Monitoring: Para	
			Flow at which abstraction starts to be restricted (L/s)	Flow at which abstraction must cease (L/s)	Flow at which abstraction starts to be restricted (L/s)	Flow at which abstraction must cease (L/s)
MDC	53	GW	-	-	-	-
Picton GC	0.44	GW	-	-	-	-
Waitohi	35.0	GW	50	30	135	100
Fearn	23.1	GW	73	53	158	123
Twose	34.7	GW	n.s.	n.s.	193	158
Picton GC	0.39	SW	n.s.	n.s.	228	193
*Bampton**	*30*	*SW*			*258*	*228*
*MDC**	*4.75*	*GW*	-	-	-	-
*Fearn**	*16.2*	*GW*			*274*	*258*

Note: * proposed abstractions; n.s. not specified

The consent condition data in Table 4 indicate that the minimum flow for the 'first' abstractor, other than the un-restricted abstractions by MDC and the Picton Golf Club, is 100 L/s at Para Road, the corresponding cut-off flow at Speeds Road is 30 L/s.

Using Para Road as the prime monitoring location, the equivalent flows for Speeds Road are given in Table 4.

5.3 Effect of existing abstractions on Tuamarina River

Current monitoring of river flows already includes the effects of existing water abstractions by MDC and irrigators. Therefore, in order to assess the potential effects of existing abstractors on flow in the Tuamarina River, it is necessary to identify periods when little, if any abstraction for irrigation is being undertaken. Two flow periods are known when irrigators have not been active: once during the original pumping test in 1971, and again, during the wet December of 2004.

The potential effects of un-restricted irrigation abstractions can be crudely calculated by arithmetically removing the takes from the monitored river flow but not taking into account the proposed flow restrictions as set out in Table 4. This modified flow is presented in Figure 10 for the 1971 to 1972 period. Figure 10 shows the degree to which the Tuamarina River could be modified by removing all current and proposed abstractions were there no low flow conditions imposed. Although this crude modelling process shows the imperative for low flow restrictions, it is not as useful as one that realistically models the imposition and effects of flow restrictions, as presented in the following section.

6.0 Likely effects of proposed consents on the surface water regime

The potential effects of proposed irrigation takes in addition to current ones modelled in the previous section of this report, can be modelled on existing flows. In Figures 11 and 12 the effects of the Bampton and Fearn takes are shown on the monitored Tuamarina River record for the period April 2004 to February 2005. The same data are presented as an exceedance plot in Figure 13. Note that the effects of the proposed takes lower the river flow somewhat, but do not produce significant ‘flat-lining’ of the flow (periods when flow is held constant as a result of individual abstractions being restricted in direct proportion to the river flow. This is because the natural variability of the river flow is of a much greater magnitude than that of the abstractions.

Fortunately for the irrigators, the period April 2004 to February 2005 was not characterised by particularly low flows. Therefore, in order to illustrate the potential effect of low flows on the takes allowed by abstractors, the data used in Figure 12 have been ‘reduced’ by 200 L/s, to produce Figure 14. Figure 14 shows the effects of abstraction and how the effects are reduced as the cut-off flows of 258 L/s and 228 L/s are reached. Flat-lining of the flows is visible in Figure 14 for short periods of 2 to 3 days. The timing of flat-lining occurs between the restriction and cessation flows when the proportion of allowable take is pro-rated directly (1:1) to the flow in the river. Flat-lining is not ecologically desirable because flow variability creates short-lived episodes of aeration, transport and deposition that encourage healthy fish and plant habitat. However, based on the simulation in Figure 14, the effect appears to be of small magnitude and is unlikely to be an environmental issue.

The likely effects of the additional takes proposed by Bampton and Fearn are such that flows lower than 228 L/s are unaffected. The increase in time period when flows of 228 L/s are experienced in the river is likely to be only in the order of a few days.

6.1 Minimising effects of takes at low flows

The consent conditions currently allow Marlborough District Council the option to reduce a user’s take in line with decreasing flow in the Tuamarina River, known as a pro-rata reduction. Alternatively, the Council may opt to use only the lower flow condition to restrict users in an on-off fashion.

The pro-rata type of take restriction can produce an environmental effect in the river, known as flat-lining. In addition, irrigators traditionally like to operate their equipment at maximum abstraction rate, not at the progressively reduced abstraction rates implied by the restrictions imposed in the management plan. Accordingly, it may be preferable for users to decrease their take by increasing the timing between successive applications rather than by decreasing flow. In such a case, a roster would be developed in order to minimise the in-stream effects of the combined takes of abstractors such that not every abstractor takes water at the same time. Such a roster could be developed by the setting up of a water user group and by restricting users in allocation blocks of 3 to 4 irrigators who would operate on a roster when flows dropped into their allocation flow regime. For example, based on current applications it may be practical to have an allocation block of 100 L/s, which must cease abstraction at 228 L/s (Para Road) and is pro-rated downwards from flows of 328 L/s, or (if 100 L/s has not been allocated) from a flow of 228 L/s plus the current allocations in that block.

Such a pro-rata scheme comes at a price, more complex monitoring, and continued agreement between users. The small risk of flat-lining may be offset by the advantages gained by operating a simple on-off flow restriction method that is solely reliant good monitoring and communication of the flow regime to users.

7.0 Conclusions and Recommendations

The following conclusions may be made from the data analysed in this report on the Tuamarina River Catchment:

- That groundwater takes produce an immediate and substantial stream depletion effect on the Tuamarina River up to 95% of the abstraction rate;
- The Tuamarina River in the vicinity of the Speeds Road area is a gaining stream, one that increases its flow downstream as a result of discharge from groundwater;
- Groundwater takes are expected to divert groundwater from entering the surface water, they do not, under normal circumstances actually abstract river water;
- Surface water takes do not produce short-term effects on the groundwater. However, in the long-term, a take from a river will slightly reduce the amount of groundwater stored in the aquifer system;
- A catchment management plan involving the 'stacking' of abstractions, with appropriate restriction and cessation flows is a satisfactory method of minimising the adverse effects of takes on the ecological health of a river, especially during low flows. However, a practical alternative allocation scheme may be achieved by grouping abstractors so that they can operate a rostered system of water sharing during times of low flow.

The following recommendations are made as a result of the conclusions reached in this report:

- That once Well 3 has been re-configured, data should be collected regarding the new drawdowns in each of the wells for a variety of pumping rates and pump use scenarios;
- That steps be taken to collect data regarding the actual elevation of the river surface at Speeds Road (relative to Picton Borough Datum) during times of low flow, along with corresponding measurements of groundwater level and river flow.

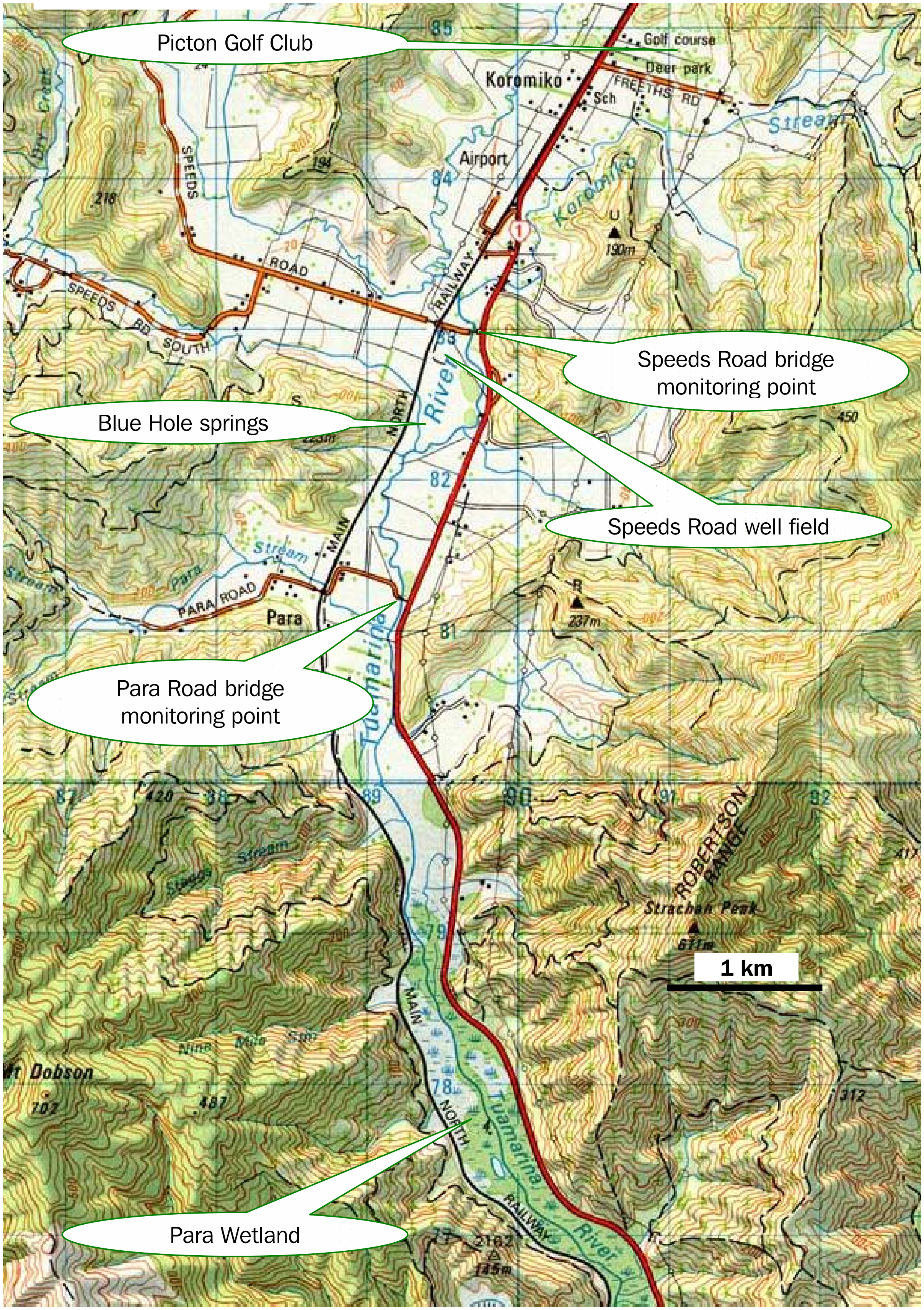

Figure 1: Map of the lower part of the Tuamarina River Catchment, showing locations of Para Road wetland, Speeds Road well field, the Picton Golf Club

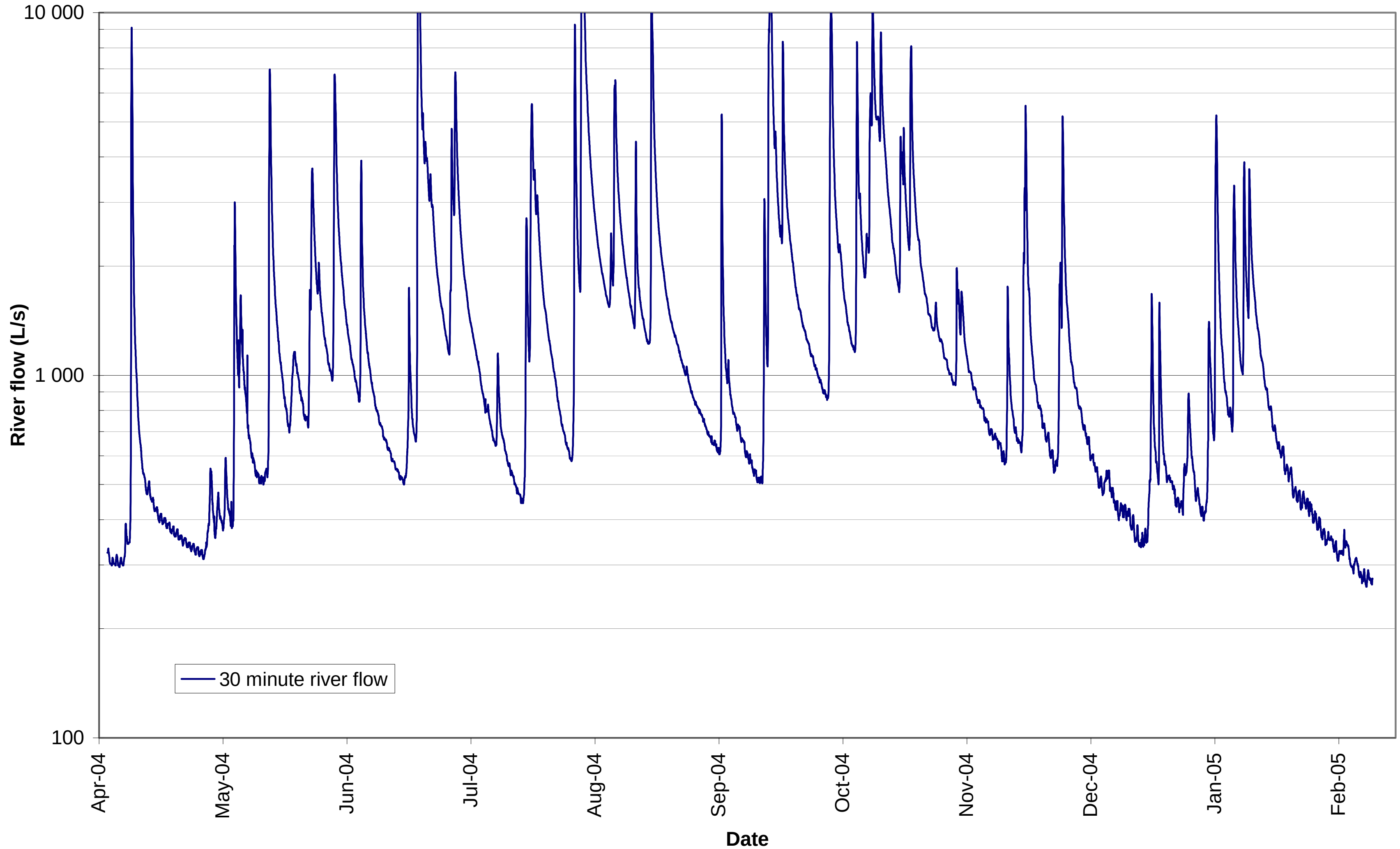

Figure 2: Time series plot of Tuamarina River flow monitored at Para Road

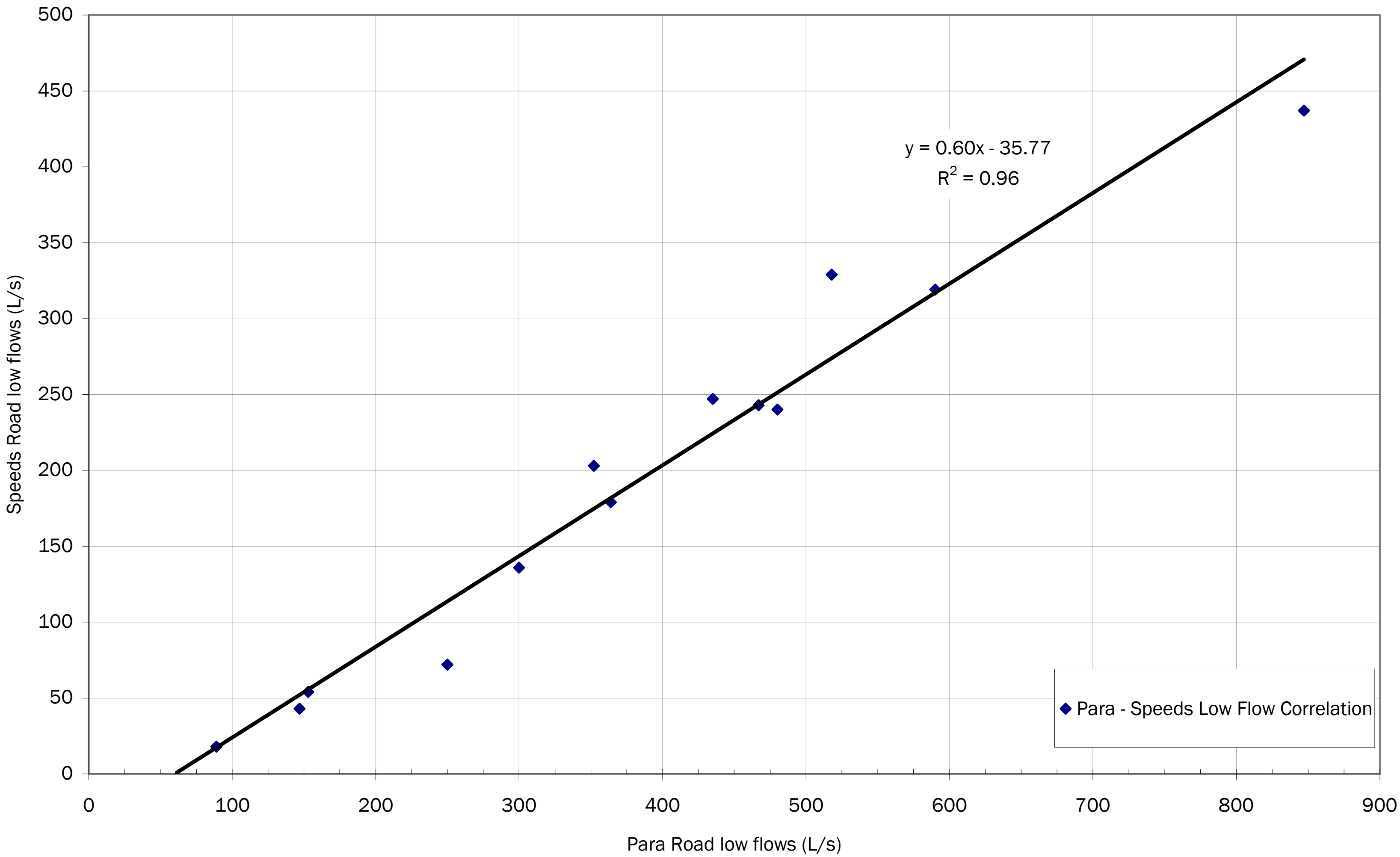

Figure 3: Correlation plot of Tuamarina River flow as monitored at Para Road and Speeds Road

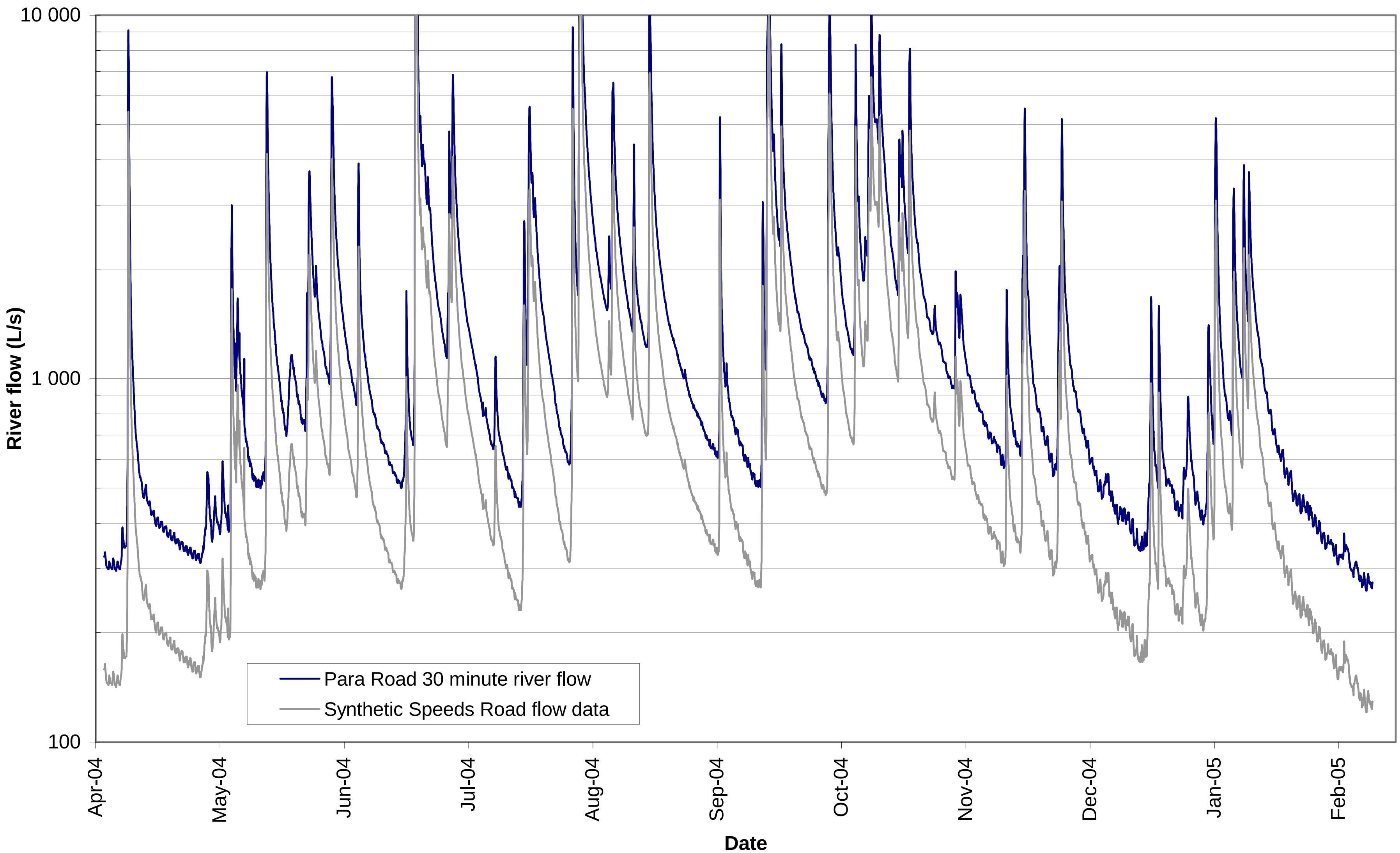

Figure 4: Time series plot of Tuamarina River flow monitored at Para Road with synthetic flow data for Speeds Road

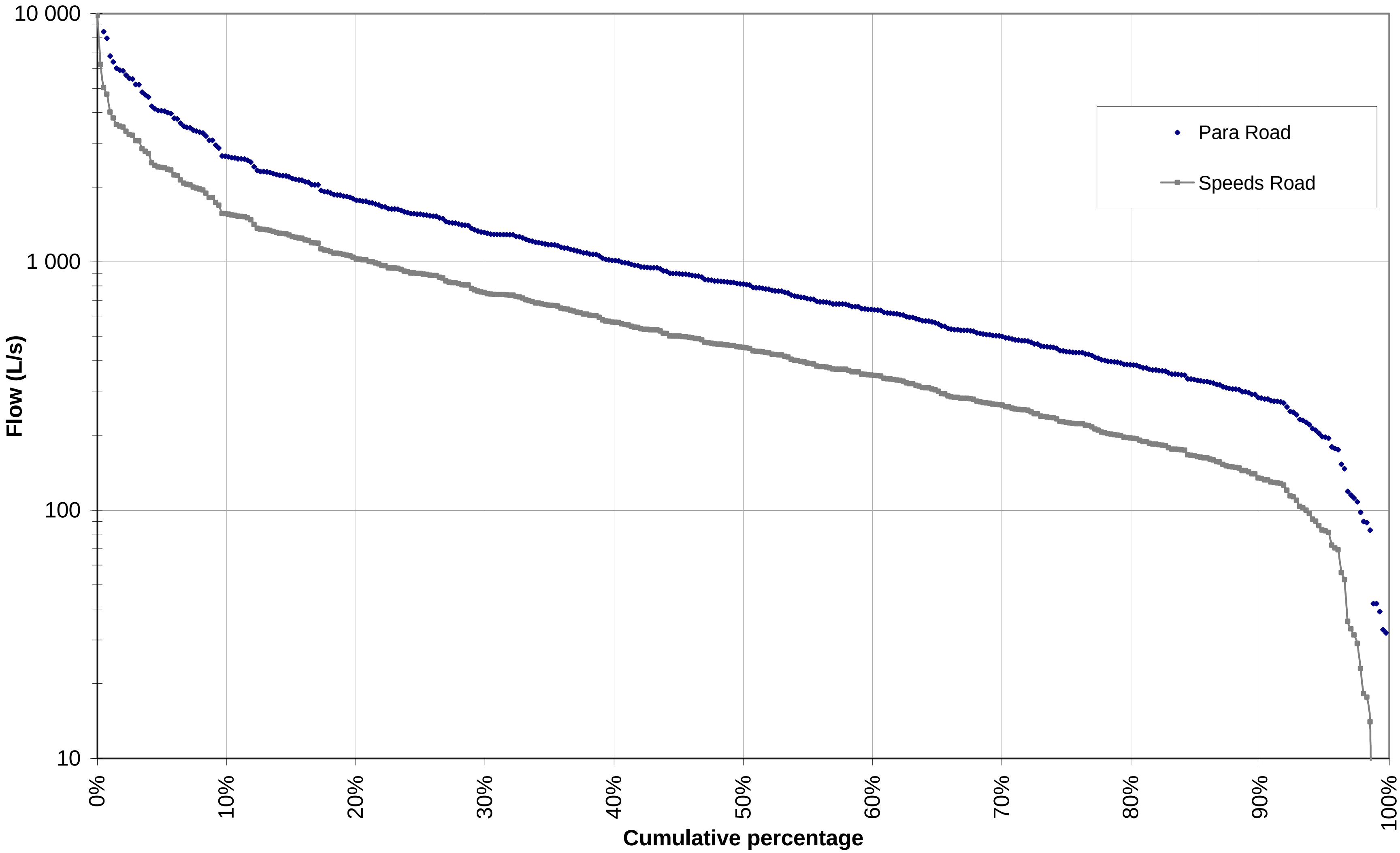

Figure 5: Exceedance plot of Para Road and Speeds Road flows – showing percentage of time that the river flow is greater than a particular flow

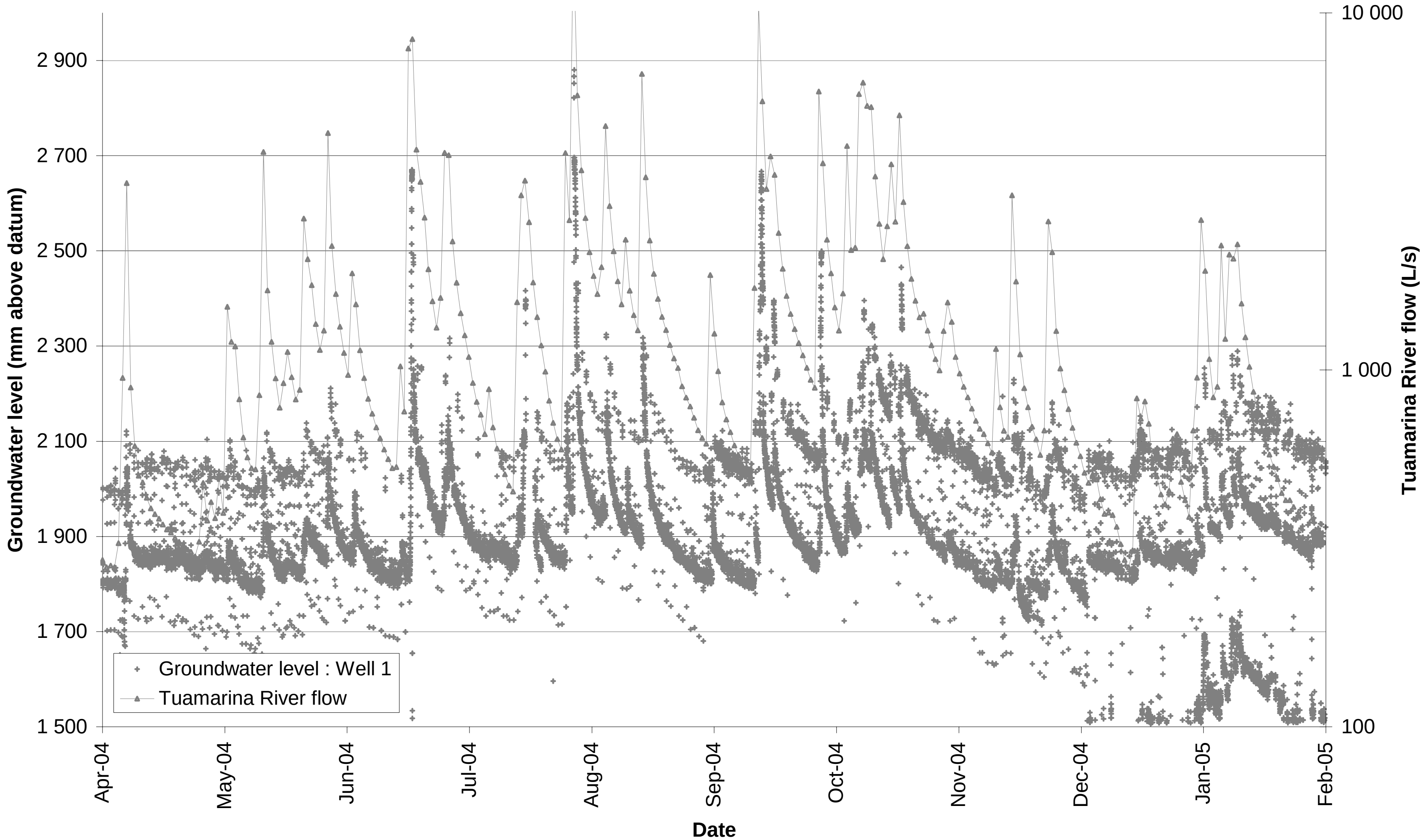

Figure 6: Combined time series plot Tuamarina River flow at Para Road and groundwater levels in Speeds Road Well 1

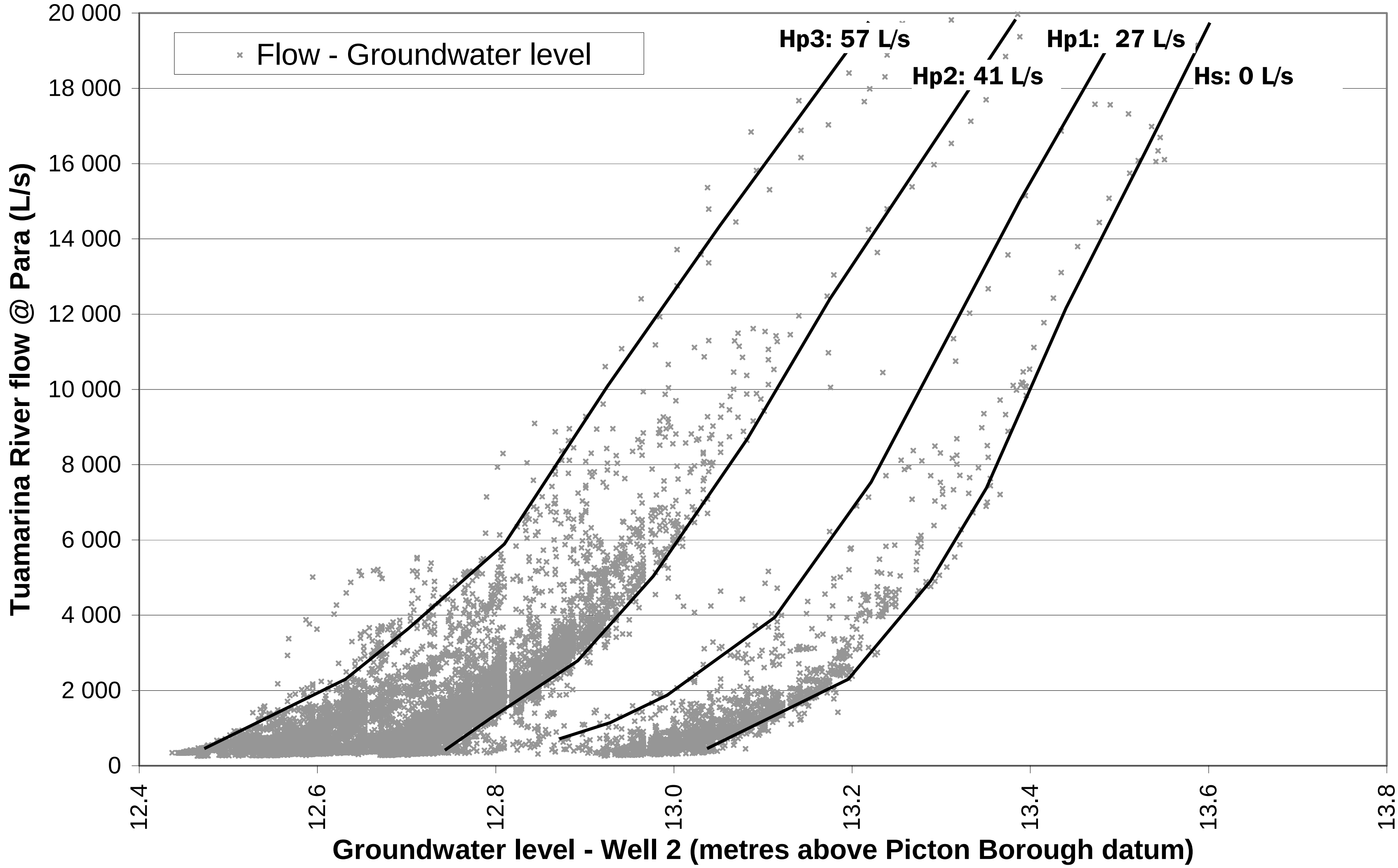

Figure 7: Plot of Tuamarina River flow at Para Road versus groundwater levels at Speeds Road Well 2 (linear). Zone of linear relationship between groundwater level and Tuamarina River flow corresponds with flows > 3000 L/s: non-linear at flows < 3000 L/s.

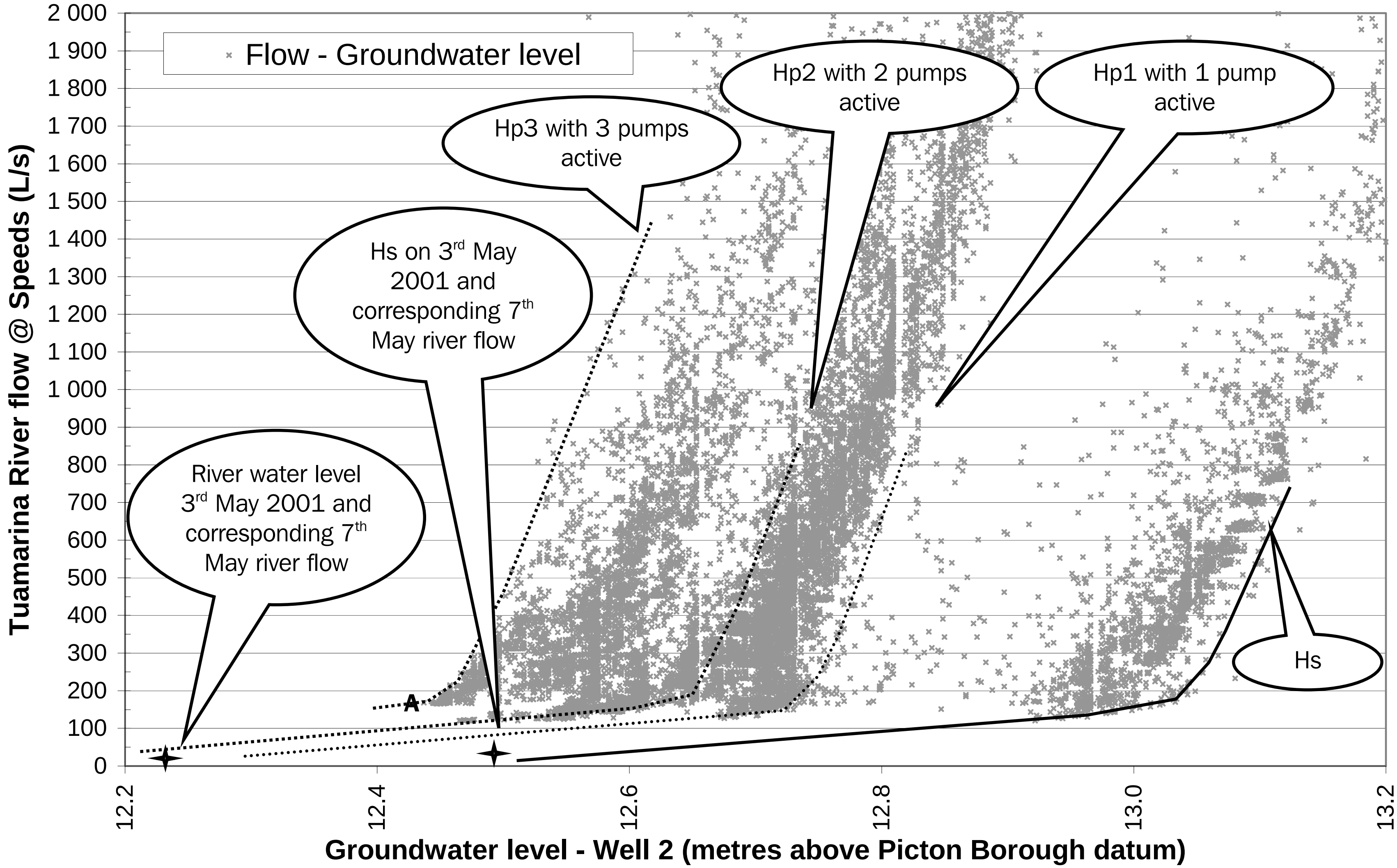

Figure 8: Plot of calculated Tuamarina River flow (7th May) at Speeds Road versus groundwater levels at Speeds Road Well 2. The Tuamarina River water elevation on 3rd May 2001, with corresponding static water level in well 2, and river flow (7th May) are also shown. The Hp envelopes for one and two wells pumping are shown to indicate their relationship with the Hs envelope .

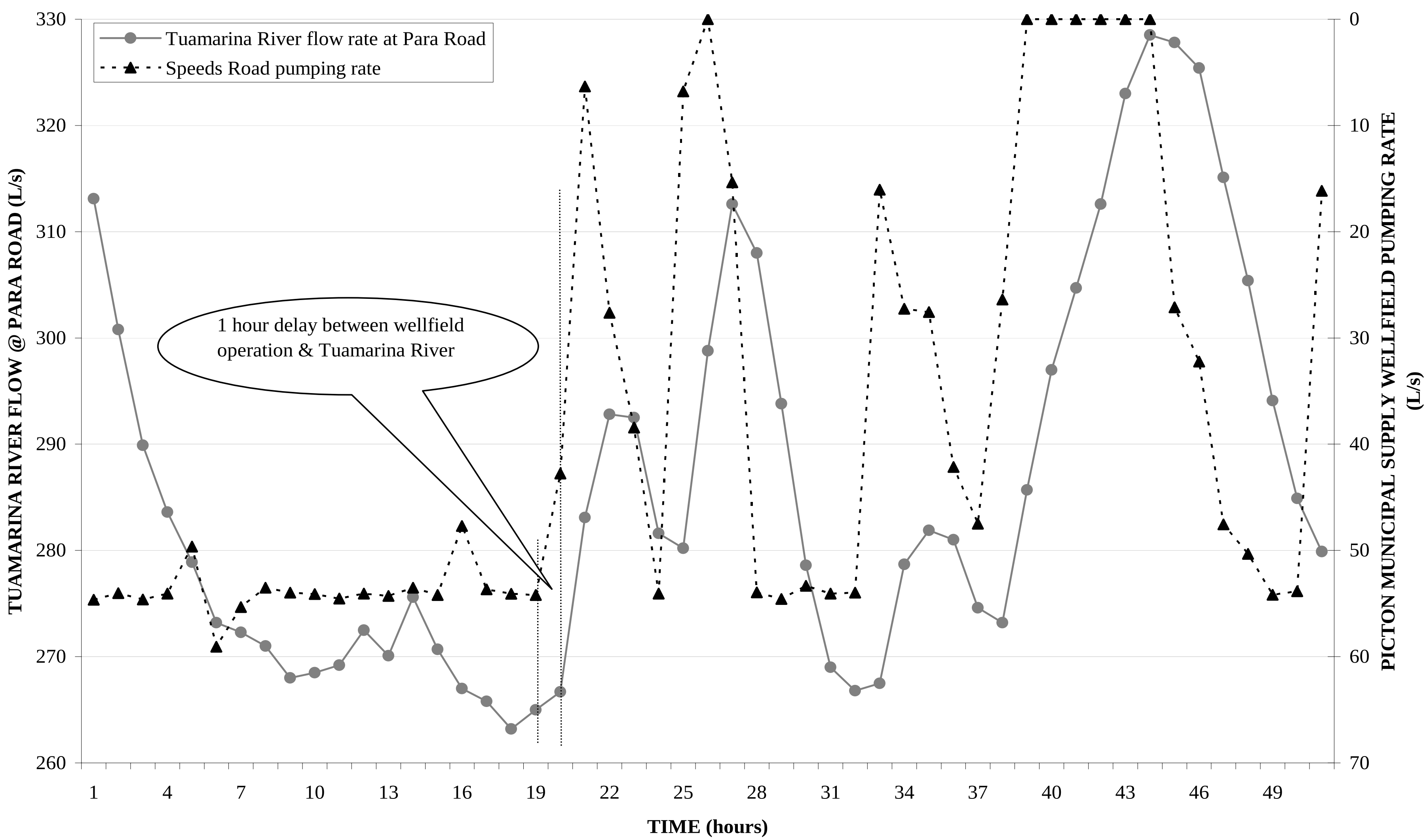

Figure 9: Plot of the relationship between Tuamarina River flow at Para Road versus abstraction at Speeds Road well field

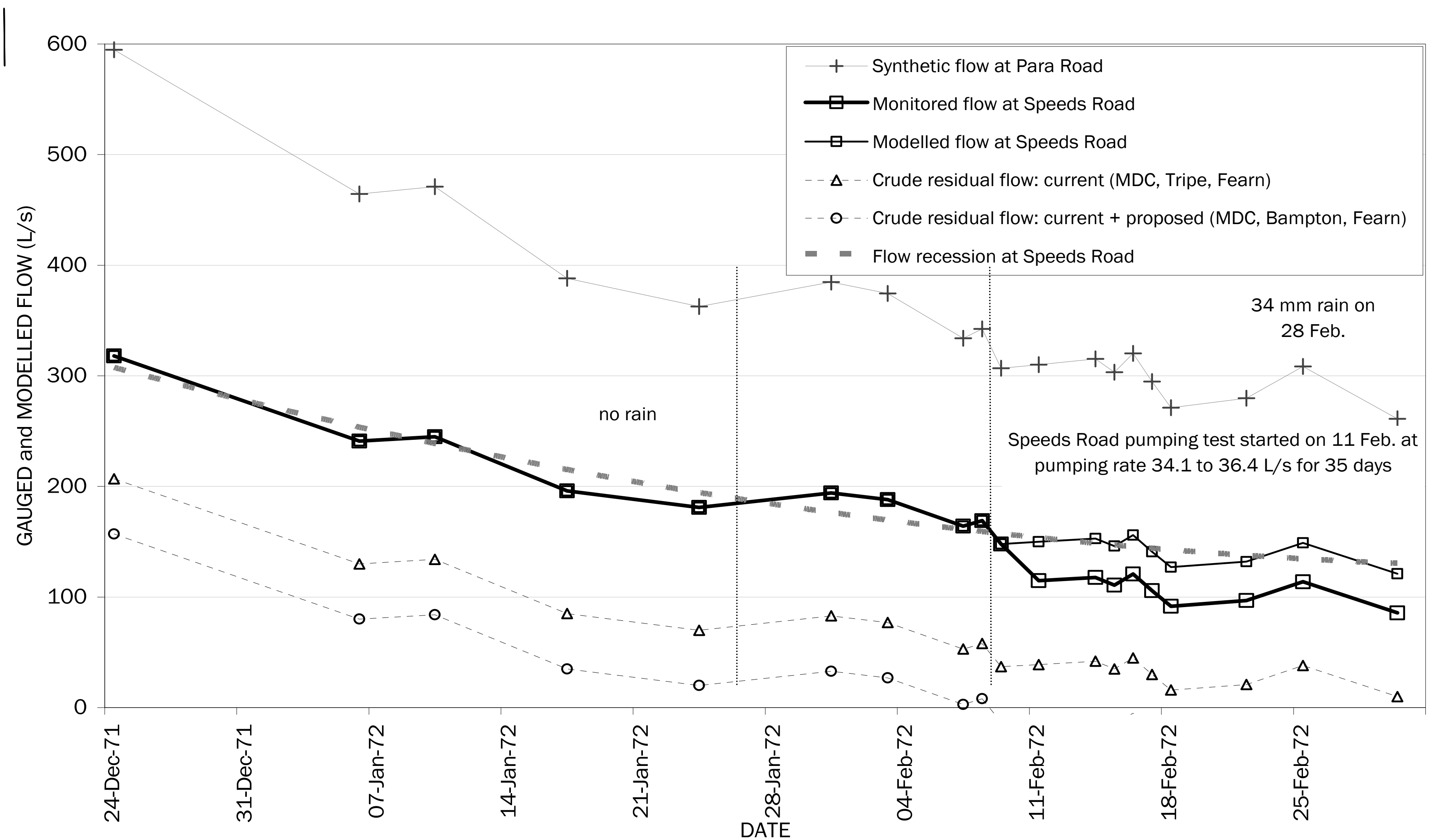

Figure 10: Modelled effects of current and proposed abstractions on Tuamarina River flow for the period December 1971 to February 1972

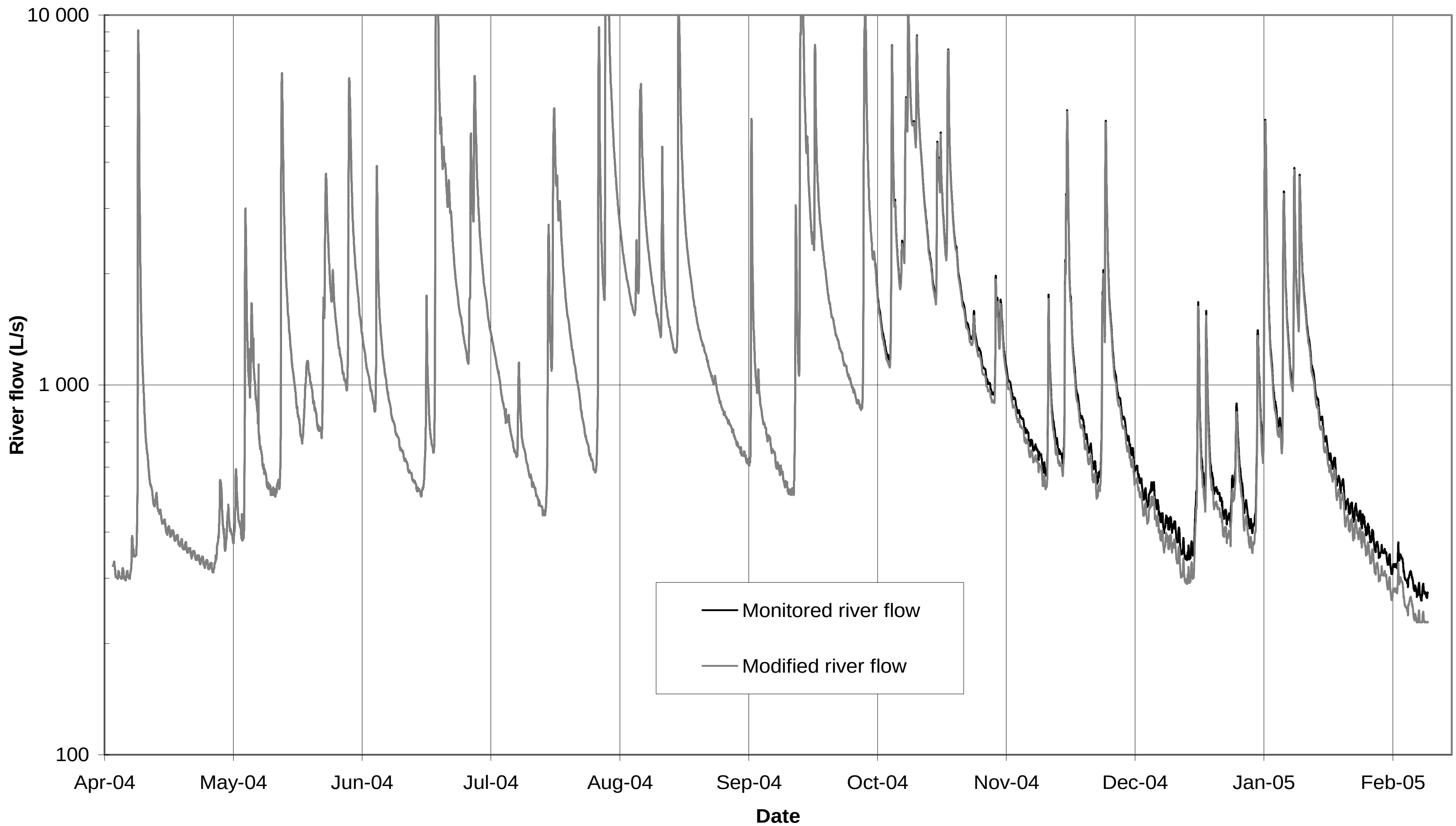

Figure 11: Modelled effects of proposed abstractions on monitored flow in the Tuamarina River at Para Road for the period April 2004 to February 2005

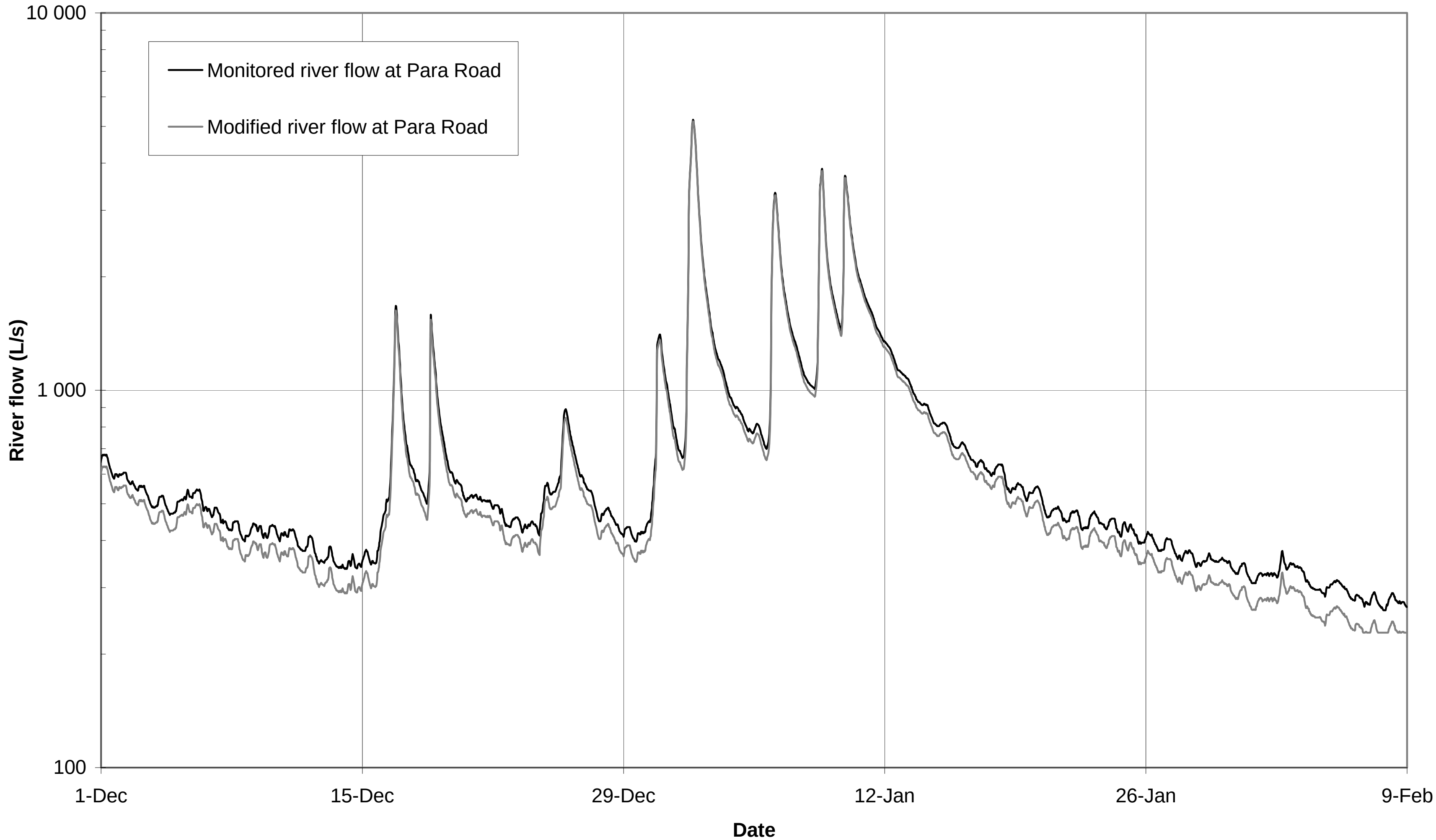

Figure 12: Modelled effects of proposed abstractions on monitored flow in the Tuamarina River at Para Road for the period December 2004 to February 2005 (detail of Figure 11)

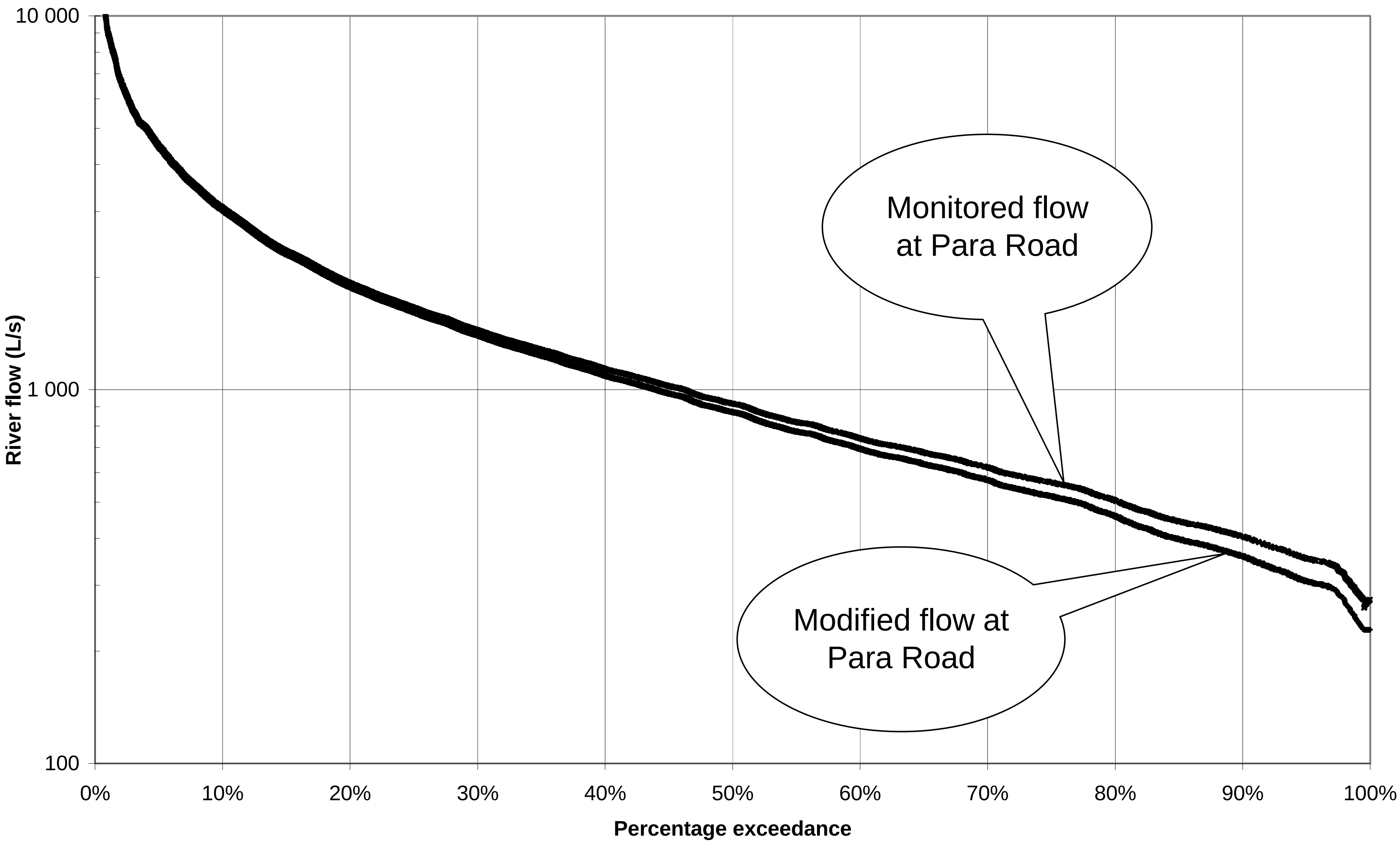

Figure 13: Exceedance plot of modelled effects of proposed abstractions on monitored flow in the Tuamarina River at Para Road for the period April 2004 to February 2005

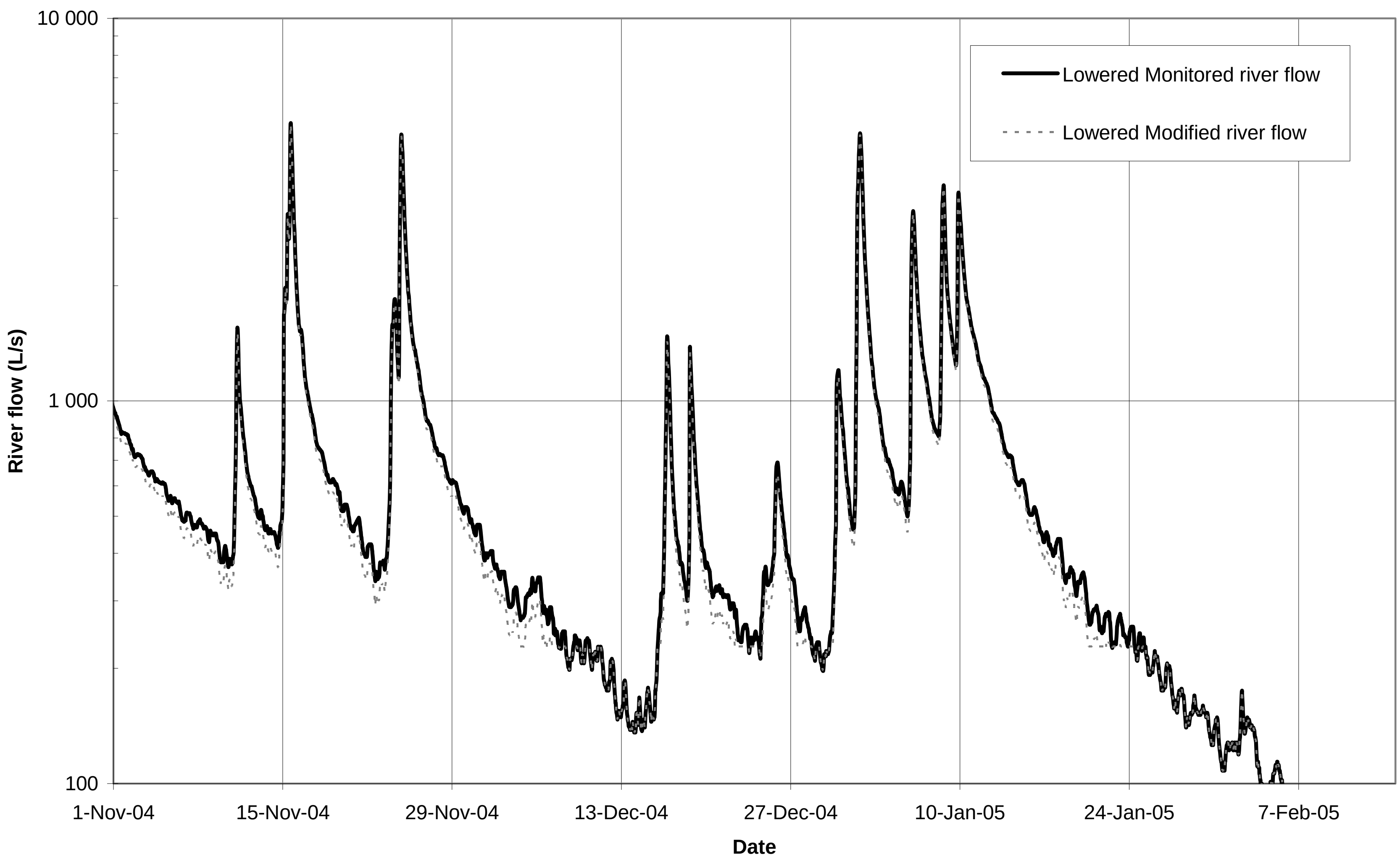

Figure 14: Modelled effects of proposed abstractions on artificially lowered flow in the Tuamarina River at Para Road for the period April 2004 to February 2005

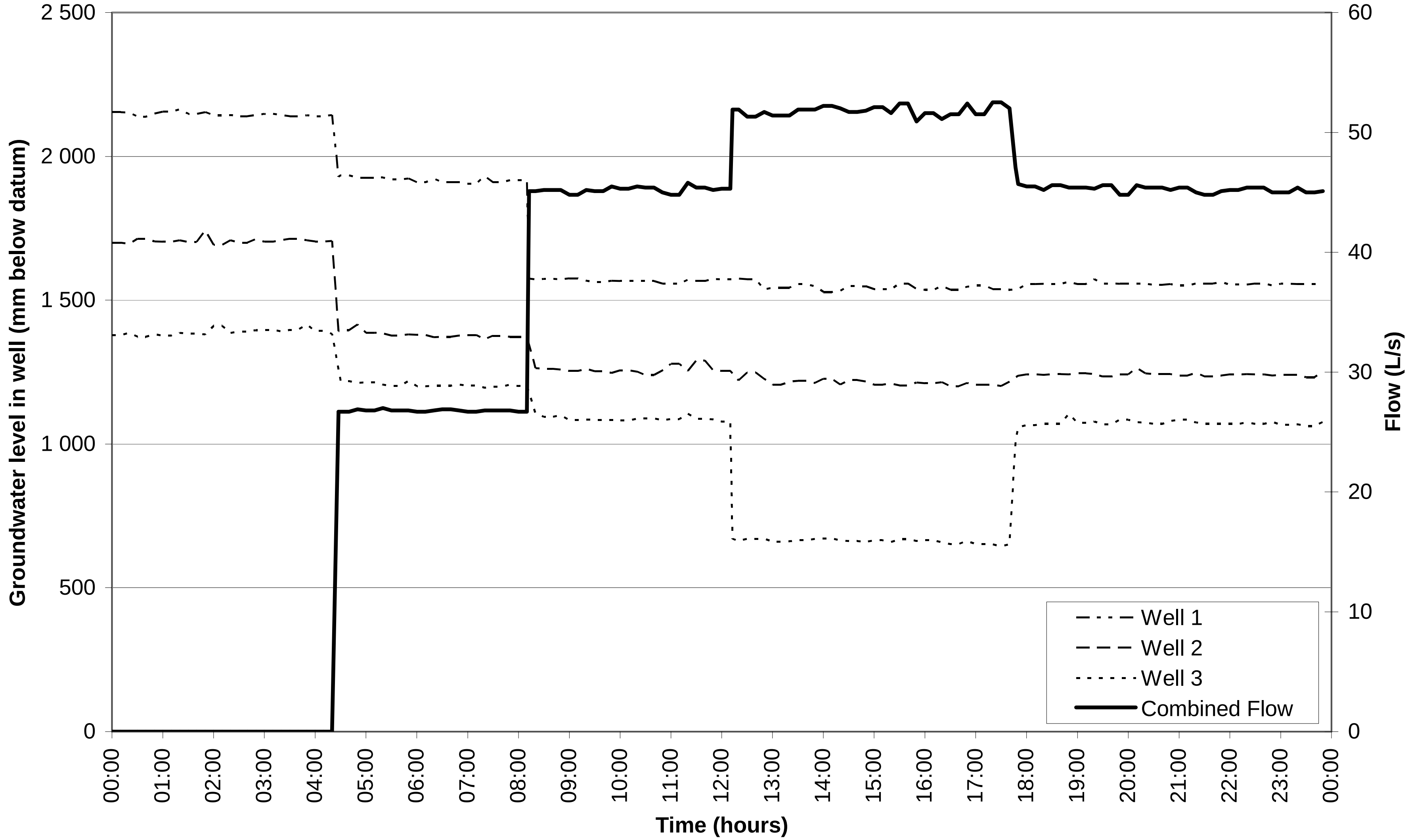

Figure 15: Plot of water levels within each of the three wells at Speeds Road, and corresponding combined flow rates