Suspended sediment monitoring in the Motueka catchment: data report to 1 May 2006

NIWA Client Report: CHC2006-087
July 2006

NIWA Project: LAN06501

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Prepared for

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NIWA Client Report: CHC2006-087
July 2006
NIWA Project: LAN06501

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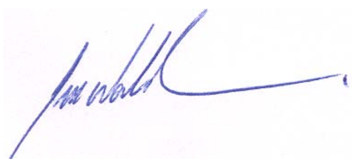
Reviewed by:



Jeremy Walsh

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Executive Summary

Turbidity sensors and auto-samplers were initially installed at three sites in the Motueka Catchment for the Integrated Catchment Management Programme. These sites are on the Motueka at Woodman's Bend (representing the discharge to the coast), the Motupiko at Christie's (representing the 'East Bank' tributaries draining the Moutere Gravels terrain), and the Wangapeka at Walter Peak (representing the 'West Bank' tributaries draining the complex basement rock terrain). Records commenced in mid November 2002, and a continuous record of turbidity has been compiled at each site since then. In April 2004 the Motueka at Gorge site was also added to the programme (representing the steep/mountainous, relatively high rainfall terrain underlain by old sedimentary and ultramafic basement rocks that typify the south-eastern Motueka River headwaters).

The collection of auto-samples has enabled calibration relationships to be established that relate turbidity to suspended sediment concentration (SSC) for all four sites. For all sites (except Motueka at Gorge) at least two turbidity/SSC relationships have now been developed to account for new turbidity sensors (and in one case a new site location) or reprogramming of sensors. At present the new turbidity sensor at the Wangapeka at Walter Peak site, installed on 22 December 2005, does not have enough auto-sample data to allow a turbidity/SSC relationship beyond this date.

1. Background

In the 2002/2003 year, suspended sediment monitoring commenced at three stations in the Motueka Catchment to provide improved information on river suspended loads to the Integrated Catchment Management (ICM) Programme. The sites are on the Motueka mainstem at Woodman's Bend (representing the discharge to the coast), the Motupiko at Christie's (representing the 'East Bank' tributaries draining the Moutere Gravels terrain), and the Wangapeka at Walter Peak (representing the complex basement rock terrain on the West Bank that includes the Mt Arthur Group sedimentary rocks, the Riwaka Igneous Complex, and the Separation Point Granite). In April 2004, the Motueka at Gorge site was also added to the programme (representing the steep/mountainous, relatively high rainfall terrain underlain by old sedimentary and ultramafic basement rocks that typify the south-eastern Motueka River headwaters).

The aim of the data collection is to compile continuous records of suspended sediment concentration (SSC) and to determine the particle size distribution of the suspended load during a representative event for all four sites. The SSC records will be used to compute sediment loads during runoff events and long-term yields.

The measurement strategy has three main components:

- to continuously record back-scatter-type turbidity as a surrogate for SSC
- to collect samples using automatic samplers in order to compile calibration relationships between turbidity and SSC beside the sensors
- to collect a series of depth-integrated samples at multiple verticals so that
    1. the auto-sampled SSC can be related to mean cross-section concentration, and
    2. the particle size distribution of the suspended load can be sampled.

This report describes the installations, the data that has been collected as far as 1 May 2006, and the turbidity/suspended sediment concentration relationships developed.

2. Instrumentation

At all four sites, the basic instrumentation includes a data-logger, a turbidity sensor, a stage sensor, and an automatic sampler. Site-specific instrumentation is detailed in Appendix 1. The Motueka at Woodman's Bend instrumentation was integrated with Tasman District Council's water level recorder installation, and so can be accessed via their telemetry operation. The installations at the Motupiko, Wangapeka and Motueka at Gorge are stand-alone systems, and turbidity data from these sites are down-loaded from the data-loggers manually during field visits.

The installations are shown on Figures 1.1 to 1.5. It should be noted that the Motupiko at Christie's installation is now 400-500 m downstream of the original bridge location, as of 26 May 2005. The original turbidity sensor and pressure transducer were washed away during the Easter 2005 floods (Figure 1.1). The Motueka at Gorge equipment was also inundated during this event (Figure 1.5).

The stage sensor record is used by the data-logger to provide a running total of water discharge so that the auto-samplers can be activated on a flow-proportional basis once a threshold stage is passed. A simulation program was used with several years of water discharge record from each site to determine appropriate threshold values for the activation stage and discharge volume (Appendix 2). Threshold values have been occasionally modified if more/less samples were required.

Turbidity and stage are logged every 15 minutes. The turbidity sensors are of the nephelometric/back-scattering type. They are equipped with a small water pump which regularly squirts a jet of water over the lens to inhibit bio-fouling. All of the water pumps were replaced on 24/25 November 2004 as they were becoming less reliable.

The sites were activated on the following dates:

- Motupiko at Christie's (original site now abandoned): 18 November 2002
- Motupiko at Christie's (new site): 26 May 2005
- Wangapeka at Walter Peak: 19 November 2002
- Motueka at Woodman's Bend: 23 November 2002
- Motueka at Gorge: 6 April 2004

Figure 1.1: Motupiko at Christie's original site. On top photograph, turbidity sensor is to left of staff gauge, auto-sampler intake pipe is to right. Bottom photograph shows the site after the Easter 2005 flood washed away the monitoring equipment.

Figure 1.2: **Motupiko at Christie's new site. This site is located approximately 400 to 500 m downstream of the original site.**

Figure 1.3: **Wangapeka at Walter Peak. The turbidity sensor and stage sensor are in the white plastic tube. The auto-sampler intake hose runs through the steel pipe several metres downstream.**

Figure 1.4: **Motueka at Woodman's Bend (before installation). The sensors and auto-sampler intake are fixed to the rip-rap; the auto-sampler sits on the bank; the data is cabled to a data-logger housed in a hut to the right of the picture.**

Figure 1.5a: **Motueka at Gorge. Turbidity sensor is hidden within plastic tube, while steel pipe is linked to auto-sampler.**

Figure 1.5b: Motueka at Gorge. Grey box holds battery and data-logger. Top photograph shows the auto-sampler under the walkway. Bottom photograph shows debris from Easter 2005 flooding.

3. Field procedures, laboratory analyses, and data archiving

Field procedures are detailed in Appendix 2.

A ‘triage’ procedure has been developed for selecting which auto-samples to analyse for SSC in the laboratory. While it would be ideal to analyse every auto-sample collected, the budget prevents this, and so only a selection of samples are processed. The selection process for each batch of auto-samples involves first inspecting the matching raw turbidity sensor record. If the record appears sensible (i.e., it is not corrupted by fouling and is in phase with the stage record), then usually only a small sub-set of samples are kept for analysis, covering the range of turbidity encountered while the batch was collected. This quasi-regular collection of a few samples allows us to track any drift in the SSC versus turbidity relationship. If, however, the turbidity range extends higher than previously recorded and auto-sampled, then most of the samples from the higher range are processed in order to extend the calibration relationship. If the turbidity record appears to be erroneous, then most of the samples are processed in order to create a SSC record directly from the auto-samples. When a new site, or a new turbidity sensor, is installed a larger number of auto-samples are processed to allow a new SSC versus turbidity relationship to be established.

The time series data are archived into raw, working, and final TIDEDA files. The raw turbidity records are archived onto Turbidity_raw.mtd along with records of stage and discharge. The master stage and discharge record is that from the existing TDC recorders and their current stage-discharge ratings. Raw data are archived under the site numbers given in Table 3.1.

Data editing, calibration, and gap-filling is then done within a working file Working_2006.mtd. As detailed in section 5, calibration is done using the relationships between SSC and turbidity. Gaps in the turbidity record are filled preferentially with auto-sample data if it exists, otherwise using a SSC vs. discharge rating relationship. The final SSC time series are then copied into the file Final_2006.mtd. Each SSC value is tagged according to whether it was derived from a calibrated turbidity record, an auto-sample, or an SSC rating. The parameters and site numbers for Working_2006.mtd and Final_2006.mtd are summarised in Tables 3.2 and 3.3, respectively. The derivations of the turbidity/SSC and river discharge/SSC relationships, using the auto-sampler data, are in an Excel table (Sensor calibrations_0306.xls).

The site numbers for the SSC time series (derived from turbidity time series), where auto-sample data and river discharge/SSC relationships have been used to fill gaps and ‘tie down’ flood peaks, are 5701511, 5703611, 5702511 and 5700811 for Motueka at

Woodman's, Motupiko at Christie's, Wangapeka at Walter Peak and Motueka at Gorge, respectively.

Table 3.1: Archive details for raw Motueka turbidity sites (Turbidity_raw.mtd)

Site	Parameter	Site No.	Item
Motueka at Woodman's Bend	Stage	57015	1
	Discharge	"	2
	Turbidity	5701502	1
	Bottle No.	"	2
Motupiko at Christie's	Stage	57036	1
	Discharge	"	2
	Turbidity	5703602	1
	Bottle No.	"	2
Wangapeka at Walter Peak	Stage	57025	1
	Discharge	"	2
	Turbidity	5702502	1
	Bottle No.	"	2
Motueka at Gorge	Stage	57008	1
	Discharge	"	2
	Turbidity	5700802	1
	Bottle No.	"	2

Table 3.2: Archive details for the Motueka turbidity sites (Working_2006.mtd).

Site	Site No.	Item	Parameter	Processing
Motueka at Woodman's Bend	57015	1	Stage	None
	"	2	Discharge	None
	87015	1	SSC	None (laboratory results)
	5701501	1	Turbidity	Spikes, bio-fouling & bad data removed. Data ramped where sensor cleaned/bio-fouling.
Motupiko at Christie's	57036	1	Stage	None
	"	2	Discharge	None
	87036	1	SSC	None (laboratory results)
	5703601	1	Turbidity	Spikes, bio-fouling & bad data removed. Data ramped (bio-fouling).
Wangapeka at Walter Peak	57025	1	Stage	None
	"	2	Discharge	None
	87025	1	SSC	None (laboratory results)
	5702501	1	Turbidity	Spikes, bio-fouling & bad data removed. Data ramped (bio-fouling).
Motueka at Gorge	57008	1	Stage	None
	"	2	Discharge	None
	87008	1	SSC	None (laboratory results)
	5700801	1	Turbidity	Spikes, bio-fouling & bad data removed. Data ramped (bio-fouling).

Table 3.3: Archive details for the Motueka turbidity sites (Final_2006.mtd)

Site	Site No.	Item	Parameter	Processing
Motueka at Woodman's Bend	15	1	SSC	Auto-sample lab results to fill gaps in the turbidity time series.
	”	2	Tag (=1)	[subset of site 89015 in Working_2006.mtd]
	57015	1	Stage	Data to derive SSC=f(Q) for gaps in turbidity time series.
	”	2	Discharge	[subset of Site 57015 in Working_2006.mtd]
	5701501	1	Turbidity	[same as Site 5701501 in working_2006.mtd]
	5701511	1	SSC	Site 5701501 converted to SSC using a turbidity/SSC relationship. Gaps filled, where possible, with auto-samples (Site 15) and SSC=f(Q) (derived from Site 57015).
		2	Tag	Tag = 0 [for SSC=f(NTU)], 1 [for auto-sample data] or 10 [for SSC=f(Q)]
Motupiko at Christie's	36	1	SSC	Auto-sample lab results to fill gaps in the turbidity time series.
	”	2	Tag (=1)	[subset of site 89036 in Working_2006.mtd]
	57036	1	Stage	Data to derive SSC=f(Q) for gaps in turbidity time series.
	”	2	Discharge	[subset of Site 57036 in Working_2006.mtd]
	5703601	1	Turbidity	[same as Site 5703601 in working_2006.mtd]
	5703611	1	SSC	Site 5703601 converted to SSC using a turbidity/SSC relationship. Gaps filled, where possible, with auto-samples (Site 36) and SSC=f(Q) (derived from Site 57036).
		2	Tag	Tag = 0 [for SSC=f(NTU)], 1 [for auto-sample data] or 10 [for SSC=f(Q)]
Wangapeka at Walter Peak	25	1	SSC	Auto-sample lab results to fill gaps in the turbidity time series.
	”	2	Tag (=1)	[subset of site 89025 in Working_2006.mtd]
	57025	1	Stage	Data to derive SSC=f(Q) for gaps in turbidity time series.
	”	2	Discharge	[subset of Site 57025 in Working_2006.mtd]
	5702501	1	Turbidity	[same as Site 5702501 in working_2006.mtd]
	5702511	1	SSC	Site 5702501 converted to SSC using a turbidity/SSC relationship. Gaps filled, where possible, with auto-samples (Site 25) and SSC=f(Q) (derived from Site 57025).
		2	Tag	Tag = 0 [for SSC=f(NTU)], 1 [for auto-sample data] or 10 [for SSC=f(Q)]
Motueka at Gorge	8	1	SSC	Auto-sample lab results to fill gaps in the turbidity time series.
	”	2	Tag (=1)	[subset of site 89008 in Working_2006.mtd]

Site	Site No.	Item	Parameter	Processing
	57008	1	Stage	Data to derive SSC=f(Q) for gaps in turbidity time series.
	”	2	Discharge	[subset of Site 57008 in Working_2006.mtd]
	5700801	1	Turbidity	[same as Site 5700801 in working_2006.mtd]
	5700811	1	SSC	Site 5700801 converted to SSC using a turbidity/SSC relationship. Gaps filled, where possible, with auto-samples (Site 8) and SSC=f(Q) (derived from Site 57008).
		2	Tag	Tag = 0 [for SSC=f(NTU)], 1 [for auto-sample data] or 10 [for SSC=f(Q)]

4. Summary of data collected to 1 May 2006

The turbidity records, auto-samples and depth-integrated suspended sediment gaugings available up to 1 May 2006 are summarised in Table 4.1.

Table 4.1: Data summary for Motueka sites

Site	Turbidity time series	Auto-samples	Depth-integrated SS gaugings
Motueka at Woodman’s Bend	23-Nov-02 to 1-May-06	277 over 29 events	2
Motupiko at Christie’s	18-Nov-02 to 1-May-06	249 over 34+ events	1
Wangapeka at Walter Peak	19-Nov-02 to 1-May-06	93 over 27+ events	-
Motueka at Gorge	6-Apr-04 to 1-May-06	154 over 30 events	-

The lower number of auto-samples collected at Wangapeka, compared to the other sites, can be partly explained by samples not being captured during the June 29 – 2 July 2003 event. During this event only one auto-sample was retained - a rat had moved into the sampler and chewed through a vital hose. There were also few auto-samples collected between March 2005 and December 2005 when the faulty Wangapeka turbidity sensor was replaced.

5. Derivation of suspended sediment concentration (SSC) time-series data

The raw water discharge and turbidity time series records up to 1 May 2006 are shown in Appendix 3 for the four turbidity sites.

The water discharge records are from the Tasman District Council. The turbidity data are raw values in NTU. The raw turbidity records contain single-value spikes generated during low flows (usually due to leaf litter around the sensor) and sometimes show drift relating to bio-fouling of the sensor. Some sites also seem to have problems with siltation around the time of flood peaks and during the flood recession. This has been observed at times when the concentration of auto-samples collected during flood events has peaked and is starting to decrease while the recorded turbidity is still increasing (or it becomes erratic). This has resulted in some auto-samples with high SSC not being able to be used in the derivation of calibration relationships, as the turbidity data relating to the same time period is unreliable. Gaps have been inserted in the turbidity time series when this occurs (these gaps are subsequently patched with the auto-sample data).

Where possible, the data spikes and drift were removed from the turbidity data before conversion to SSC records using TIDEDA editing processes. For the SSC time series derived from the turbidity time series, gaps in the record occurring during flood events (as a result of instrument malfunction, siltation, etc) were filled, where possible, to provide a continuous time series. The steps for filling gaps in the record were:

1. If a gap occurred during a period of low flow, where SSC levels are likely to remain low and constant, the gap in the record is removed by replacing it with a straight line.

2. If reliable auto-sampler data exist for the gap, auto-sample lab results for SSC are inserted into the SSC time series.

3. If there are no auto-samples to adequately fill the gap, a SSC time series based on a flow/SSC relationship is inserted in the gap.

4. If there are still gaps (i.e. no auto-samples or flow record) then the gaps in the record must remain.

Sections 5.1 to 5.4 below detail the calibration of the turbidity sensors, and the conversion of the turbidity data into a SSC time series, for each site.

5.1. Motueka at Woodman's Bend

5.1.1. Editing turbidity record

The water discharge and raw turbidity time series from 23 November 2002 to 1 May 2006 are shown in Appendix 3 (Figures A3.1 to A3.3). These raw turbidity data were edited to remove spikes and drift, likely to have been caused by bio-fouling or silting up of the turbidity sensor. Closer examination of the turbidity record also revealed a distinct change in the values recorded by the sensor after a gap in the record at the beginning of April 2004. At this time the 'base' turbidity increased from approximately 3 NTU to 17 NTU, and there was also an increase in the sensitivity of the recorder to fluctuations in turbidity, which we assume is due to reprogramming of the sensor. Accordingly, separate turbidity/SSC relationships were developed for before and after this change.

5.1.2. Generating turbidity/SSC relationship

Auto-sampler data were used to generate the turbidity/SSC relationships. The auto-sampler collects water samples each time a water volume of 2 million m^3 passes the site while the stage exceeds a threshold level. As described in section 3, a selection of the auto-samples is forwarded for laboratory analysis of SSC. Overall, a total of 277 auto-samples from 29 events between 29 June 2003 and 25 April 2006 have been analysed.

Once laboratory analyses determined the SSC (mg/L) of each auto-sample, the data are compared against the recorded turbidity and river discharge at the time that each auto-sample was collected. Any points that did not follow the trend of the turbidity and/or river discharge data were excluded from further analyses. In July 2004 the laboratory analysis of auto-samples was expanded to include analysis of nephelometric turbidity. These data are used to check for drift in the site sensor, and also provide further insight as to whether the turbidity time series, flow time series or auto-sampled SSC are reliable. After eliminating erroneous data (e.g., typically due to there not being a reliable concurrent match between the auto-sample SSC and sensor turbidity, due perhaps to sensor fouling or confusion over auto-sample timing or labeling), 188 of the 277 auto-samples collected were used to derive a relationship for SSC from turbidity at Woodman's Bend. These auto-sample data are plotted in Figure 5.1.

The SSC versus turbidity data (Figure 5.1) were first inspected for signs of drift – i.e., a systematic shift in the relationship with time that might result from instrument drift. A previous report describing data collected up until June 2004 (Wild et al, 2004) observed that, while scatter occurred among the data from various events (assumed to be associated with variations in suspended sediment particle size) no systematic drift was detected. However, as more data have been collected, and the analysis revisited, it was noted that:

- the first event (June/July 2003) generally gave lower SSC values for the same recorded turbidity reading compared to the events between September 2003 and February 2004,

- auto-samples from May 2004 onwards also tended to have lower SSC values for the same recorded turbidity reading. This change appears to be due to a sensor calibration change rather than bio-fouling[1].

Thus, best-fit lines were fitted to 3 periods of time to cover all of the data to 1 May 2006 (Figure 5.1). The resulting relationships, which were used to convert the turbidity time series (NTU) into a suspended sediment concentration (SSC) time series, are summarised in Table 5.1.

The edited turbidity time series (and therefore the generated SSC time series) has approximately 74 days of gaps (excluding gaps occurring during low flows/low NTU time periods which have already been removed).

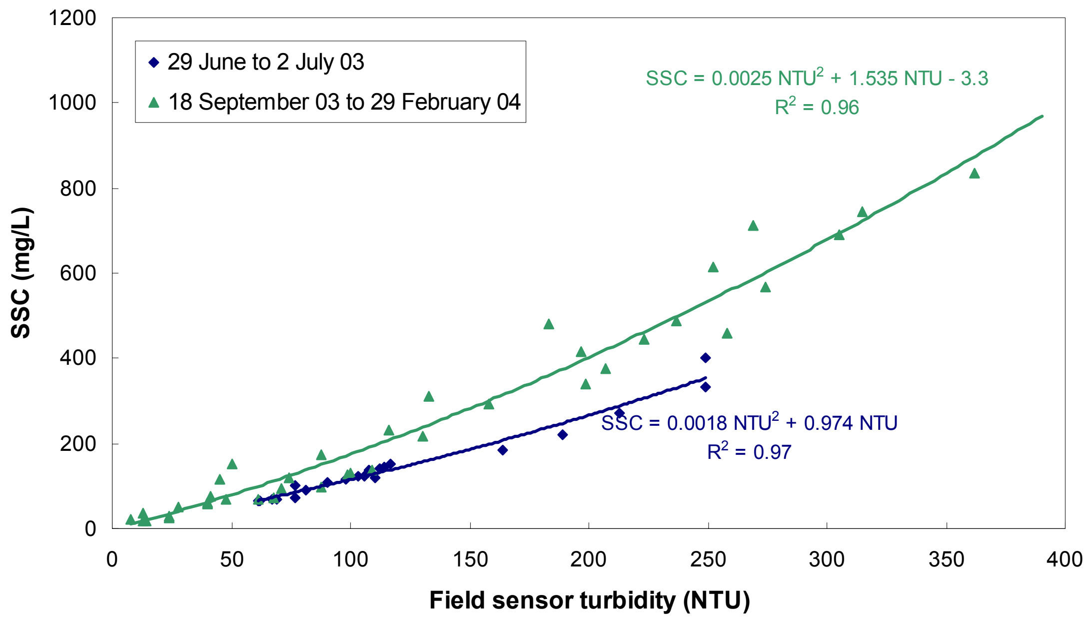
We note that the turbidity/SSC relationships have some curvature, despite the expected linear response of the Greenspan turbidity sensor. We suspect that this may reflect the effect of a slight overall coarsening of sediment particle size as sediment concentration increases at the site (for a given SSC, the sensors indicate a lower NTU value for coarser sediment).

Table 5.1: Turbidity/SSC relationship for Motueka at Woodman's Bend

Date Range	Turbidity range (NTU)	Equation
23 Nov 2002 to 1 Sep 2003	0 - 250	$SSC = 0.0018\ NTU^2 + 0.974\ NTU$
1 Sep 2003 to 1 Apr 2004	0 - 400	$SSC = 0.0025\ NTU^2 + 1.54\ NTU - 3.3$
1 Apr 2004 to 1 May 2006	0-700	$SSC = 0.0014\ NTU^2 + 1.47\ NTU - 29.1$
1 Apr 2004 to 1 May 2006	700-1500	$SSC = 2.95\ (NTU – 700) + 1686.4$

[1] Our experience from using turbidity sensors in many rivers suggests that sensors can undergo calibration jumps, possibly due to knocks.

Motueka at Woodmans Bend



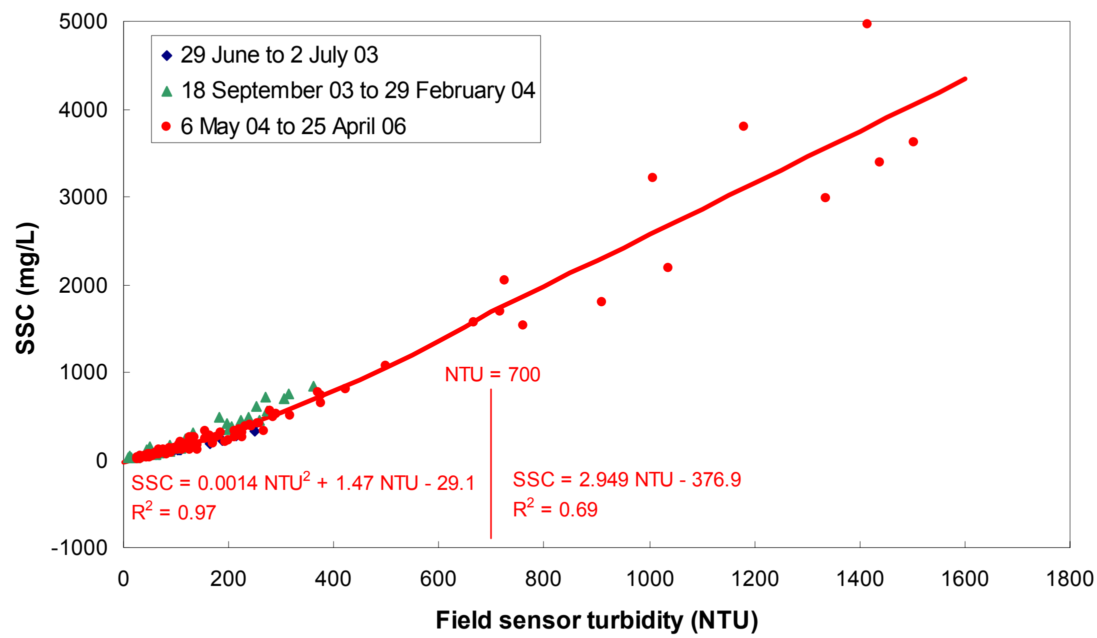


Figure 5.1: **Measured auto-sample SSC versus recorded turbidity for Motueka at Woodman's Bend (top figure shows derived relationships between turbidity and SSC up to March 2004, bottom figure shows all auto-sample points and turbidity/SSC relationship after March 2004).**

5.1.3. Generating river discharge/SSC relationship

Although some of the gaps in the turbidity record can be filled with auto-sample data, there are still several gaps between June 2003 and April 2004 that need to be filled using a river discharge/SSC relationship. This was developed using auto-sample data for events occurring between June 2003 and March 2004. This relationship excluded any SSC results that did not follow the general trend of the river discharge data (some samples were inadvertently mislabeled, confusing their time of collection, while others appear to have sucked water from too close to the bed). In total, 96 of the 102 auto-samples collected between June 2003 and March 2004 were used to derive a relationship for SSC from discharge. Only one relationship was developed to cover all of the gaps occurring over this time. The auto-sample data is plotted in Figure 5.2 and the relationship is given in Table 5.2.

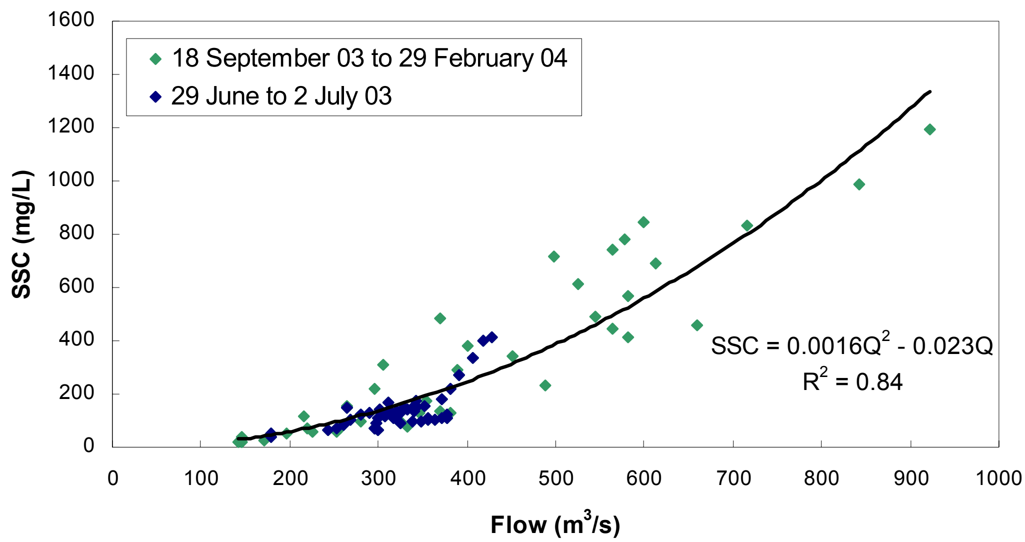


Figure 5.2: Measured auto-sample SSC versus recorded river discharge for Motueka at Woodman's Bend for June 2003 to March 2004.

Table 5.2: River discharge/SSC relationship for Motueka at Woodman's Bend

Date Range	Flow range (m^3/s)	Equation
23 Nov 2002 to 1 Apr 2004	0 - 950	SSC = $0.0016\ Q^2 - 0.023\ Q$

5.1.4. Final SSC time series

All of the gaps in the SSC time series generated from the turbidity time series (up to 1 May 2006) can be filled with auto-sample data and SSC derived from the river discharge record. The main flood/sediment events, along with periods in the SSC time series where gaps in the turbidity record occurred, are shown in Appendix 4 in Figures A4.1 to A4.5.

There is a smooth transition between the different methods of generating SSC in all cases, although there is a certain level of speculation with the Easter/March 2005 event (Figure A4.4). Straight lines are needed to join the gaps between SSC generated from the turbidity/SSC relationship and the inserted auto-sample points. For this event there is also some uncertainty regarding the accuracy of the auto-sample collection times. Data for this event should therefore be used with caution.

5.2. Wangapeka at Walter Peak

5.2.1. Editing turbidity record

The water discharge and raw turbidity time series from 19 November 2002 to 1 May 2006 are shown in Appendix 3 (Figures A3.4 to A3.6). These raw turbidity data were edited to remove spikes and drift, likely to have been caused by bio-fouling or silting up of the turbidity sensor. In places, minor drift of up to 5-10 NTU occurred (e.g. around late January-early February 2003), while larger discrepancies/drift occurred between October – December 2005 of the order of 300+ NTU. It is not known if this was due to bio-fouling, siltation or problems with the instrumentation (the turbidity sensor was replaced not long after, and the pump was also observed to not be working properly).

5.2.2. Generating turbidity/SSC relationship

The Wangapeka at Walter Peak auto-sampler collects water samples each time a water volume of 0.4 million m^3 passes the site while the stage exceeds a threshold level. A total of 91 auto-samples, collected over 26+ events between 14 December 2002 and 28 July 2005, were analysed for SSC. After checking against the recorded turbidity and river discharge at the times that these auto-samples were collected and also checking against the laboratory-analysed turbidity (following the approach outlined in section 5.1.2), 72 of these SSC results were used to derive a relationship for SSC from turbidity. These auto-sample data are plotted in Figure 5.3.

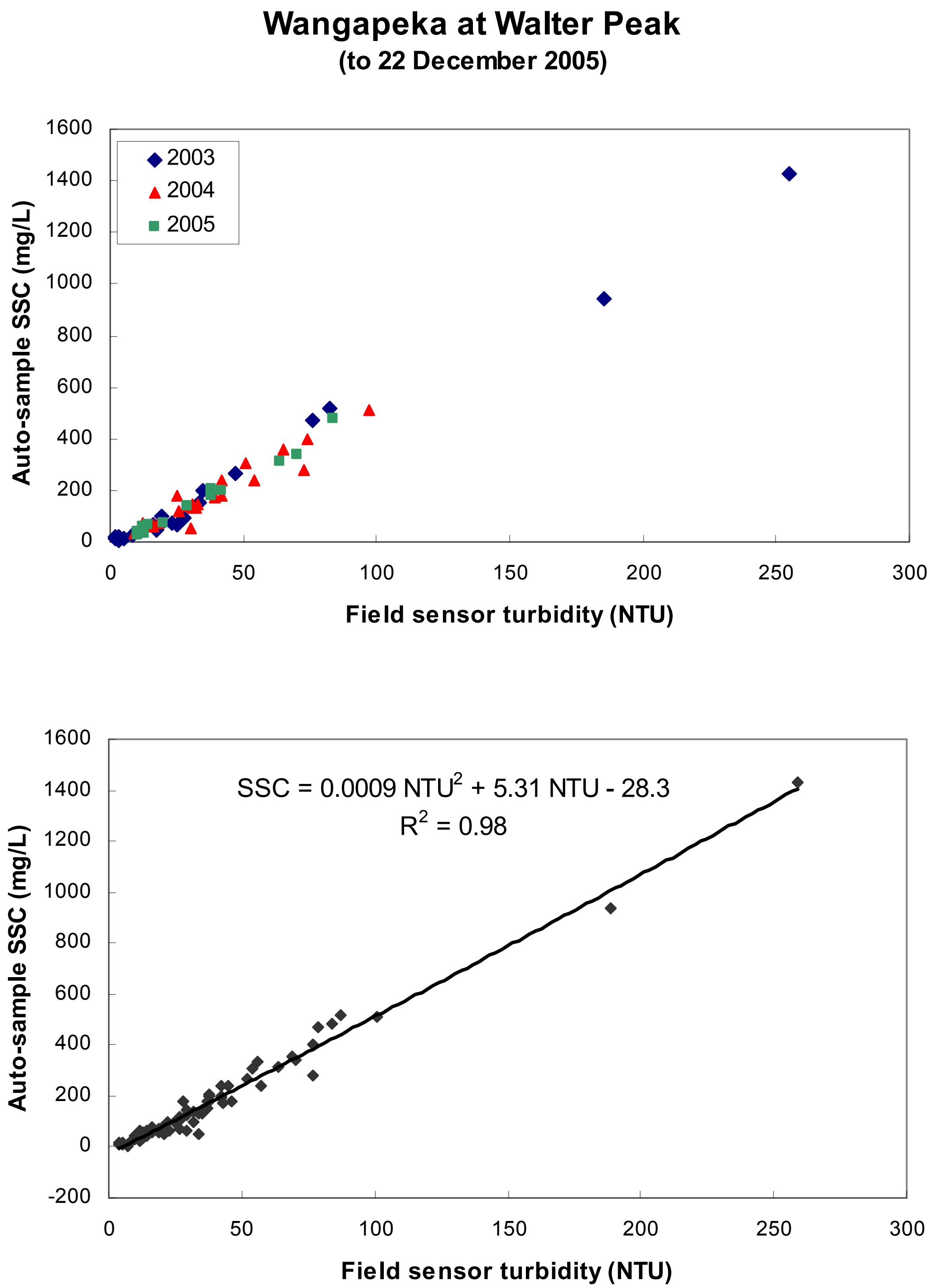


Figure 5.3: **Measured auto-sample SSC versus recorded turbidity for Wangapeka at Walter Peak (bottom figure shows derived relationships between turbidity and SSC for the record up to 22 December 2005).**

It should also be noted that on 22 December 2005 the turbidity sensor was replaced, so that a new turbidity/SSC relationship is required from this date. Unfortunately, between 22 December 2005 and 1 May 2006 only 2 auto-samples were collected and analysed so, at present, the Wangapeka at Walter Peak derived SSC series finishes on 22 December 2005. This series will be able to be extended once more auto-sampler data become available.

The SSC versus NTU data (Figure 5.3) was initially inspected for signs of drift – i.e., a systematic shift in the relationship with time that might result from instrument drift. A previous report describing data collected up until June 2004 (Wild et al, 2004) observed that no drift was present in the data ending at June 2004. No drift was observed between then and December 2005 either. Therefore, only one best-fit line is required to convert the edited turbidity time series (NTU) into a suspended sediment concentration (SSC) time series from 19 November 2002 up to 22 December 2005. The best-fit line is shown in Figure 5.3 and the equation is given in Table 5.3.

Table 5.3: Turbidity/SSC relationship for Wangapeka at Walter Peak

Date Range	Turbidity range (NTU)	Equation
19 Nov 2003 to 22 Dec 2005	0 – 260	$SSC = 0.0009\ NTU^2 + 5.31\ NTU – 28.3$

The edited turbidity time series (and therefore the generated SSC time series) has approximately 114 days of gaps in the record up to 22 December 2005. Approximately 112 days occurred from 22 March 0005 up to 22 December 2005 when the turbidity sensor was replaced. The other, smaller gaps were mainly inserted into the turbidity record during flood events, where, for example, siltation may have occurred around the turbidity sensor (elevating turbidity readings at or immediately after flood peaks). Discrepancies in the turbidity record were confirmed by comparing SSC values (derived using Table 5.3), flow/stage records and auto-sample lab results. If there was any doubt, a gap was inserted in the turbidity record so that auto-sample data could be used instead.

5.2.3. Generating river discharge/SSC relationship

Although some of the gaps in the turbidity/SSC relationship could be replaced with auto-sample data, there were still several large gaps between 14 March 2005 and 22 December 2005 that needed to be filled using a river discharge/SSC relationship.

Using auto-sample data for events occurring between May 2003 and July 2005, a discharge/SSC relationship was developed. This relationship excluded any SSC results that did not follow the trend of the river discharge data, and resulted in a total of 72 of the 91 auto-samples being used to derive a relationship for SSC from discharge. Only one relationship was required to cover all of the gaps occurring up to 22 December 2005. The auto-sample data is plotted in Figure 5.4 and the relationship is given in Table 5.4.

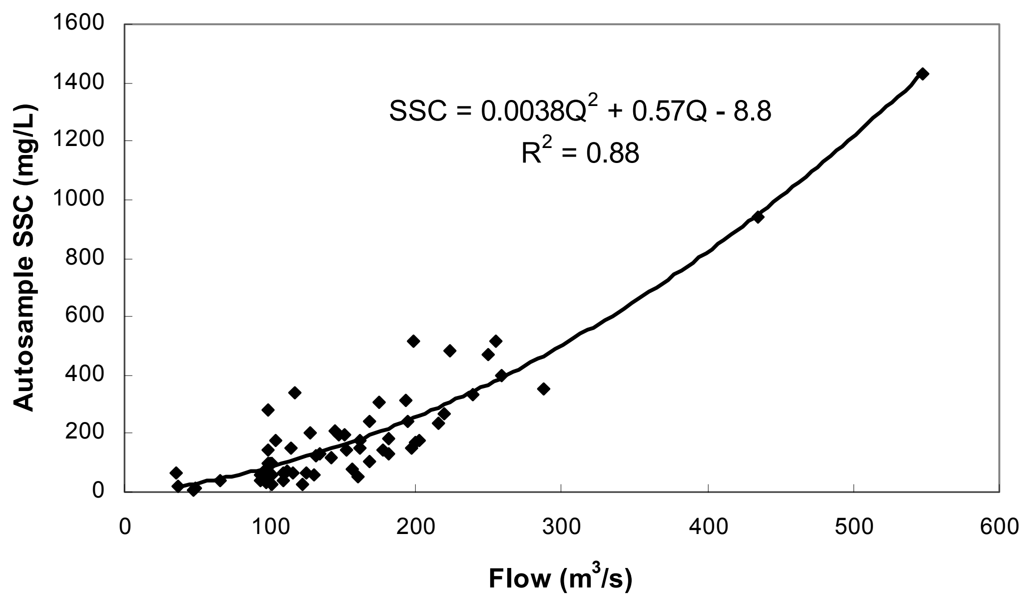


Figure 5.4: **Measured auto-sample SSC versus recorded river discharge for Wangapeka at Walter Peak for May 2003 to July 2005.**

Table 5.4: **River discharge/SSC relationship for Wangapeka at Walter Peak**

Date Range	Flow range (m^3/s)	Equation
19 Nov 2002 to 22 Dec 2005	0 - 550	$SSC = 0.0038 Q^2 + 0.57 Q – 8.8$

5.2.4. Final SSC time series

All of the gaps in the SSC time series generated from the turbidity time series (up to 22 December 2005) can be filled with auto-sample data and SSC time series derived from the river discharge record. The main flood/sediment events, along with periods in the SSC time series where gaps in the turbidity record occurred, are shown in Appendix 5 in Figures A5.1 to A5.5.

There is a smooth transition between the different methods of generating SSC in all cases, and the river discharge/SSC relationship is only required to fill gaps at low flows (all less than 100 m^3/s).

It should be noted that:

- several small ‘turbidity’ events do not show up on the stage/flow record (e.g. 28-29 June 2003, 14 & 16 September 2003). This is unexplained.

- The largest recorded ‘turbidity event’, on 31 December 2004, does not have any significant increase in stage/flow as you would expect (i.e. the turbidity is unusually high). This is unexplained.

5.3. Motupiko at Christie’s Bridge

5.3.1. Editing turbidity record

The original Motupiko at Christie’s Bridge site was washed away in the Easter 2005 flood. As a result, a new site was established on 26 May 2005, approximately 400 to 500 m downstream of the original bridge location. In this report the Motupiko at Christie’s Bridge SSC data is treated as though it all came from the same site, except that each site will have different turbidity/SSC and flow/SSC relationships.

The water discharge and raw turbidity time series from 18 November 2002 to 1 May 2006 are shown in Appendix 3 (Figures A3.7 to A3.9). From 26 May 2005, the turbidity data are recorded at the new site (along with a new pressure transducer to measure water levels for activating the auto-sampler); while the main water discharge time series is still recorded at the original site. This raw turbidity data was edited to remove spikes and drift, likely to have been caused by bio-fouling or silting up of the turbidity sensor.

The Motupiko at Christie’s Bridge original site had a turbidity record with some erratic data - indicating high turbidity at times when there was no increase in stage (e.g. October 2003 and October 2004) and immediately after flood events (e.g. after the early October 2003 flood event). Some of these discrepancies may be due to channel works upstream of the site, occurring between 22 December 2003 and 30 March 2004 (excluding Christmas holidays), but the increase in turbidity immediately after flood events is likely to be because of siltation. Where there is any doubt as to the reason for increases in turbidity, the data has been removed.

Both of the Motupiko at Christie's sites (original and new sites) are not ideal, due to the unstable bed. However, no better sites are available.

5.3.2. Generating turbidity/SSC relationship

Original Site – to March 2005

The auto-sampler at the original Motupiko at Christie's Bridge site collected water samples each time a water volume of 0.1 million m^3 passed the site while the stage exceeded a threshold level. A total of 161 auto-samples were analysed for SSC, covering 24+ events between 13 December 2002 and 26 March 2005. As detailed in section 5.1.2, these SSC data were compared against the recorded turbidity and river discharge at the time that the auto-sample and also against the laboratory-analysed turbidity after July 2004. The Motupiko at Christie's Bridge original site was prone to siltation during flood events. A major 'downside' to siltation is that any auto-samples collected during a period of siltation will not be able to be used in the sensor calibration. This is because there is no reliable turbidity data to match to the SSC of the auto-samples. In consequence, only 88 of the original 161 auto-samples could be used to derive a relationship for SSC from turbidity up to March 2005. These auto-sample data are plotted in Figure 5.5.

The SSC versus turbidity data (Figure 5.5) were first inspected for signs of drift – i.e., a systematic shift in the relationship with time that might result from instrument drift. A previous report describing data collected up until June 2004 (Wild et al, 2004) stated that no systematic drift was detected in the data up to June 2004. The additional data up to March 2005 did not show any signs of drift either. Therefore only one best-fit line is required to convert the edited turbidity time series (NTU) into a suspended sediment concentration (SSC) time series from 18 November 2002 up to 26 March 2005. The best-fit line is shown in Figure 5.5 and the equation is given in Table 5.5. This relationship was used to convert the edited turbidity time series (NTU) into a suspended sediment concentration (SSC) time series.

The edited turbidity time series (and therefore the generated SSC time series) from 18 November 2002 to 8 March 2005 has approximately 166 days of gaps. A gap of 79 days also occurs between 8 March 2005 and 26 May 2005. This is due to the loss of the sensor in the Easter flood and the replacement site not being established until 26 May 2005.

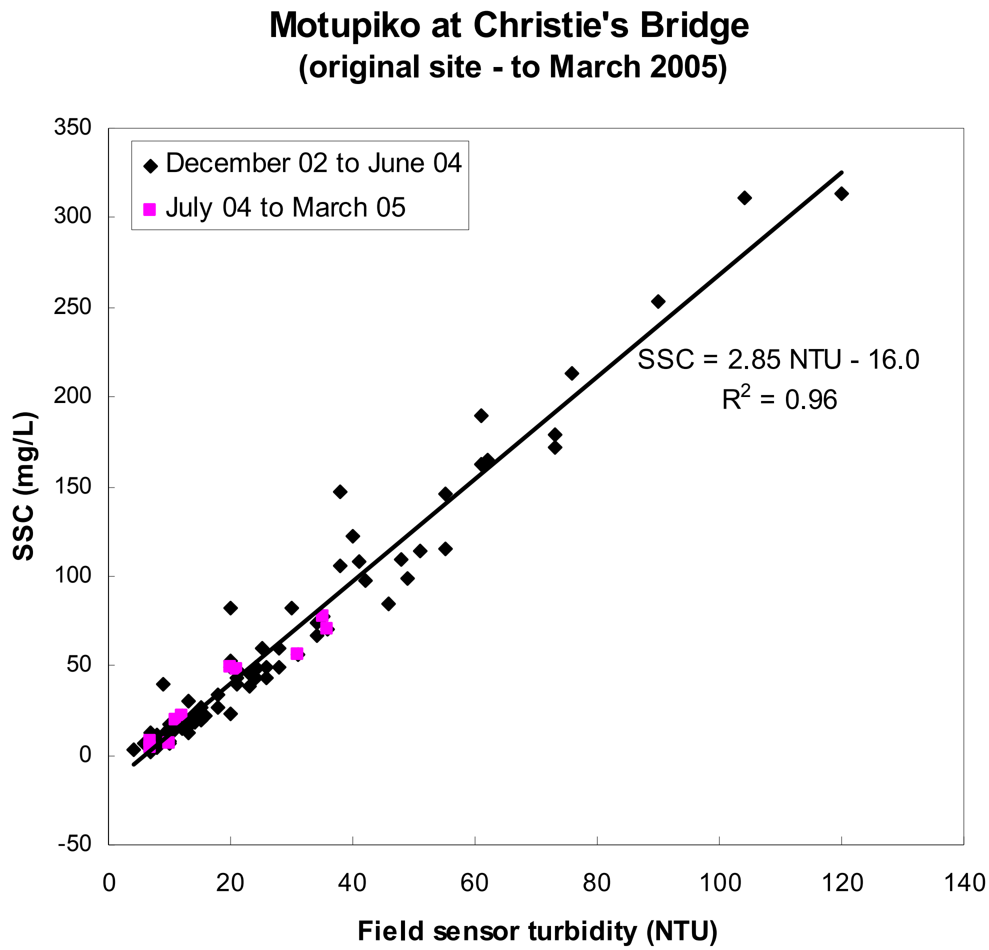


Figure 5.5: Measured auto-sample SSC versus recorded turbidity for Motupiko at Christie's Bridge (original site)

<u>New Site – May 2005 to May 2006</u>

As with the old site at Christie's Bridge, the auto-sampler at the new Motupiko at Christie's site collects water samples each time a water volume of 0.1 million m^3 passes the site while the stage exceeds a threshold level. A total of 88 auto-samples were analysed. These covered 10 events between 21 June 2005 and 26 April 2006. After data-checking as per section 5.1.2, 67 of the 88 auto-samples were used to derive the relationship for SSC from turbidity up to 1 May 2006. These auto-sample data are plotted in Figure 5.6.

The SSC versus turbidity data (Figure 5.6) were first inspected for signs of drift – i.e., a systematic shift in the relationship with time that might result from instrument drift.

From Figure 5.6 we can see that the new Motupiko at Christie's Bridge site appears to have a different turbidity/SSC relationship for the large event occurring from 24-26 April 2006. All events prior to this have a lower SSC for the same turbidity sensor reading.

It is unclear why this change occurred. Possibly it was because of a data-logger programming mistake. Possibly it reflects a change in sediment size grading - the 24-26 April 2006 event was the largest sampled to date. Possibly the sensor calibration shifted after a knock. To be safe, we chose to use a second calibration relationship for this event. We will wait to see whether this latter relationship will remain valid beyond 26 April 2006. The two best-fit lines are shown in Figure 5.6 and the equations given in Table 5.5. These relationships were used to convert the edited turbidity time series (NTU) into a suspended sediment concentration (SSC) time series.

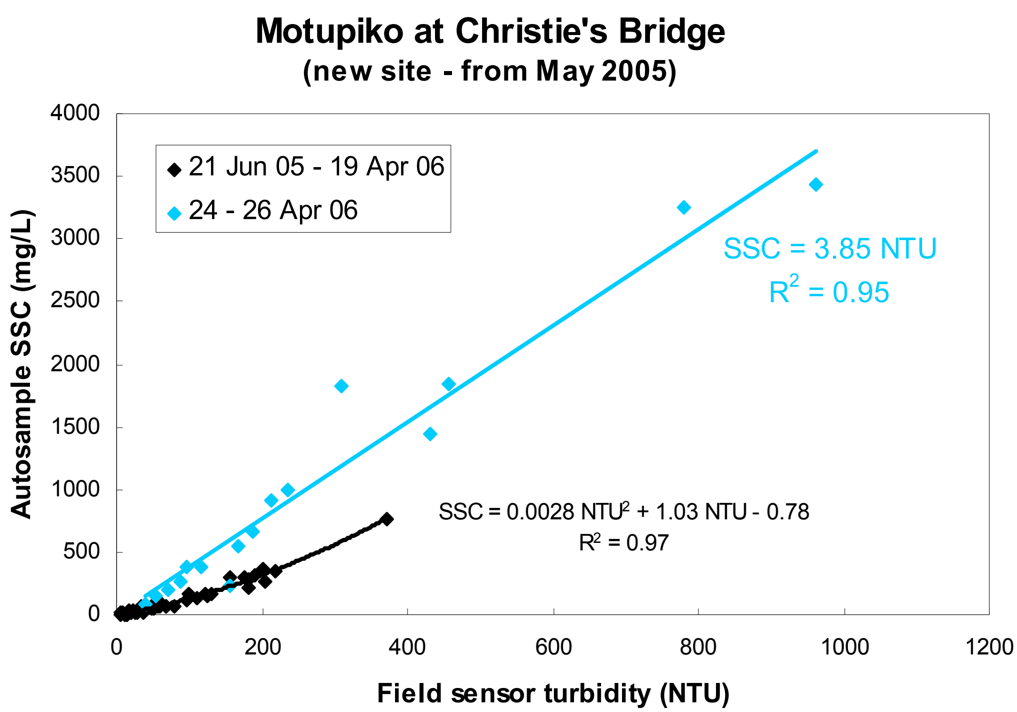


Figure 5.6: Measured auto-sample SSC versus recorded turbidity for Motupiko at Christie's Bridge (new site)

Table 5.5: Turbidity/SSC relationship for Motupiko at Christie's Bridge

Date Range	Turbidity range (NTU)	Equation
18 Nov 2003 to 8 Mar 2005	0 – 120	SSC = 2.85 NTU – 16.0
26 May 2005 to 19 Apr 2006	0 - 350	SSC = 0.0028 NTU^2 + 1.03 NTU – 0.78
19 Apr 2006 to 1 May 2006	0 - 1000	SSC = 3.85 NTU

5.3.3. Generating river discharge/SSC relationship

Although some of the gaps in the turbidity/SSC relationship can be filled with auto-sample data, there are still several large gaps in the original site record between 20 September 2003 and 23 November 2004 that need to be filled using a river discharge/SSC relationship.

Original Site – to March 2005

Using auto-sample data for events occurring between 18 September 2003 and 10 January 2005, four slightly different river discharge/SSC relationships were developed. These relationships excluded any SSC results that did not follow the trend of the river discharge data, and resulted in use of 72 of the 91 auto-samples collected. The auto-sample data is plotted in Figure 5.7 and the relationships are given in Table 5.6, along with the appropriate flow ranges for which they were defined. Note that even though several of these relationships are very similar (suggesting that the data could be pooled and used to define just one relationship), these similar relations are separated in time by different relations. Thus we adopted the conservative approach of defining a separate relation for each time period.

Table 5.6: River discharge/SSC relationship for Motupiko at Christie's Bridge (original site)

Date Range	Flow range (m^3/s)	Equation
18 Nov 2002 to 22 Dec 2003	0 – 35	SSC = 0.36 Q^2 + 0.31 Q
22 Dec 2003 to 29 Feb 2004	0 – 10	SSC = 0.73 Q^2 + 0.61 Q
29 Feb 2004 to 1 July 2004	0 – 30	SSC = 0.41 Q^2 – 1.00 Q
1 July 2004 to 1 April 2005	0 – 15	SSC = 0.41 Q^2 + 0.68 Q

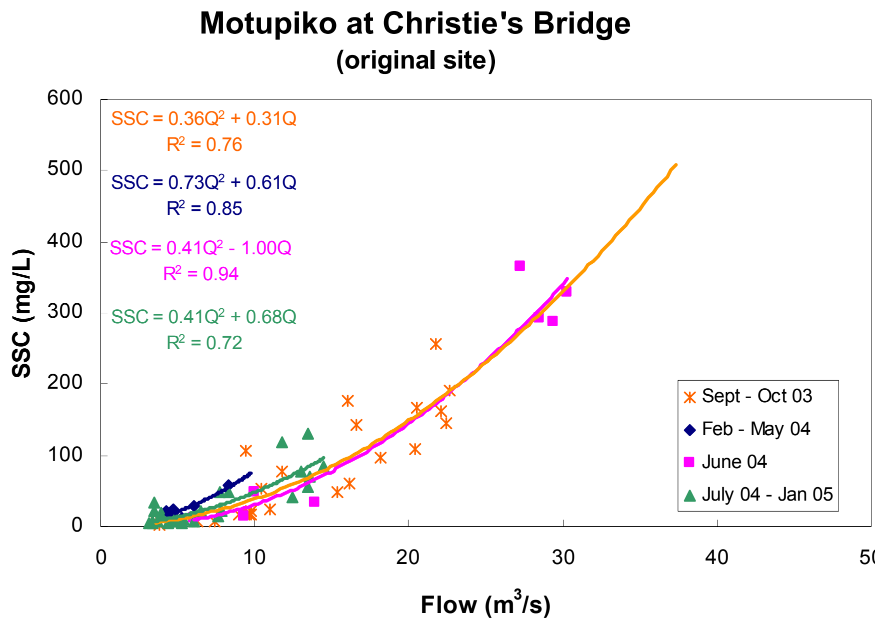


Figure 5.7: Measured auto-sample SSC versus recorded river discharge for the original Motupiko at Christie's Bridge site.

<u>New Site – May 2005 to May 2006</u>

Two large gaps occur in the new site record from 31 May to 14 June 2005 (14 days) and 6 to 31 December 2005 (26 days). Unfortunately no auto-samples or river discharge data were available over this time period so no SSC time series can be generated. All other gaps after 31 May 2005 are able to be filled with auto-sample data, so no river discharge/SSC relationship has been needed.

5.3.4. Final SSC time series

The final SSC time series generated from the turbidity time series (up to 1 May 2006) has 3 large gaps. They are:

- 8 March to 26 May 2005 (79 days),
- 31 May to 14 June 2005 (14 days),
- 6 to 31 December 2005 (26 days)

The main flood/sediment events, along with periods in the SSC time series where gaps in the turbidity record occurred, are shown in Appendix 6 in Figures A6.1 to A6.6.

There is generally a smooth transition between the different methods of generating SSC, and the river discharge/SSC relationship is usually only required to fill gaps at low flow. Two events where higher flows are used to generate SSC values are 20-28 June 2004 (Appendix 6, Figure A6.3) and 15 August 2004. The synthetic SSC record for these events should be used with care.

5.4. Motueka at Gorge

5.4.1. Editing turbidity record

The water discharge and raw turbidity time series from 6 April 2004 to 1 May 2006 are shown in Appendix 3 (Figures A3.10 and A3.11). These raw turbidity data were edited to remove spikes and drift, likely to have been caused by bio-fouling or silting up of the turbidity sensor.

5.4.2. Generating turbidity/SSC relationship

At Motueka at Gorge, the auto-sampler collects water samples each time a water volume of 0.4 million m^3 passes the site while the stage exceeds a threshold level. A total of 154 auto-samples have been analysed for SSC, covering 30 events between 4 May 2004 and 27 April 2006. After data checking as detailed in section 5.1.2, 134 of these 154 auto-samples were used to derive a relationship for SSC from turbidity. These auto-sample data are plotted in Figure 5.8.

The SSC versus turbidity data (Figure 5.8) were first inspected for signs of drift – i.e., a systematic shift in the relationship with time that might result from instrument drift. In the previous report describing data collected up until June 2004 (Wild et al, 2004) this site had only been operating for a short period of time so no drift would have been able to be observed. Figure 5.8 shows the data collected after June 2004 compared to the data collected up to June 2004. While scatter occurs among the data from various events (assumed to be associated with variations in suspended sediment particle size) no systematic drift was detected.

Therefore, one best-fit line was fitted to all of the data to date. The resulting relationship, converting the edited turbidity time series (NTU) into a suspended sediment concentration (SSC) time series, is given in Table 5.7.

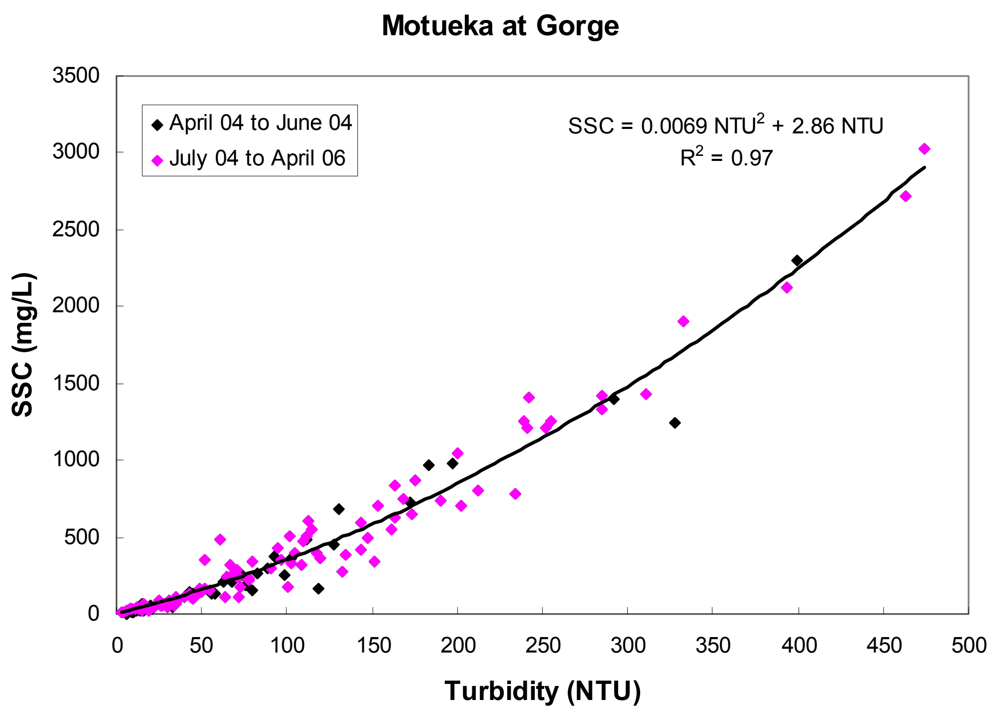


Figure 5.8: **Measured auto-sample SSC versus recorded turbidity for Motueka at Gorge (best-fit line is fitted to all of the data points from April 2004 to April 2006).**

Table 5.7: **Turbidity/SSC relationship for Motueka at Gorge**

Date Range	Turbidity range (NTU)	Equation
6 Apr 2004 to 1 May 2006	0 - 480	SSC = 0.0069 NTU^2 + 2.86 NTU

The edited turbidity time series (and therefore the generated SSC time series) has approximately 41 days of gaps.

We note that the turbidity/SSC relationships have some curvature, despite the expected linear response of the Greenspan turbidity sensor. This may reflect the effect of a slight overall coarsening of sediment particle size as sediment concentration increases at the site (for a given SSC, the sensors indicate a lower NTU value for coarser sediment).

5.4.3. Generating river discharge/SSC relationship

Although some of the gaps in the turbidity/SSC relationship can be filled with auto-sample data, there are still gaps in June 2004 and April 2006 that need to be filled using a river discharge/SSC relationship.

Using auto-sample data for events occurring between 4 May 2004 – 7 March 2005 (for the June 2004 gap) and 7 – 27 April 2006 (for the April 2006 gap), two discharge/SSC relationships were developed. These relationships, excluding any SSC results that did not follow the trend of the river discharge data, are plotted in Figure 5.9 and the relationships are given in Table 5.8.

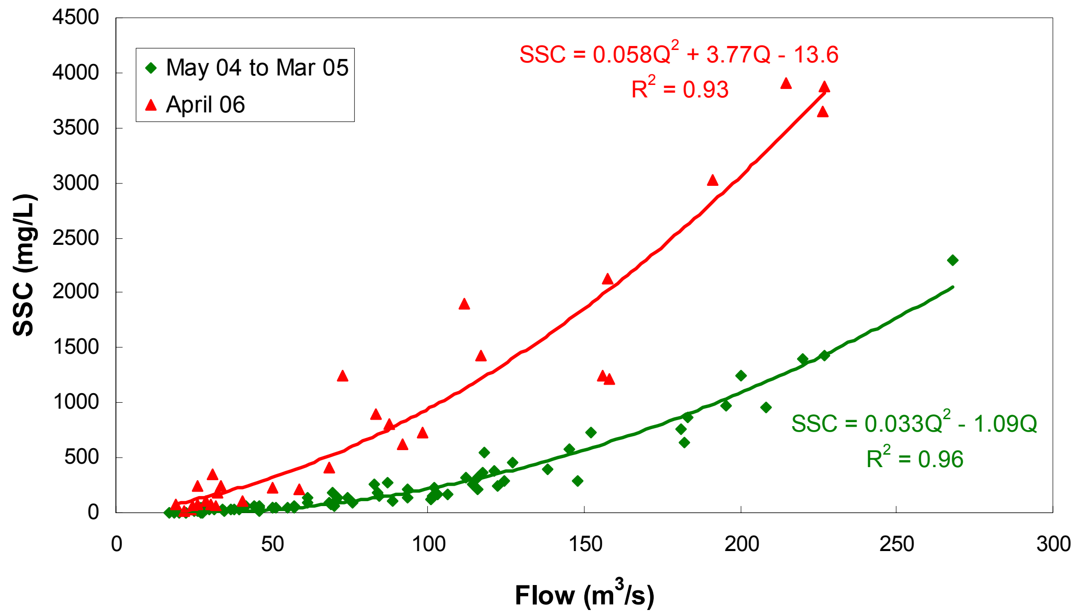


Figure 5.9: Measured auto-sample SSC versus recorded river discharge for Motueka at Gorge for May 2004 to March 2005 and 7 to 27 April 2006.

Table 5.8: River discharge/SSC relationship for Motueka at Gorge

Date Range	Flow range (m^3/s)	Equation
4 May 04 to 7 Mar 05	0 - 270	$SSC = 0.033\,Q^2 – 1.09\,Q$
7 Apr 06 to 27 Apr 06	0 – 225	$SSC = 0.058\,Q^2 + 3.77\,Q – 13.6$

From Figure 5.9 we can see that there is a significant change in the river discharge/SSC relationship between March 2005 and April 2006. This means that there is now a greater SSC for the same flow. This change occurred after the Easter 2005 flood.

5.4.4. Final SSC time series

Not all of the gaps in the SSC time series generated from the turbidity time series (up to 22 December 2005) can be filled with auto-sample data and SSC derived from the river discharge record. This is because a gap of 24 days from 8 March 2005 to 1 April 2005 is not covered by auto-samples or a river discharge time series due to site equipment damage during the Easter 2005 flood (see Figure 1.5b). The other 17 days

of gaps in the Motueka at Gorge turbidity record can be filled with auto-samples or discharge/SSC relationships, or the flow record indicates that there are no events in the gap and therefore the gap can be deleted.

The main flood/sediment events, along with periods in the SSC time series where gaps in the turbidity record occurred, are shown in Appendix 7 in Figures A7.1 to A7.5.

There is a smooth transition between the different methods of generating SSC in all cases, and the river discharge/SSC relationship is only required to fill gaps at relatively low flows (all less than 140 m^3/s).

6. Sensor calibrations

The sensor turbidity and auto-sampled SSC relationships used in the analyses are shown in Figure 6.1. Figure 6.2 shows the fit between the measured and predicted SSC values using the calibration relationships derived in Sections 5.1 to 5.4. From Sections 5.1 to 5.4 and Figure 6.2 it appears that the calibrations are quite reasonable, although there is still a need for more data in the higher NTU ranges (i.e. >500 NTU) for all sites except Motueka at Woodman's Bend to further calibrate the sensors.

Probably, the different relations among the four sites are a result of variations in suspended sediment particle size. Specific turbidity (NTU/mgL^{-1}) tends to be lower for coarser particles. The steepest relation (lowest specific turbidity) occurs at the Wangapeka, where we expect the suspended load to be coarser, with a higher sand component, due to the granitic source terrain. Note, from Figure 6.1, the SSC versus turbidity relationship for Wangapeka also exhibits less curvature than the other sites for the same reason. Alternatively, the differences may reflect intrinsic differences between the sensors, perhaps relating to drift in their internal calibration (all were bench-calibrated against formazin standards before field deployment). This behaviour justifies the ongoing collection of calibration samples.

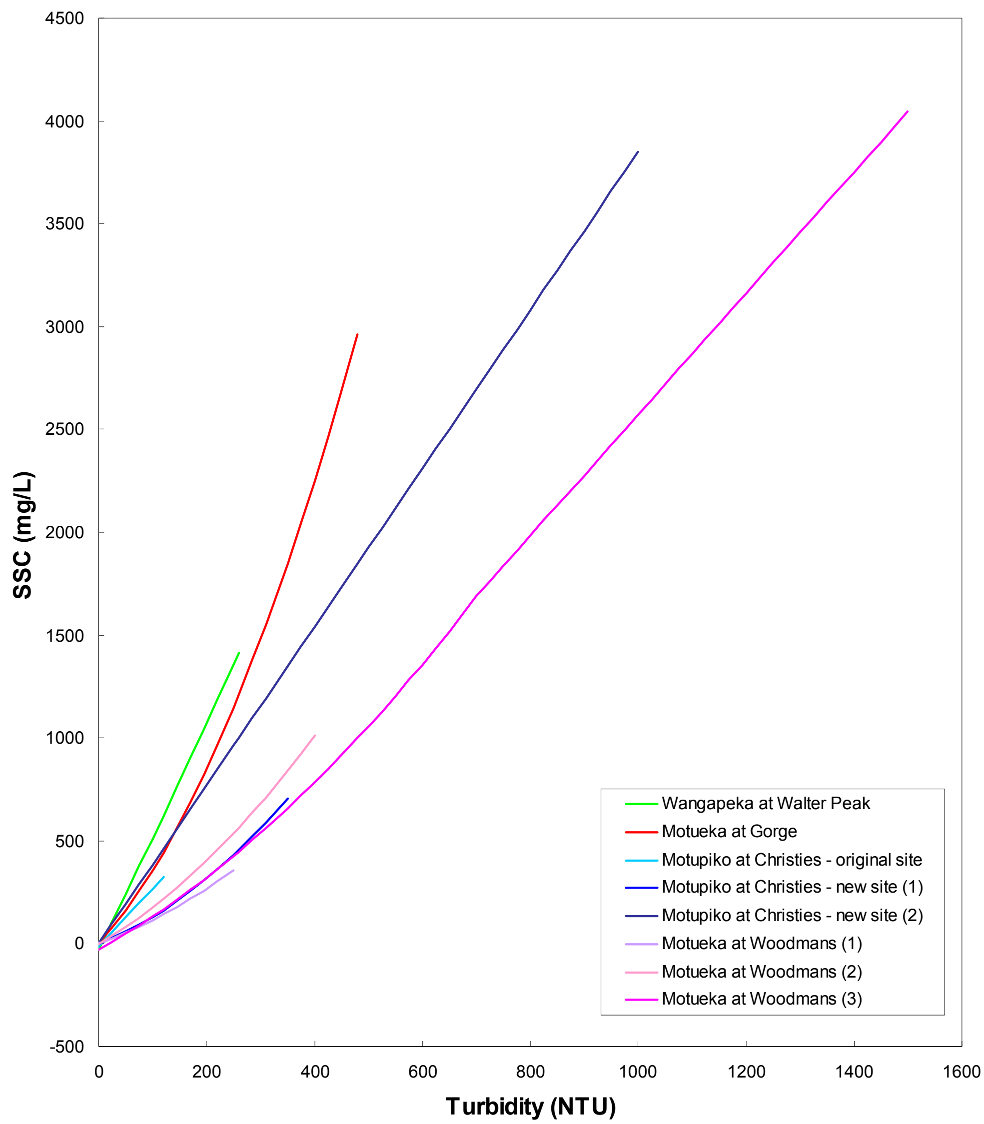


Figure 6.1: Relations between auto-sampled SSC and turbidity for the four sites for data up to 1 May 2006.

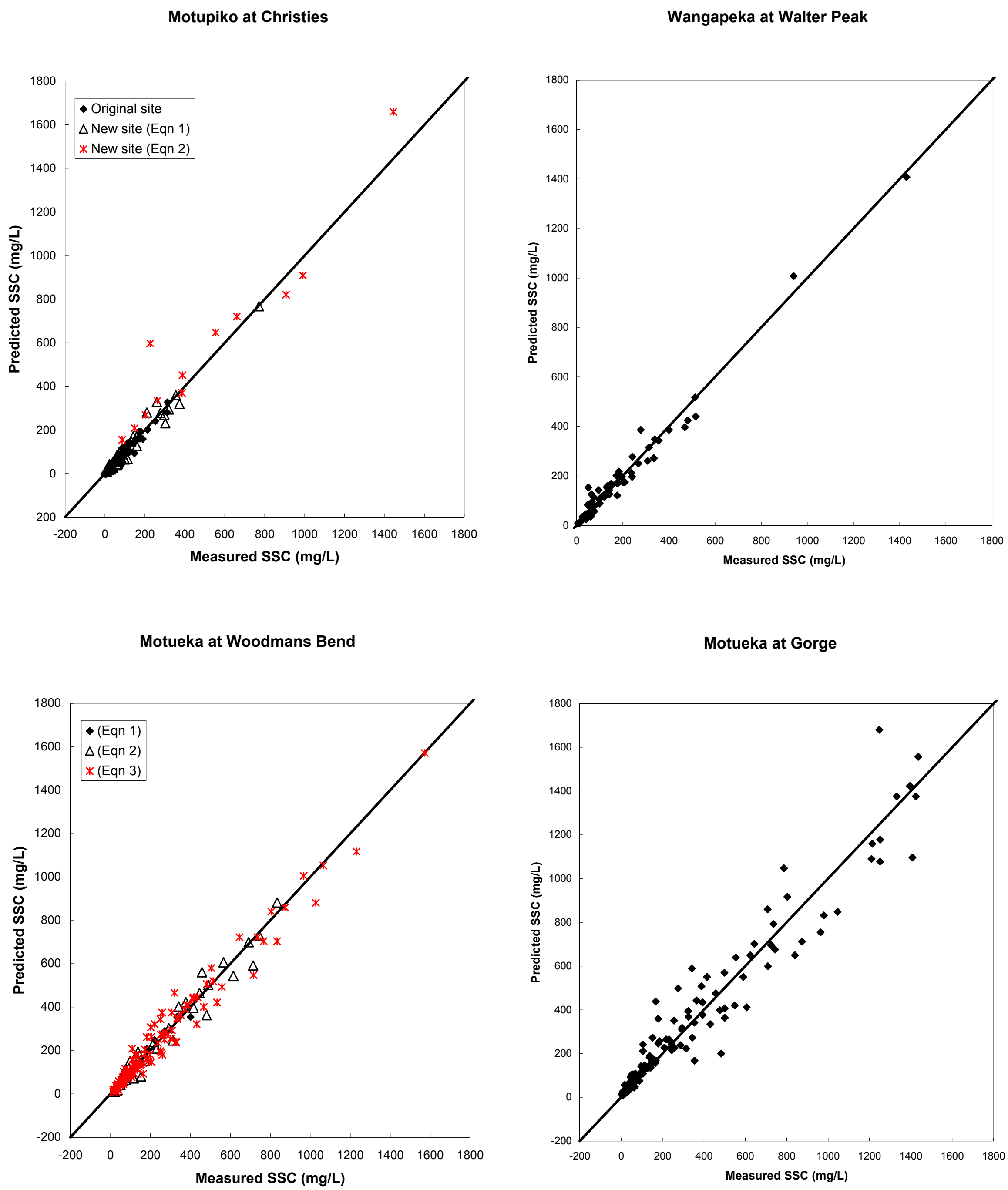


Figure 6.2: Relations between measured (from auto-samples) and predicted (from turbidity) SSC values for the four sites. Note: where more than one equation for SSC = f(NTU) has been derived (i.e. for different time ranges/calibrations), the data are plotted with different symbols.

Table 6.1 summarises the minimum and maximum turbidity, flows and SSC measured to date. It is interesting to note that both the Motueka at Woodman's Bend and Motupiko at Christie's sites have had at least one event with enough sediment in the river to saturate the sensors[2]. It is likely that there would have been enough sediment at the Motueka at Gorge site to saturate the sensor in the March (Easter) 2005 flood too.

Table 6.1: Summary of parameters for each site.

	Motueka at Woodman's Bend	Motupiko at Christie's Br.[a]	Wangapeka at Walter Peak	Motueka at Gorge[a]
Start of record	23/11/02	18/11/02	19/11/02	6/04/04
End of record	1/05/06	1/05/06	22/12/05	1/05/06
Min. Flow (m^3/s)	7.7 (26/3/06)	0 (23/4/06)	3.8 (28/3/03)	1.2 (2/4/06)
Max. Flow (m^3/s)	1119.5 (18/6/04)	37.5[c] (3/10/03)	561.0 (19/9/03)	303.8[c] (18/6/04)
Mean Flow (m^3/s)	49.3	1.6	19.2	6.7
Max Turbidity (NTU)	1648[b] (25/3/05)	1052[b,c] (24/4/06)	398 (4/1/06)	676[c] (21/6/05)
Sensor Range (NTU)	0-2000	0-1000	0-1000	0-1000
Max SSC (mg/L)	5266 (25/3/05)	3430[c] (24/4/06)	2108 (31/12/04)	5096[c,d] (21/6/05)
No. of gaps in derived SSC record	0	3	0	1
Total length of gaps (days)	0	110	0	24

[a] March (Easter) 2005 flood event not included in this dataset as site flooded and/or washed away
[b] Sensor saturated
[c] No data March 2005 event.
[d] SSC is an estimate (derived from turbidity record where turbidity/SSC relationship not in valid range).

7. Manual, depth-integrated sediment gaugings

Depth-integrated sediment gaugings allow the auto-sampled SSC (and therefore SSC time series derived in Section 5) to be related to the mean cross-section concentration. In the 2005/2006 year no manual depth-integrated sediment gaugings have been completed.

Previously, one full depth-integrated suspended sediment gauging (7 verticals) was completed at Motupiko at Christie's on 1 July 2003. The discharge-weighted cross-section average SSC was 77.0 mg/L, which was a factor of 1.14 larger than the

[2] Sensor saturation occurs when the sediment concentration is sufficiently high that a significant proportion of the light signal emitted by the instrument is absorbed rather than back-scattered. This causes the sensor output to decrease while the concentration increases. Where we detected this, the turbidity-generated SSC record was replaced with auto-sampled SSC (when the latter was available).

average auto-sampled concentration over the same time period. The gauged water discharge was 17,025 l/s.

Two full depth-integrated suspended sediment gaugings (each with 10 verticals) were also completed at the Wangapeka at Walter Peak site on 28 February 2004. The mean cross-section SSC was calculated by dividing the total mass of suspended sediment in the samples (collected for the 10 verticals) by the total volume of the samples. The matching water discharge was taken from the stage record at the mid-time of the sediment gauging. The mean cross-section SSCs (320 and 204 mg/L) were 0.85 and 0.89 times the matching auto-sampled concentrations.

8. Recommendations

- There are several gaps in the Motueka sediment records – including gaps at two sites during the March (Easter) 2005 flood. In this large event the Motupiko at Christie's site was washed away and the Motueka at Gorge site was inundated. In large flood events like Easter 2005 there is a risk of data loss, however, some of the gaps could have been reduced in length if it was known that the site was faulty earlier (i.e., if the sites were visited more regularly or telemetered). Both of these options would increase the operational cost of the sites and may still not resolve the data losses during the larger flood events where the data would be particularly valuable. However, it could also result in more auto-samples being collected during events, as there would be less chance of the sampler running out of bottles (or collection/replacement of bottles could be prioritised more effectively).

- Laboratory turbidity values as well as SSC concentrations have been collected for most auto-samples over the last year. When there is a discrepancy between turbidity time series, stage time series and lab SSC values for each auto-sample, the lab turbidity data has been useful for determining which data are incorrect. Thus the lab turbidity values should continue to be measured for each auto-sample analysed.

9. References

Wild, M.; Hicks, D.M.; Merrilees, R. (2004). Suspended sediment monitoring in the Motueka catchment: data report to 30 June 2004. NIWA Client Report CHC2004-118. Prepared for Landcare Research Ltd.

Appendix 1: Instrumentation inventory for Motueka sediment sampling stations.

Station	Equipment/ Parameter	Make	Model	S/N	Range	Signal	Owner
Motueka @ Woodman's Bend	logger	Campbell	CR10X	X5933			Landcare
	SC32A	Campbell		9702			NIWA
	logger housing						TDC
	stage	Sutron	Accubar		0 - 15m	SDI-12	TDC
	turbidity	Greenspan	TS100	18080	0 - 2000NTU	4 - 20mA	Landcare
	pump controller	Greenspan		11395			Landcare
	relay driver						NIWA
	AWS	Isco	3700	202E01000			Landcare
	AWS battery						NIWA
	logger battery						TDC
Wangapeka @ Walter Peak	logger	Unidata	Starlogger				TDC
	logger housing						TDC
	stage	Greenspan	PS210	PS2745	0 - 5m	0 - 2.5V	NIWA
	turbidity	Greenspan	TS300	16758	0 - 1000NTU	RS232	Landcare
	pump controller	Greenspan		11390			Landcare
	AWS	Isco	3700	200B00865			Landcare
	AWS battery						NIWA
	logger battery						NIWA

Station	Equipment/ Parameter	Make	Model	S/N	Range	Signal	Owner
Motupiko @ Christie's Bridge (NEW SITE)	logger	Campbell	CR10X	X1650			Landcare
	logger housing						Landcare
	stage	Greenspan	PS210	9228	0 - 5m	4 - 20mA	NIWA
	turbidity	Greenspan	TS300	18079	0 - 1000NTU	RS232	Landcare
	pump controller	Greenspan		11394			Landcare
	relay driver						NIWA
	AWS	Isco					Landcare
	AWS battery						NIWA
	logger battery						NIWA
Motueka @ Gorge	logger	Unidata	Starlogger				Landcare
	logger housing						NIWA
	stage	Kainga encoder					TDC
	turbidity	Greenspan	TS1200		0 - 1000NTU		Landcare
	pump controller	Greenspan					Landcare
	AWS	Isco	3700				Landcare
	AWS battery						NIWA
	logger battery						NIWA

Appendix 2:

Monitoring strategy and instructions for Motueka Basin suspended sediment sites, 2005-6:
Motupiko at Christie's Bridge
Wangapeka at Walter Peak
Motueka at Woodman's Bend
Motueka at Gorge

General aims and monitoring strategy
The aim at all four sites is to compile a continuous record of suspended sediment concentration (SSC) and to determine the particle size distribution of the suspended load during a representative event. The SSC records will be used to compute sediment loads during runoff events and long-term yields.

The strategy is to "sense" the SSC by the bank using the Greenspan turbidity sensors, and to convert this to cross-section mean sediment concentration by collecting calibration samples. There are two stages to this calibration: (i) turbidity signal vs. point concentration near the sensor, (ii) point concentration vs. section mean concentration. We will generally use automatic pumping samplers (coordinated with the turbidity sensor) to establish the first calibration, and manual depth-integrated sampling at several verticals for the latter.

Maintaining turbidity sensors and records
The Greenspan sensors at Motupiko, Wangapeka, and Motueka Gorge should be inspected and downloaded at least 3-monthly, more often and ideally monthly if you are in the area. The Motueka at Woodman's Bend record should be retrievable from the telemetry, but the sensor should be inspected at least 3-monthly and/or when auto-samples are retrieved.

The turbidity and stage series data should be extracted from the data-logger and/or smart-sensor and archived on TIDEDA files. Plot and inspect the series data as soon as it is downloaded, checking for problems such as fouling, drift, or missing record. It's worth doing this in the field if you have a laptop. A copy of the Tideda files should be forwarded to Murray Hicks every 3 months.

About every 6 months, the calibration of the Greenspan sensors should be field-checked. This will involve extracting the sensor from its housing and immersing it in a stock solution of formazin. Report the results back by e-mail to Michelle Wild at NIWA Christchurch.

Auto-sampler operation, maintenance, sample and data processing
The auto-samplers are there to collect calibration samples and to provide a back-up in case the turbidity record croaks. They are scheduled to sample on a flow-proportional basis, only during runoff events when the stage exceeds a given threshold. Sampling parameters have been adjusted, according to whether more or less samples are required. As of 1 July 2006 the parameters used are:

Site	*Threshold stage (mm)*	*Trigger Volume* (m^3)	*Time over-ride (hr)*
Motupiko at Christie's	1700	99,000	3
Wangapeka at Walter Peak	2300	400,000	3
Motueka at Woodman's Bend	2224	2,000,000	1[3]
Motueka at Gorge	1000	400,000	3

[3] Altered to 1.5 hours from early July 2006

You can keep track of whether the samplers should have activated by checking the TDC web-site, or better still, from the Woodman's Bend telemetry. Visit the site and recover the samples when it looks like the bottle magazine should be getting near full, and at least every 3 months.

All auto-samples should be analysed for SSC by the filtration method.
Report results in an Excel table as …

Date Time Stage SSC(auto) Turbidity (off the logger at the matching time)

Dates, times, and stage can be extracted from the logger files by matching-up bottle numbers.
Add to this table with every batch of samples, and send a copy of the table to Murray Hicks every 6 months or when there is a significant new batch of data. It is a good idea to maintain an Excel plot of Turbidity versus auto-sampled SSC, (a) to see how the calibration is coming along and (b) to pick up any problems such as might be indicated by an apparent jump or drift in calibration.

Manual sampling during events

No manual sampling done during events in 2005-06 year.

Questions/comments
Any questions, contact
Murray Hicks
Ph 03 343 7872 wk
03 351 7192 (after hours)
e-mail: m.hicks@niwa.co.nz

Murray Hicks

Appendix 3: Raw turbidity and discharge time series

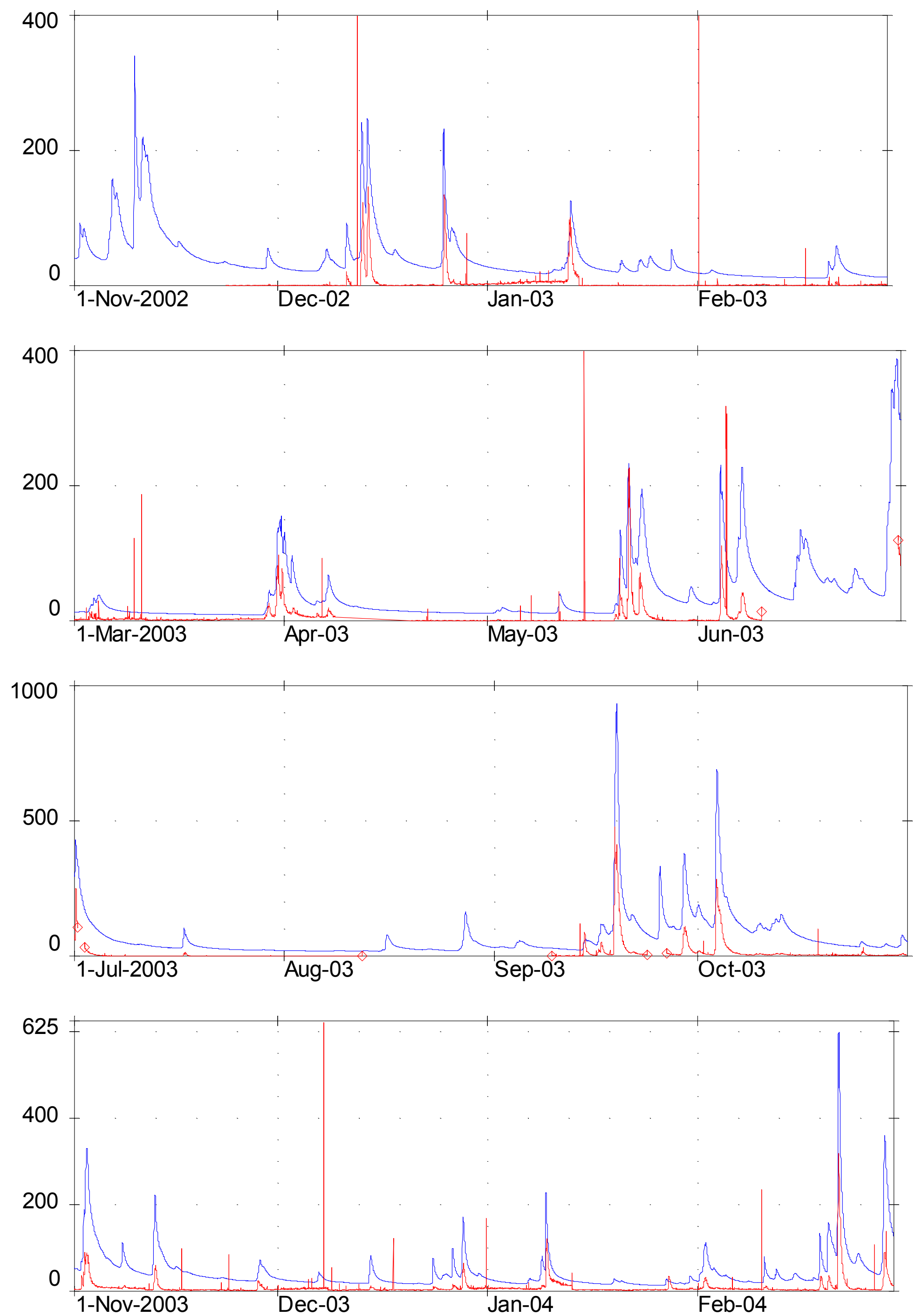


Figure A3.1: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 November 2002 to 1 March 2004 at Motueka at Woodman's Bend.

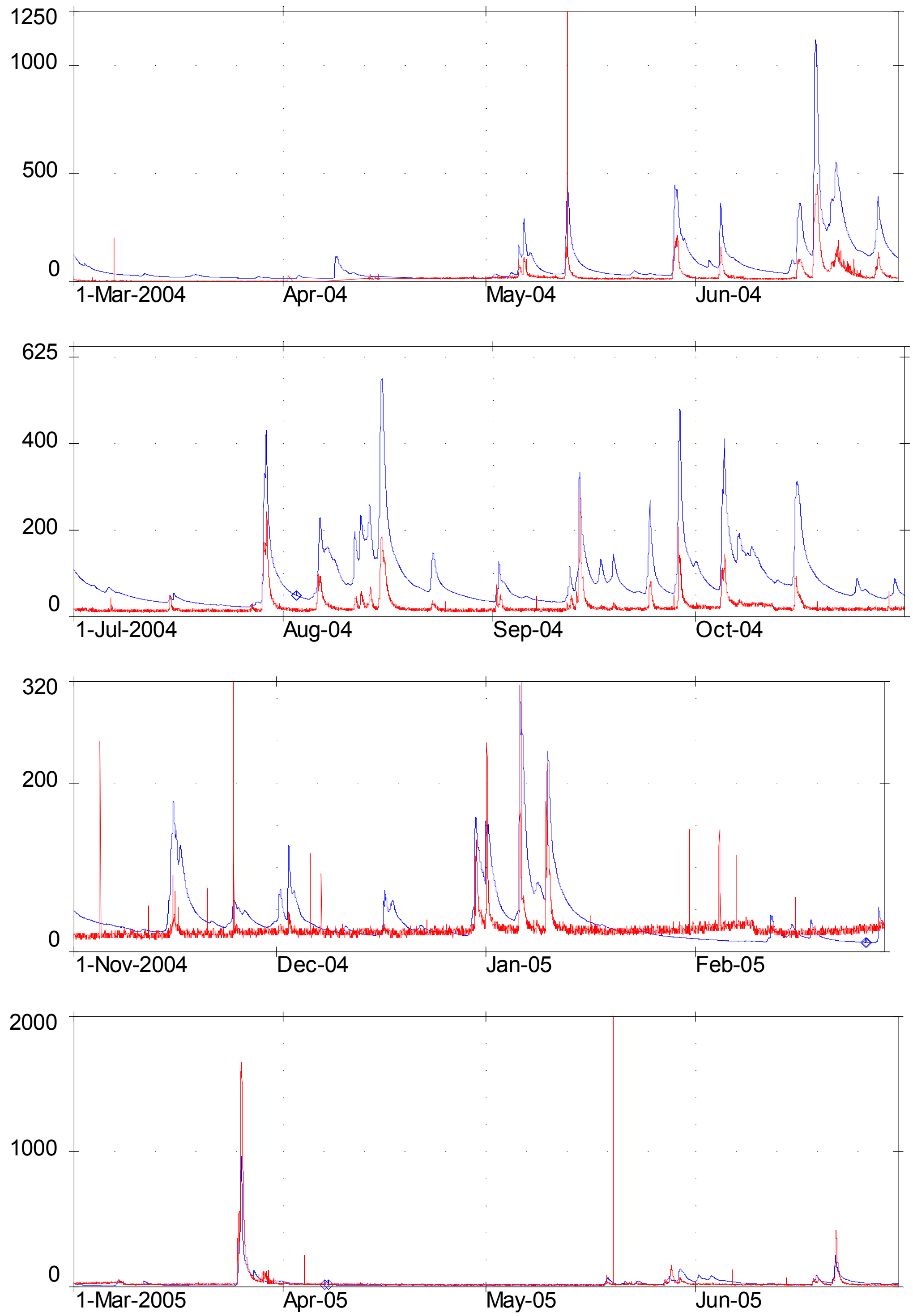


Figure A3.2: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 March 2004 to 1 July 2005 at Motueka at Woodman's Bend.

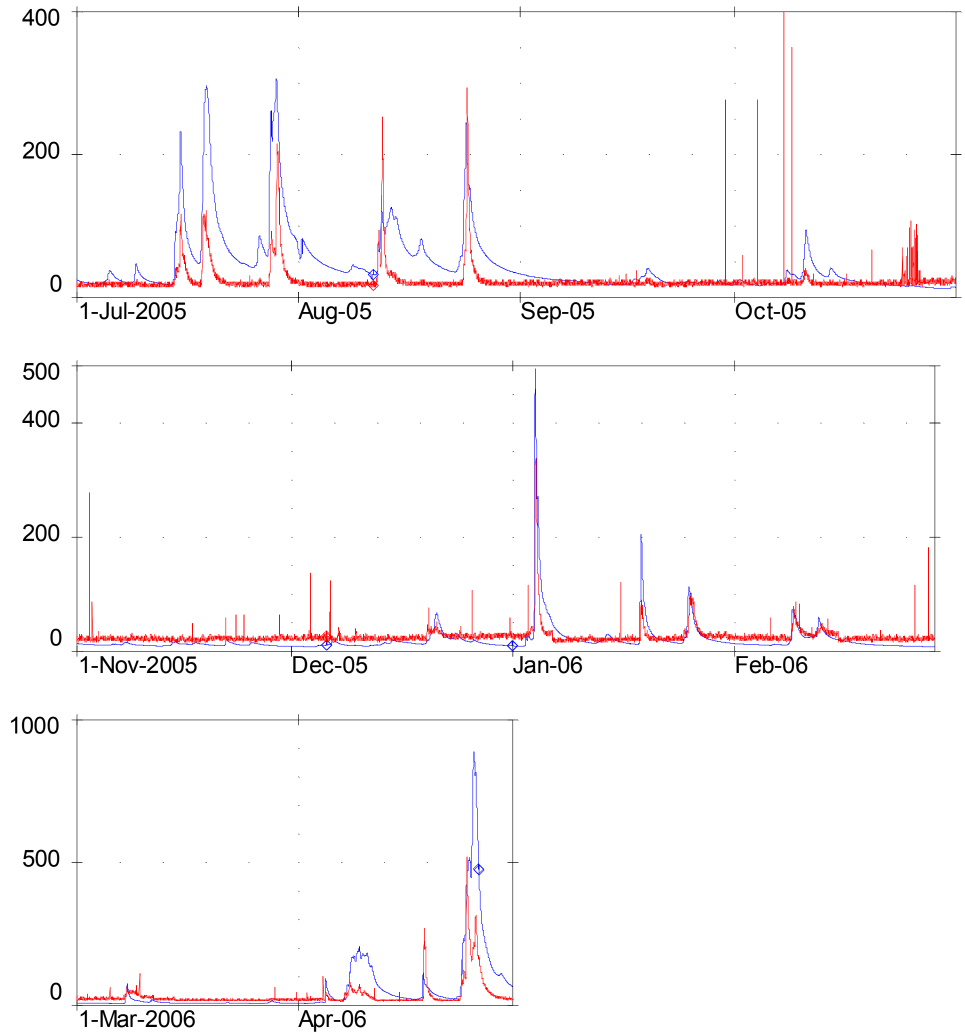


Figure A3.3: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 July 2005 to 1 May 2006 at Motueka at Woodman's Bend.

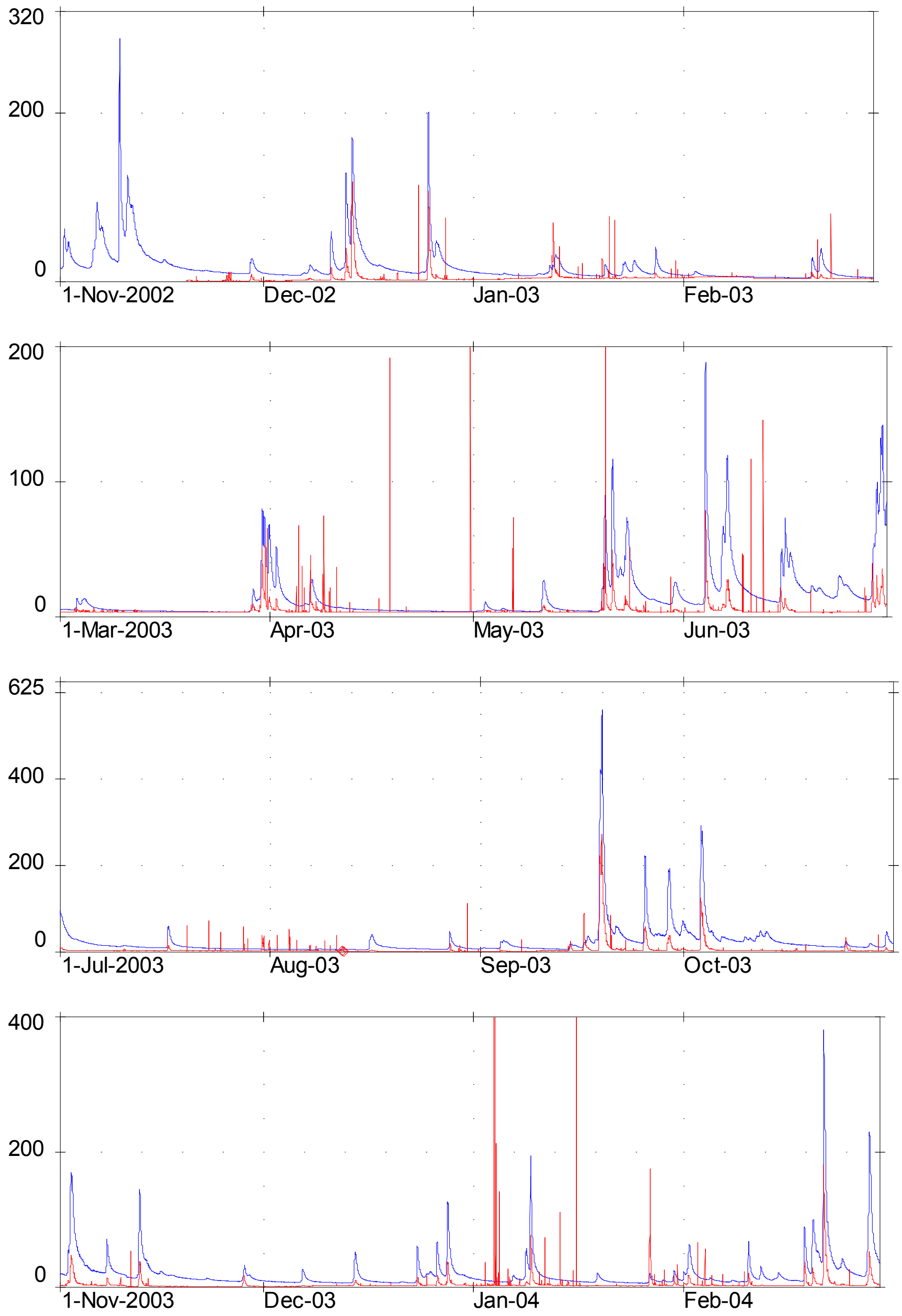


Figure A3.4: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 November 2002 to 1 March 2004 at Wangapeka at Walter Peak.

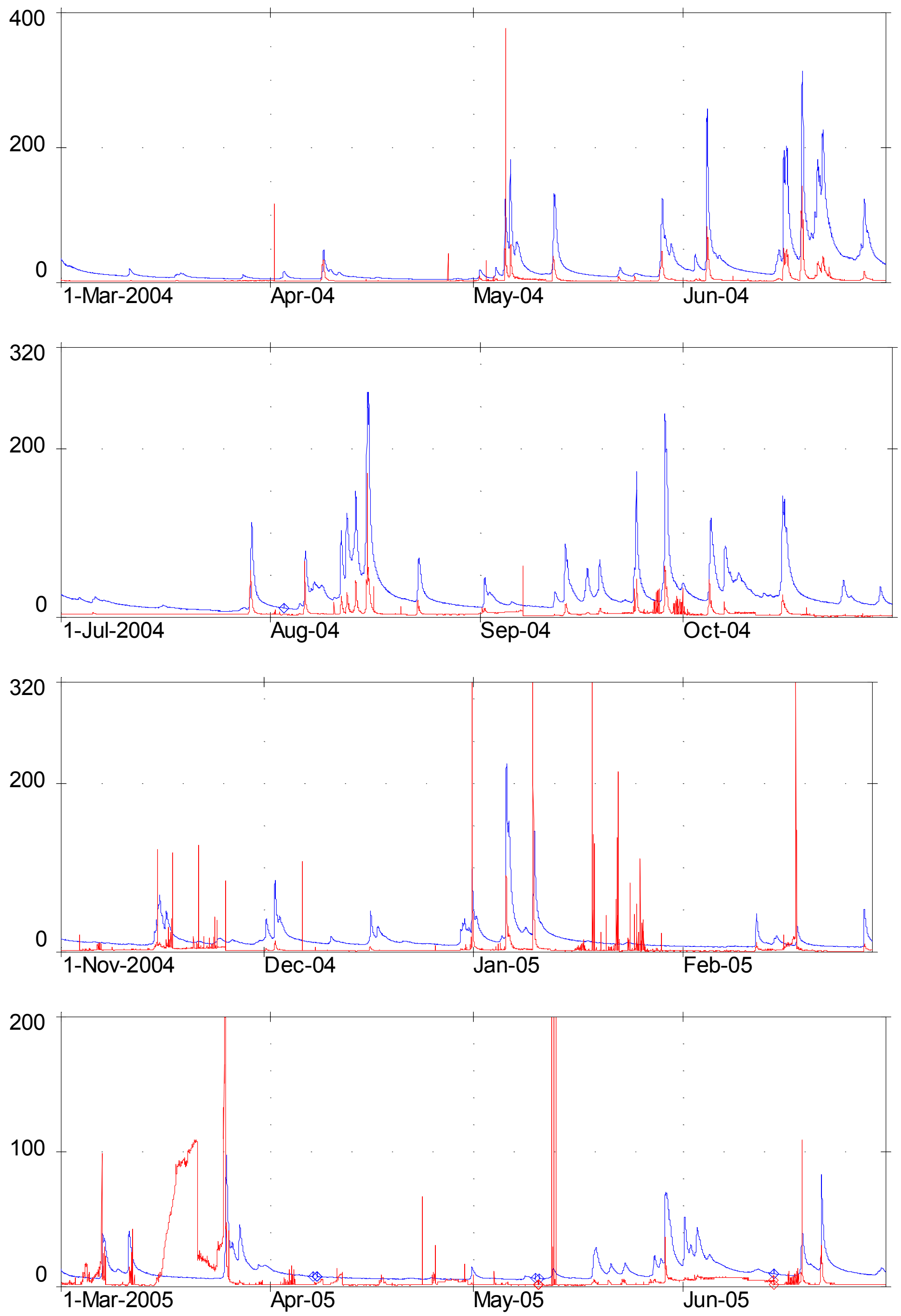


Figure A3.5: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 March 2004 to 1 July 2005 at Wangapeka at Walter Peak.

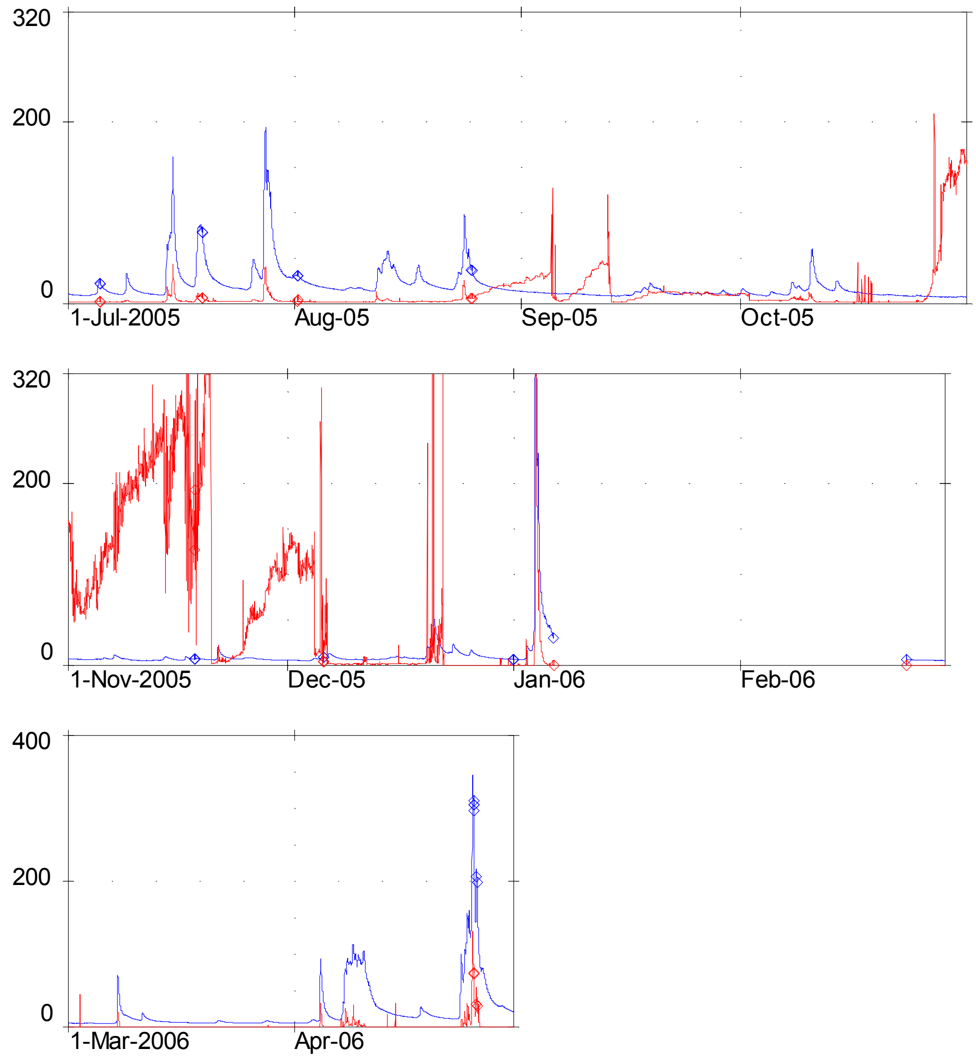


Figure A3.6: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 July 2005 to 1 May 2006 at Wangapeka at Walter Peak.

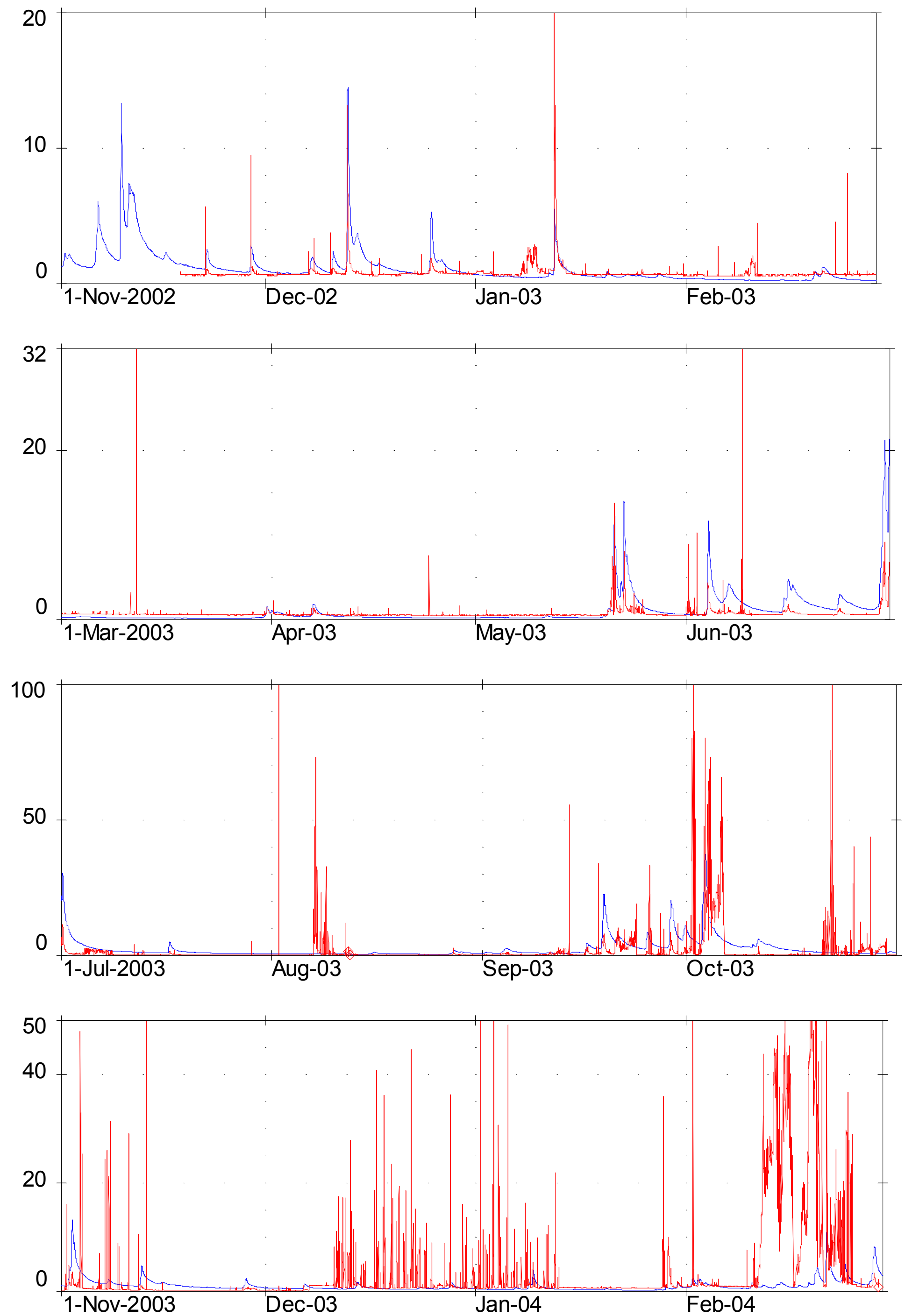


Figure A3.7: Water discharge (blue, in m^3/s) and raw turbidity (red, in 0.1*NTU so that plot ranges from 0 to 1100 NTU) records 1 November 2002 to 1 March 2004 at Motupiko at Christie's Bridge.

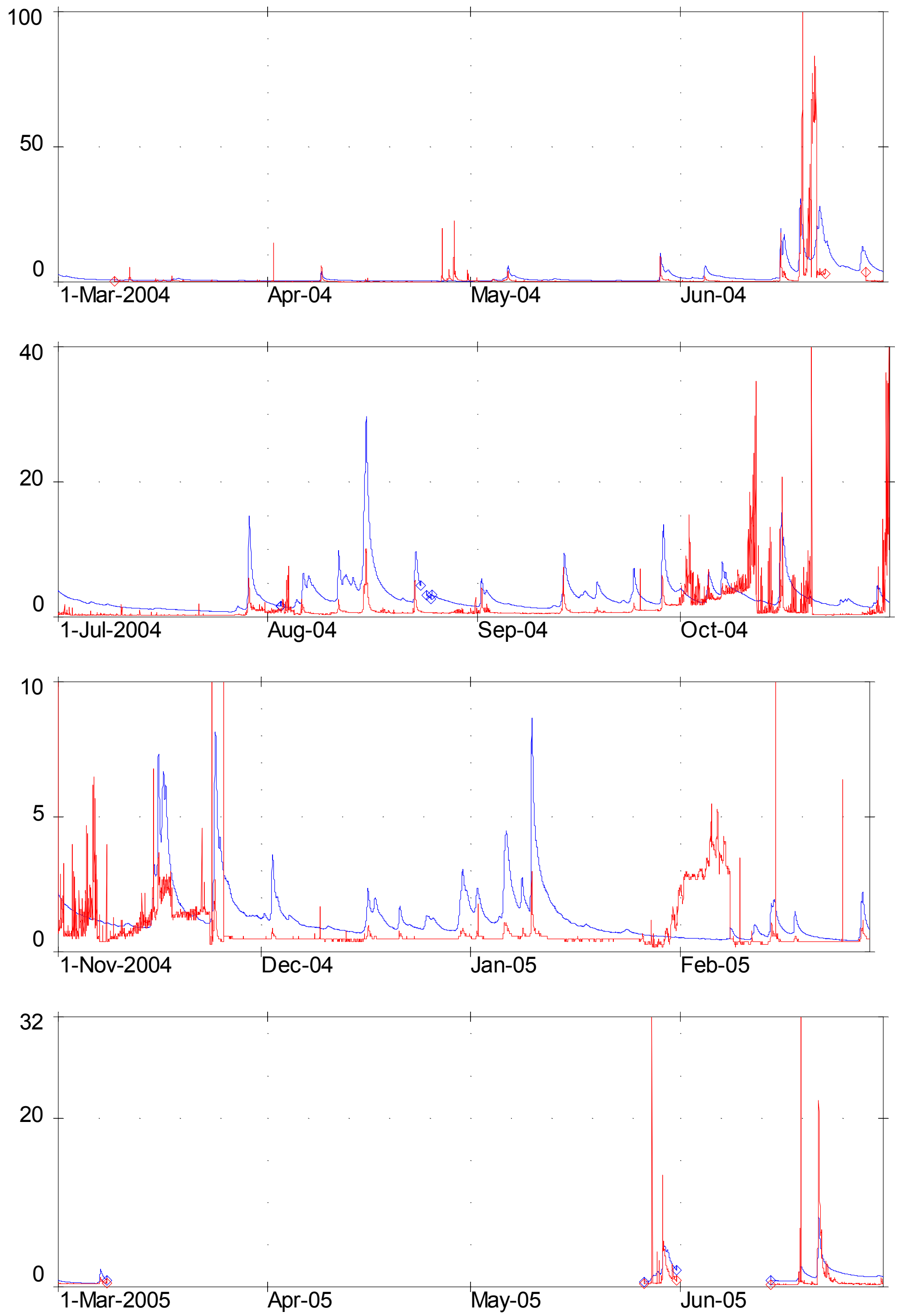


Figure A3.8: **Water discharge (blue, in m^3/s) and raw turbidity (red, in 0.1*NTU so that plot ranges from 0 to 1100 NTU) records 1 March 2004 to 1 July 2005 at Motupiko at Christie's Bridge.**

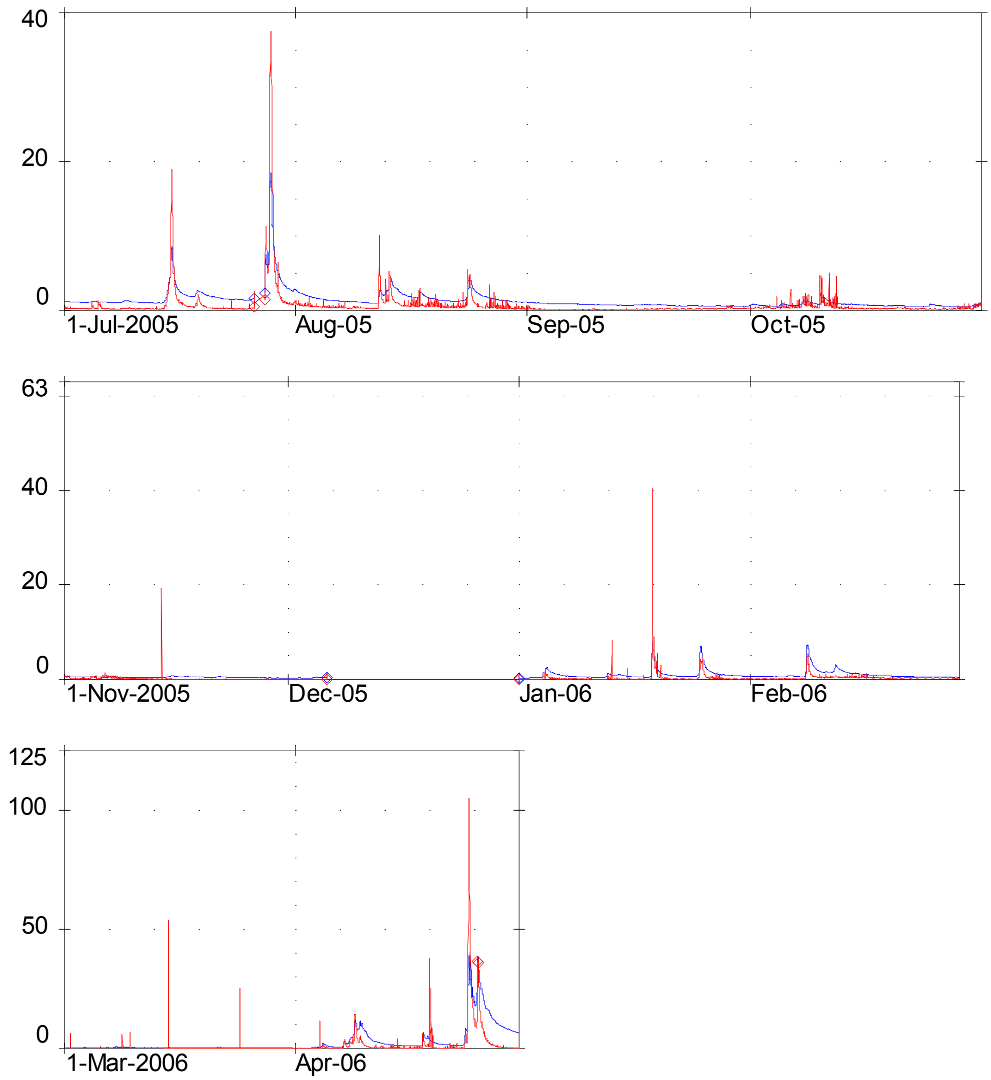


Figure A3.9: Water discharge (blue, in m^3/s) and raw turbidity (red, in 0.1*NTU so that plot ranges from 0 to 1100 NTU) records 1 July 2005 to 1 May 2006 at Motupiko at Christie's Bridge.

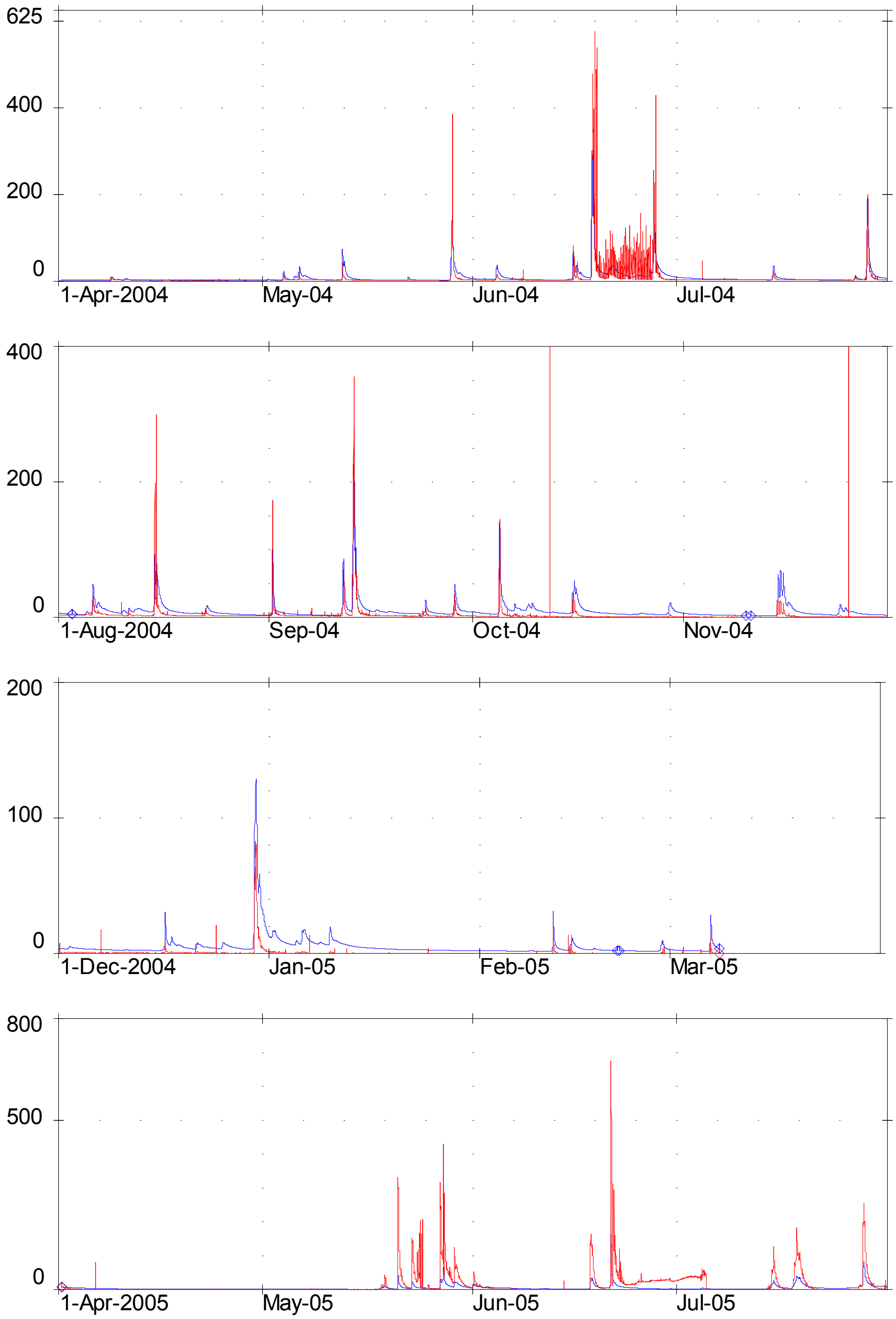


Figure A3.10: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 April 2004 to 1 August 2005 at Motueka at Gorge.

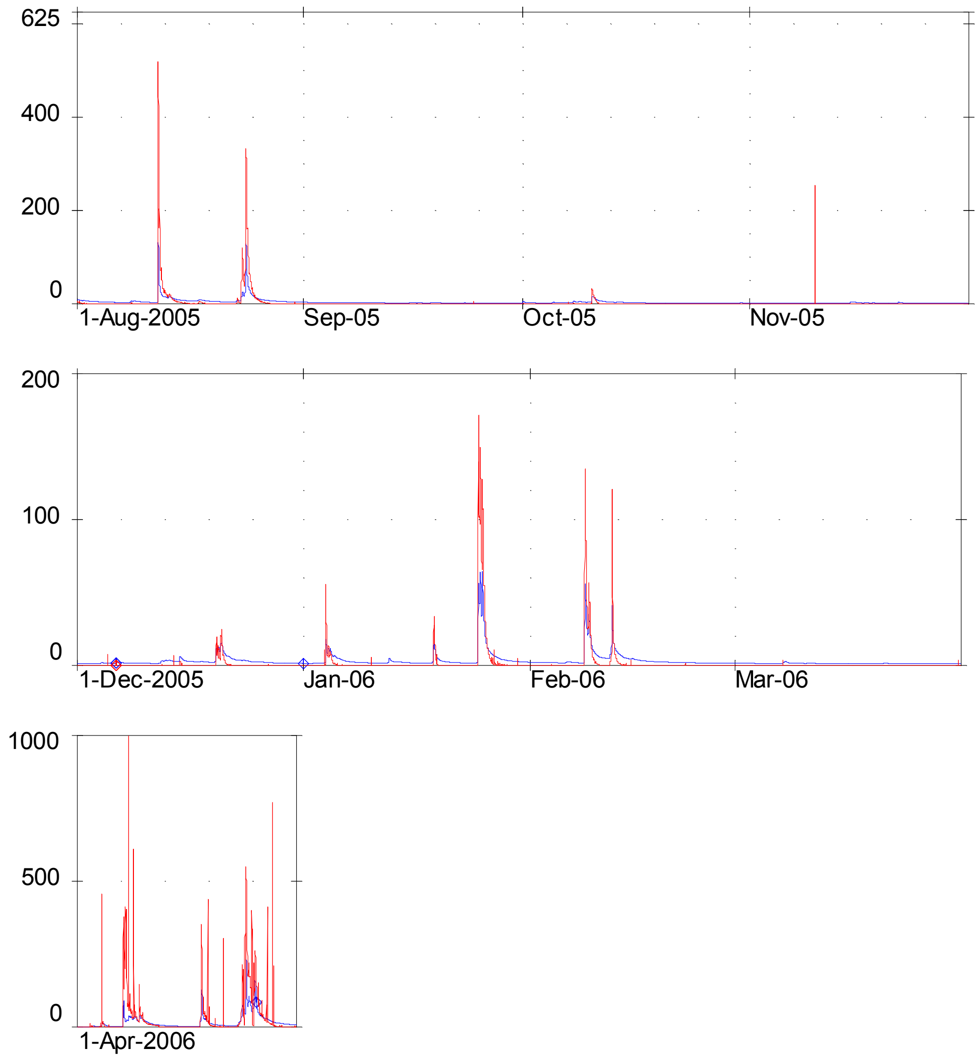


Figure A3.11: Water discharge (blue, in m^3/s) and raw turbidity (red, in NTU) records 1 August 2006 to 1 May 2006 at Motueka at Gorge.

Appendix 4: Motueka at Woodman's Bend derived SSC and discharge plots

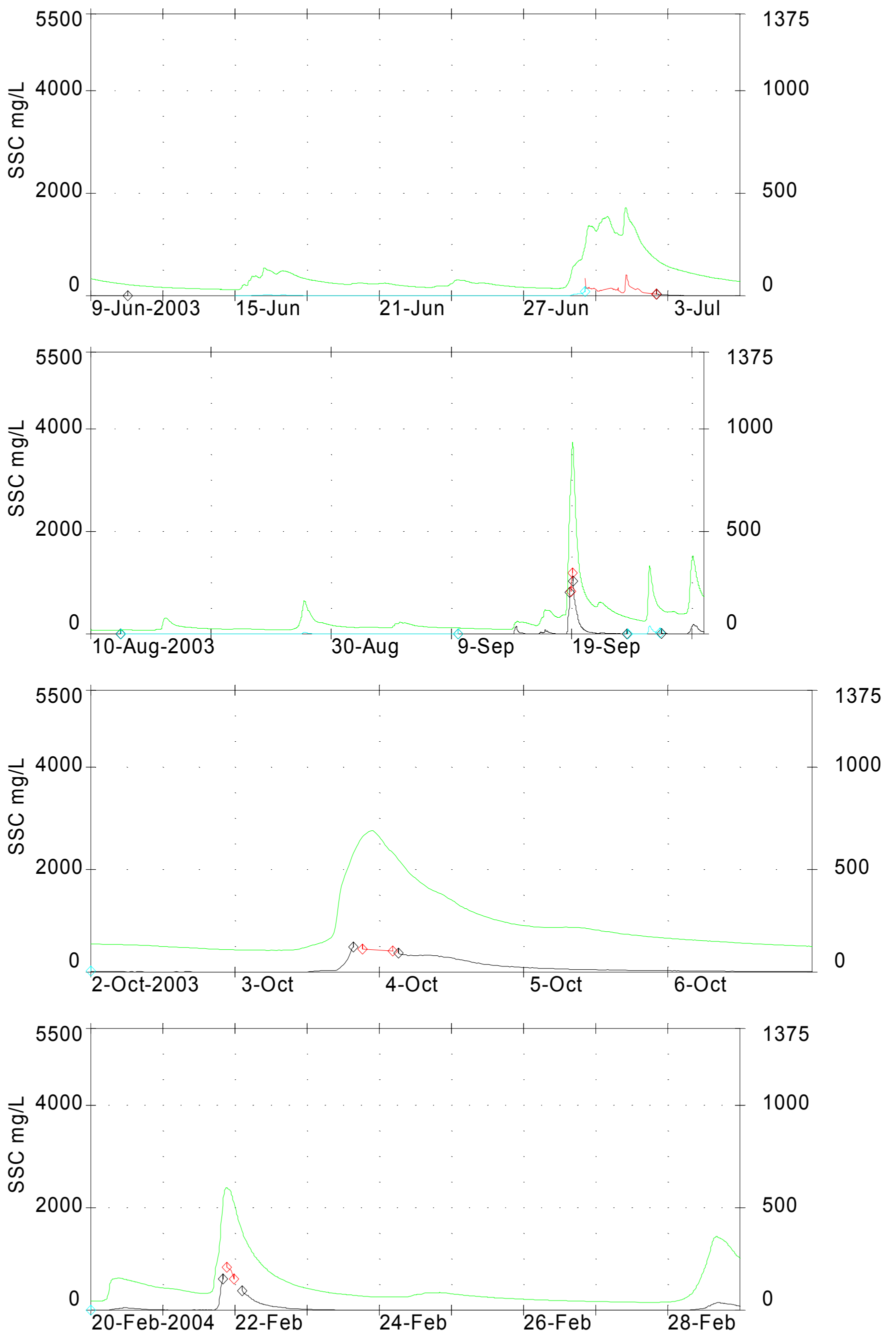


Figure A4.1: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Woodman's Bend.

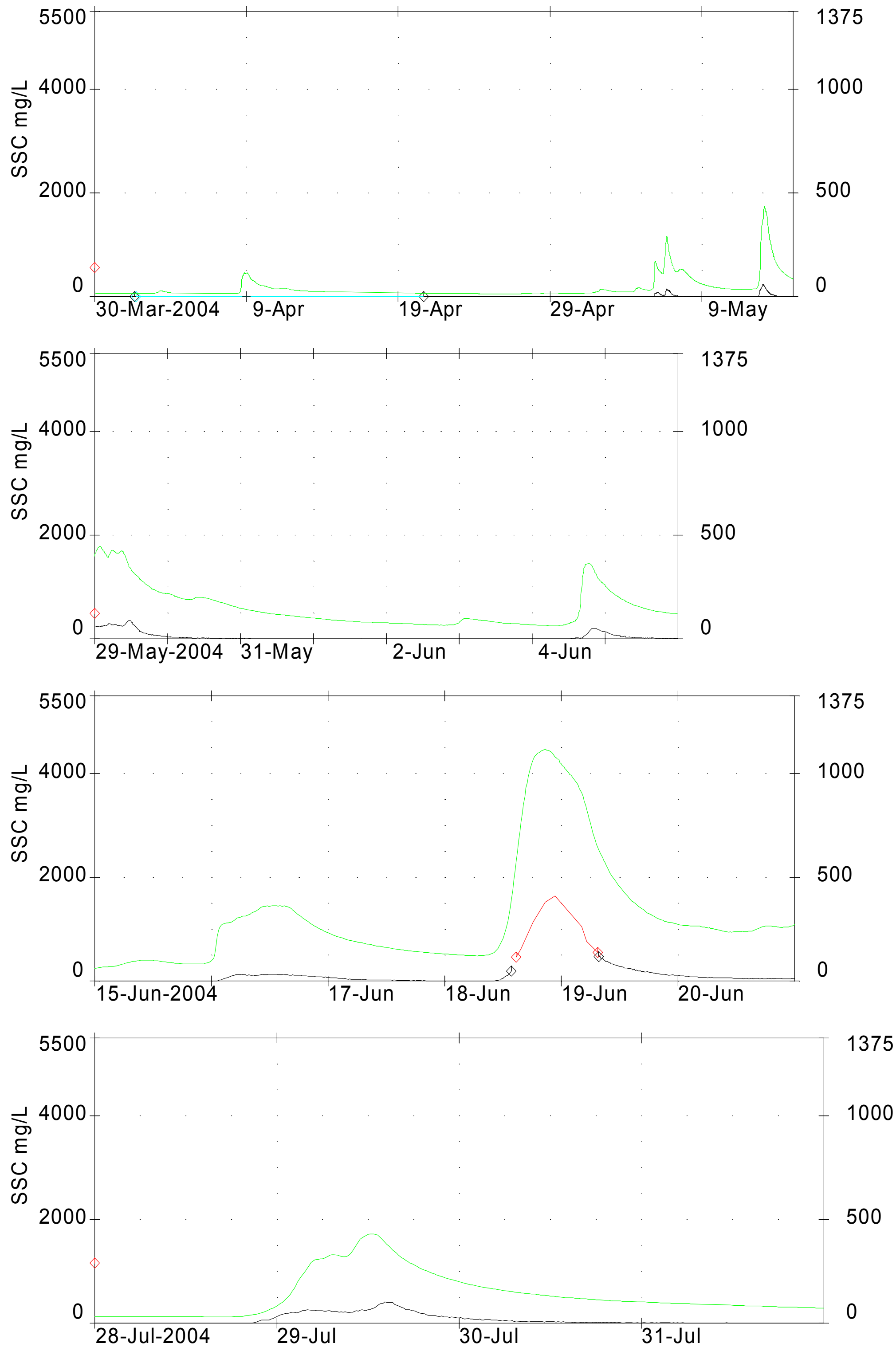


Figure A4.2: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Woodman's Bend.

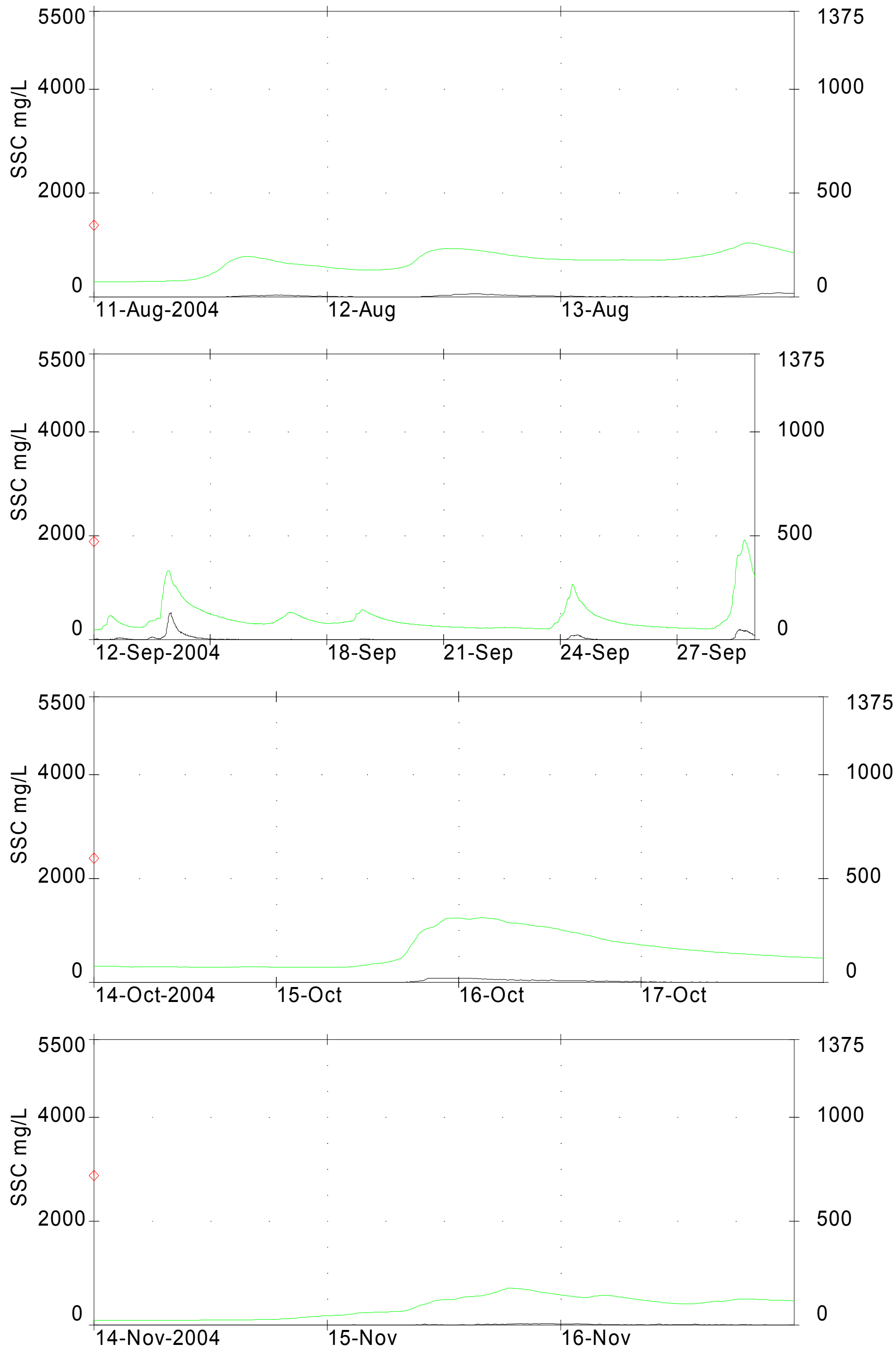


Figure A4.3: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Woodman's Bend.

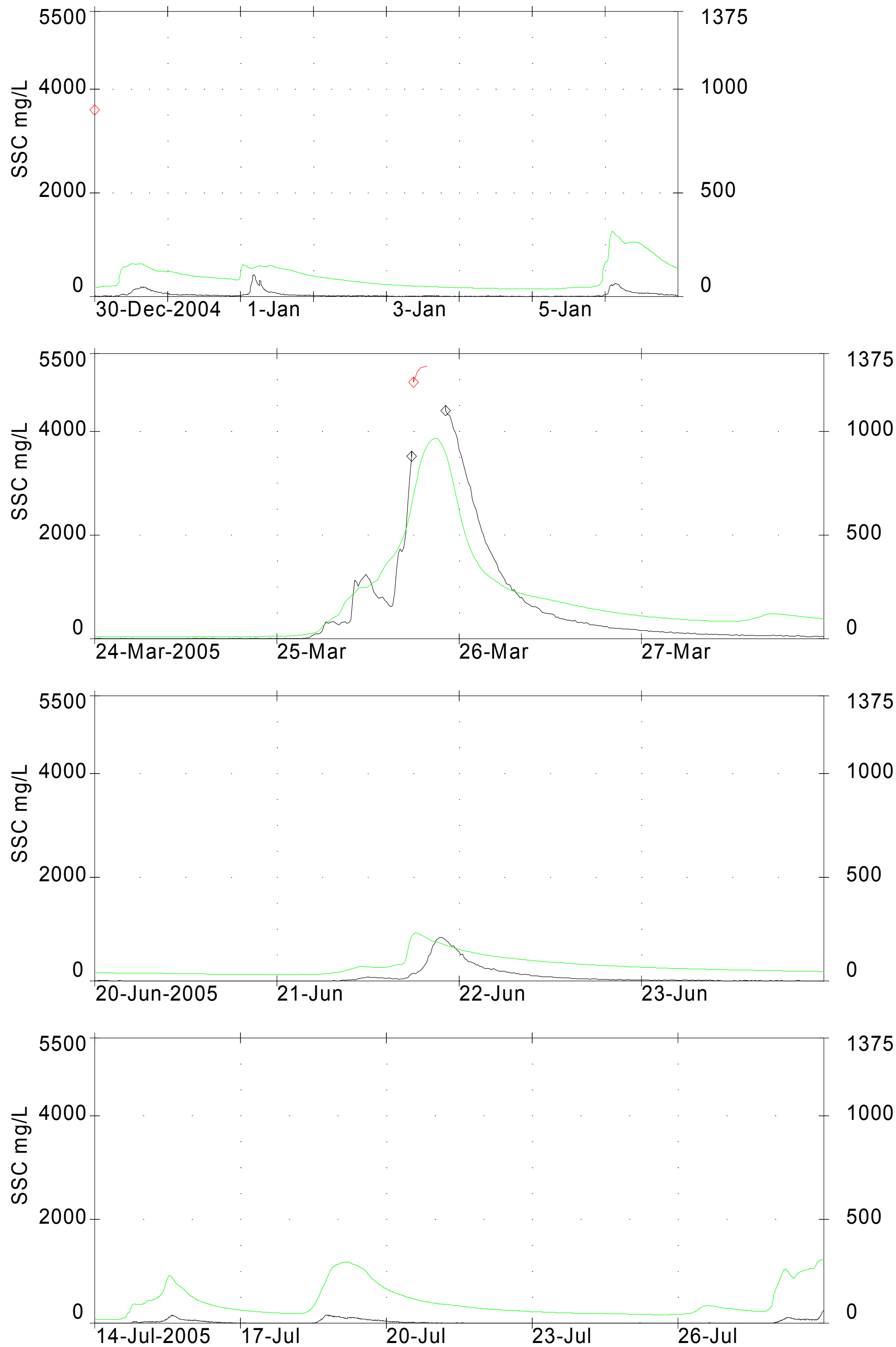


Figure A4.4: **Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Woodman's Bend.**

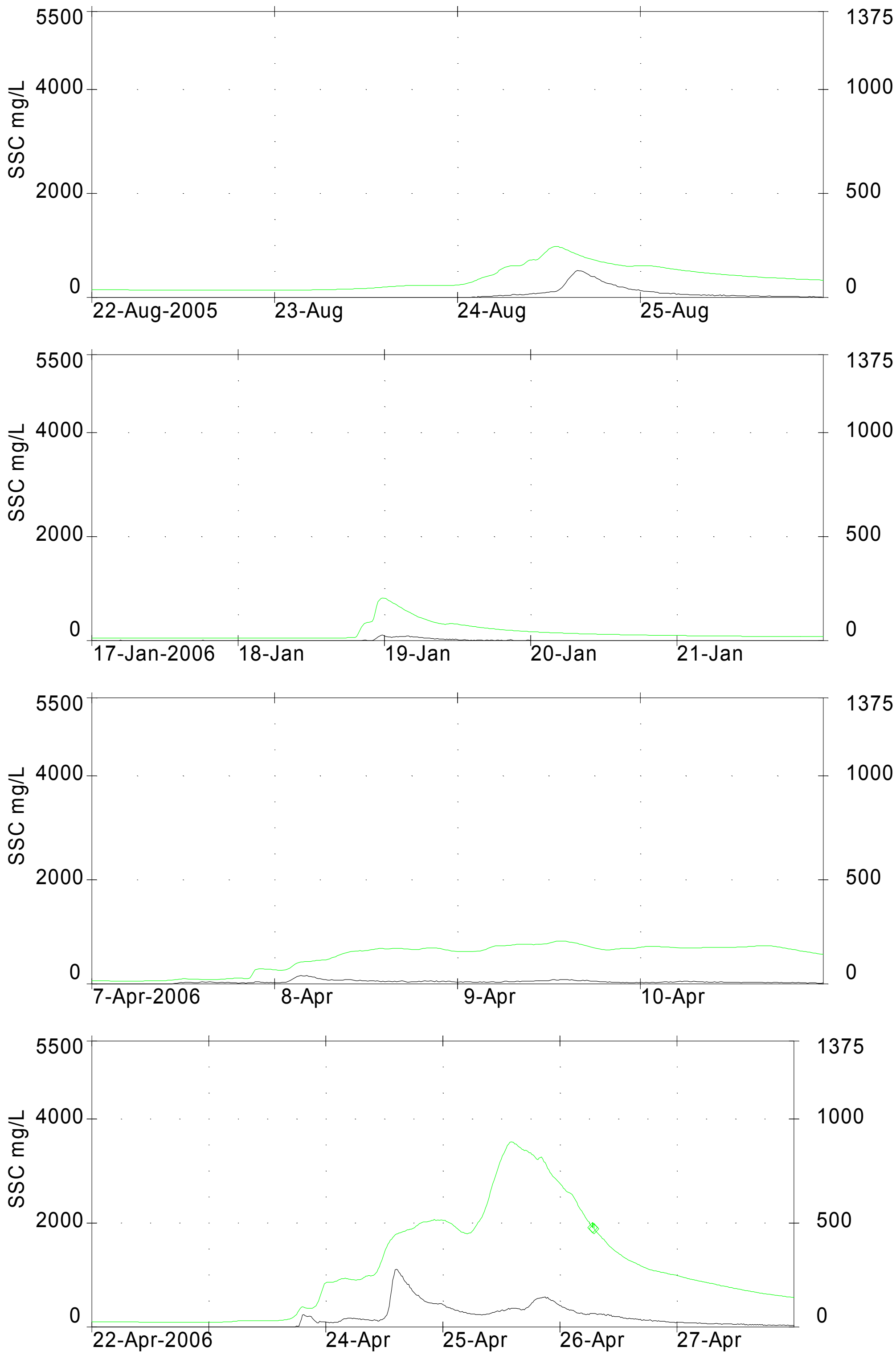


Figure A4.5: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Woodman's Bend.

Appendix 5: Wangapeka at Walter Pk derived SSC and discharge plots

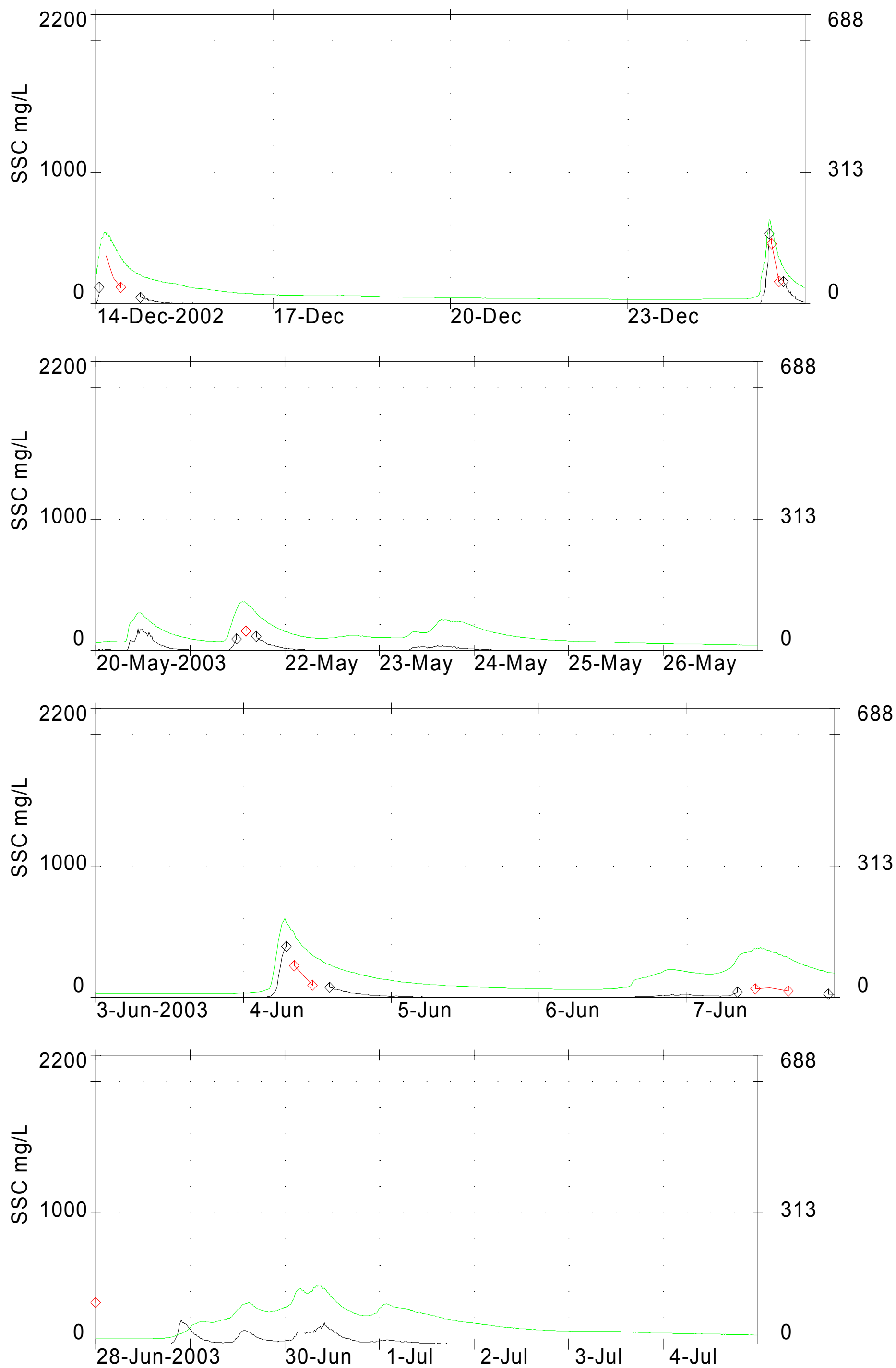


Figure A5.1: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Wangapeka at Walter Peak.

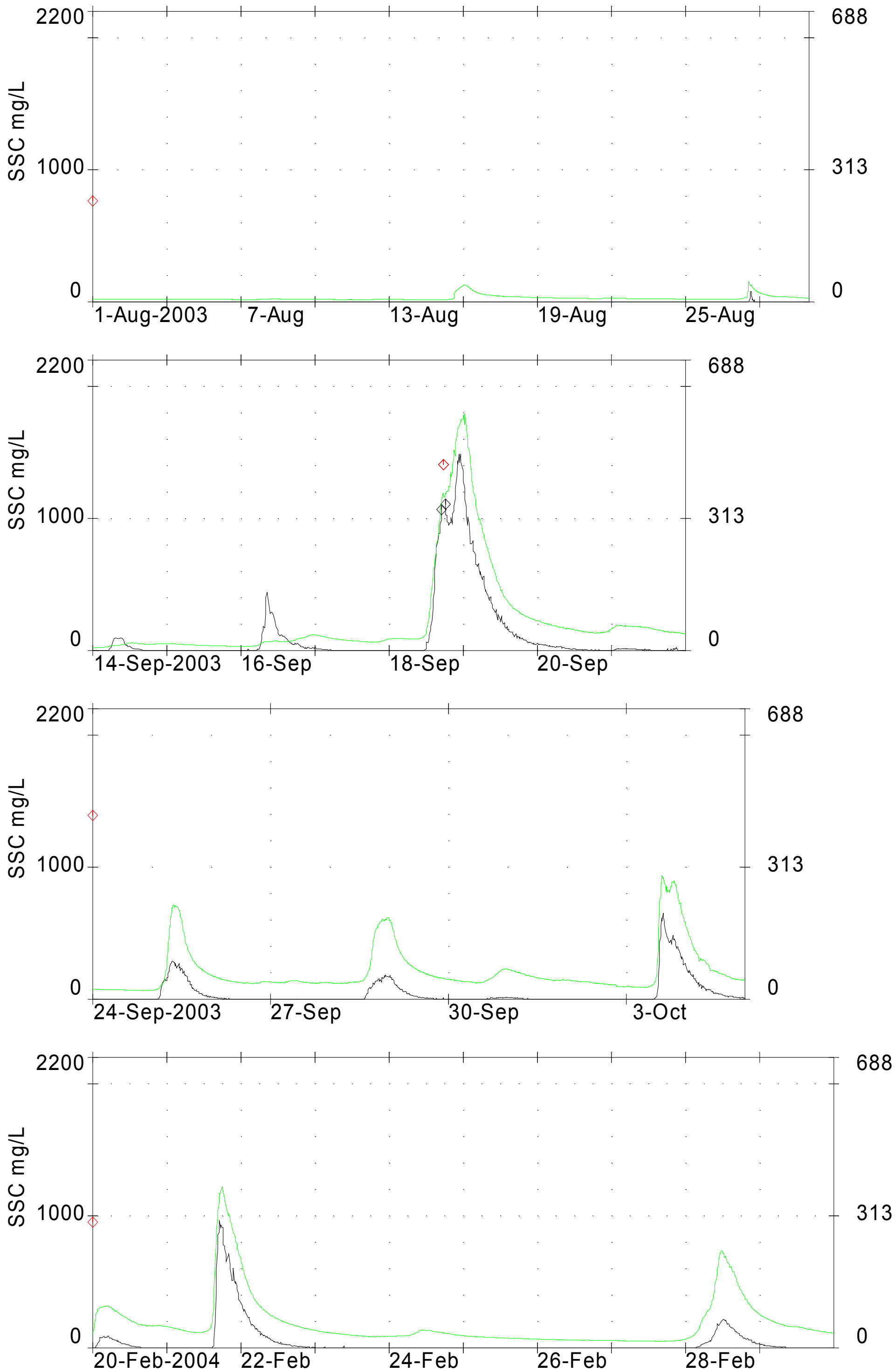


Figure A5.2: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Wangapeka at Walter Peak.

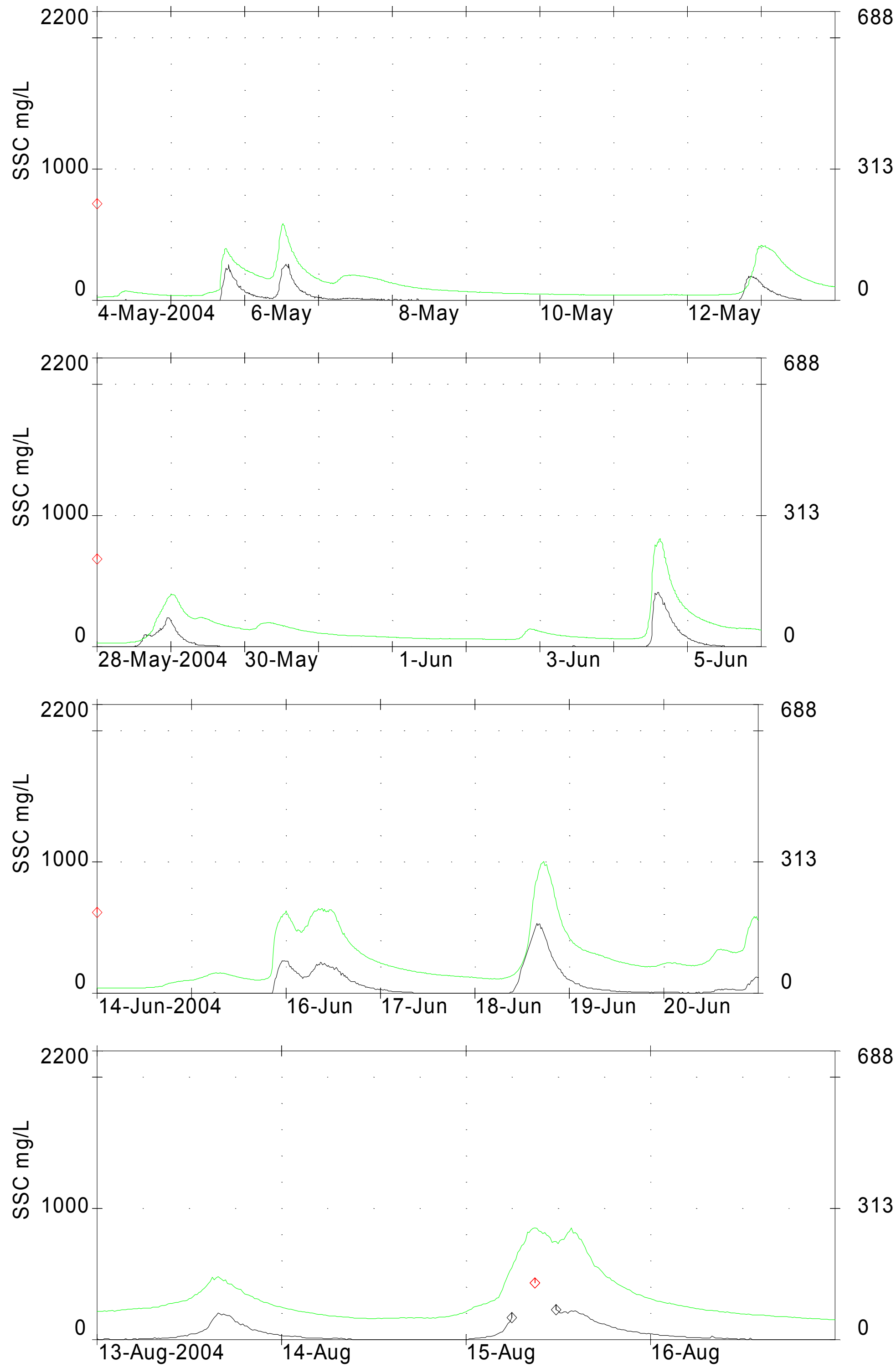


Figure A5.3: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for at Wangapeka at Walter Peak.

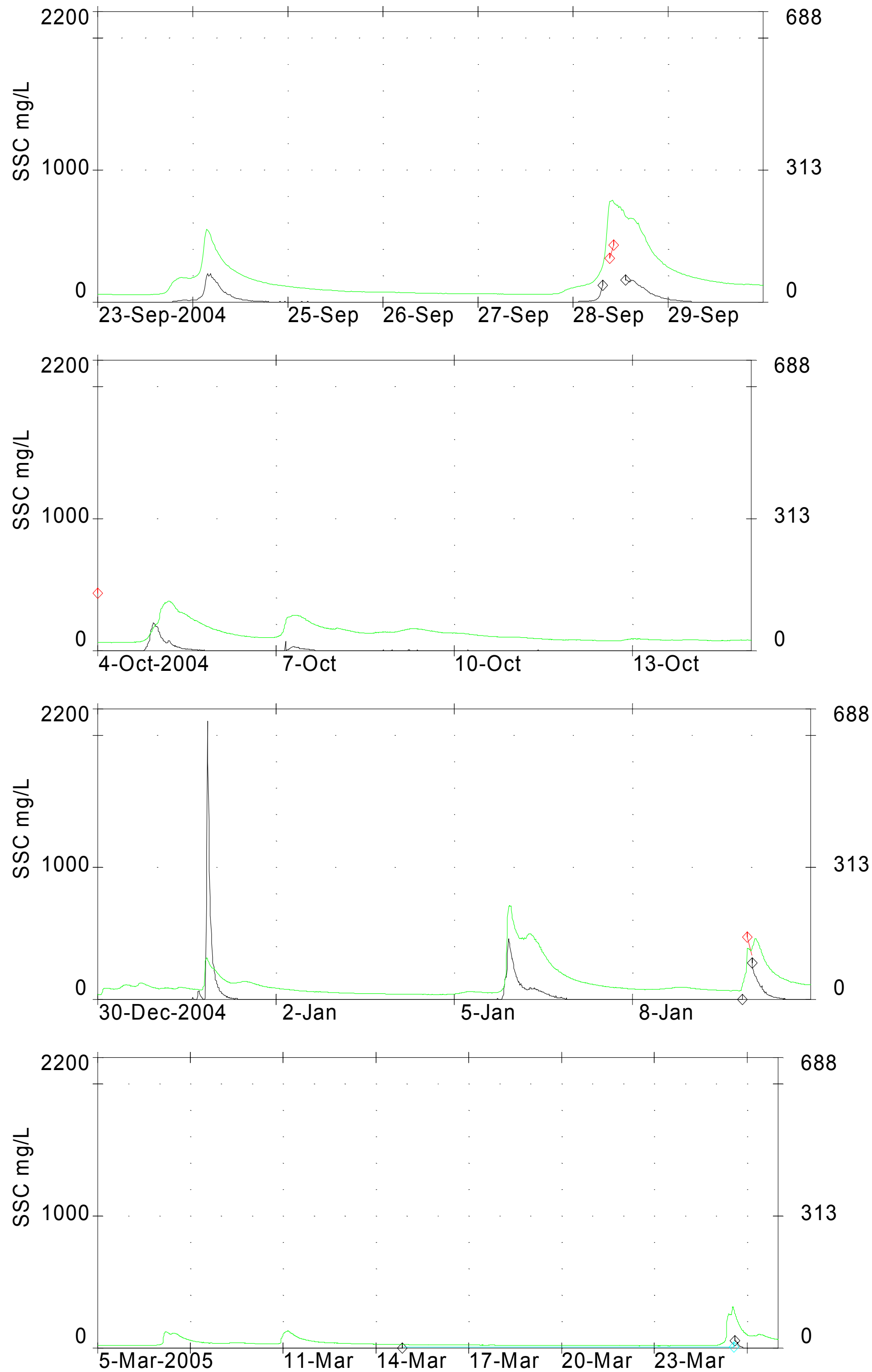


Figure A5.4: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for Wangapeka at Walter Peak.

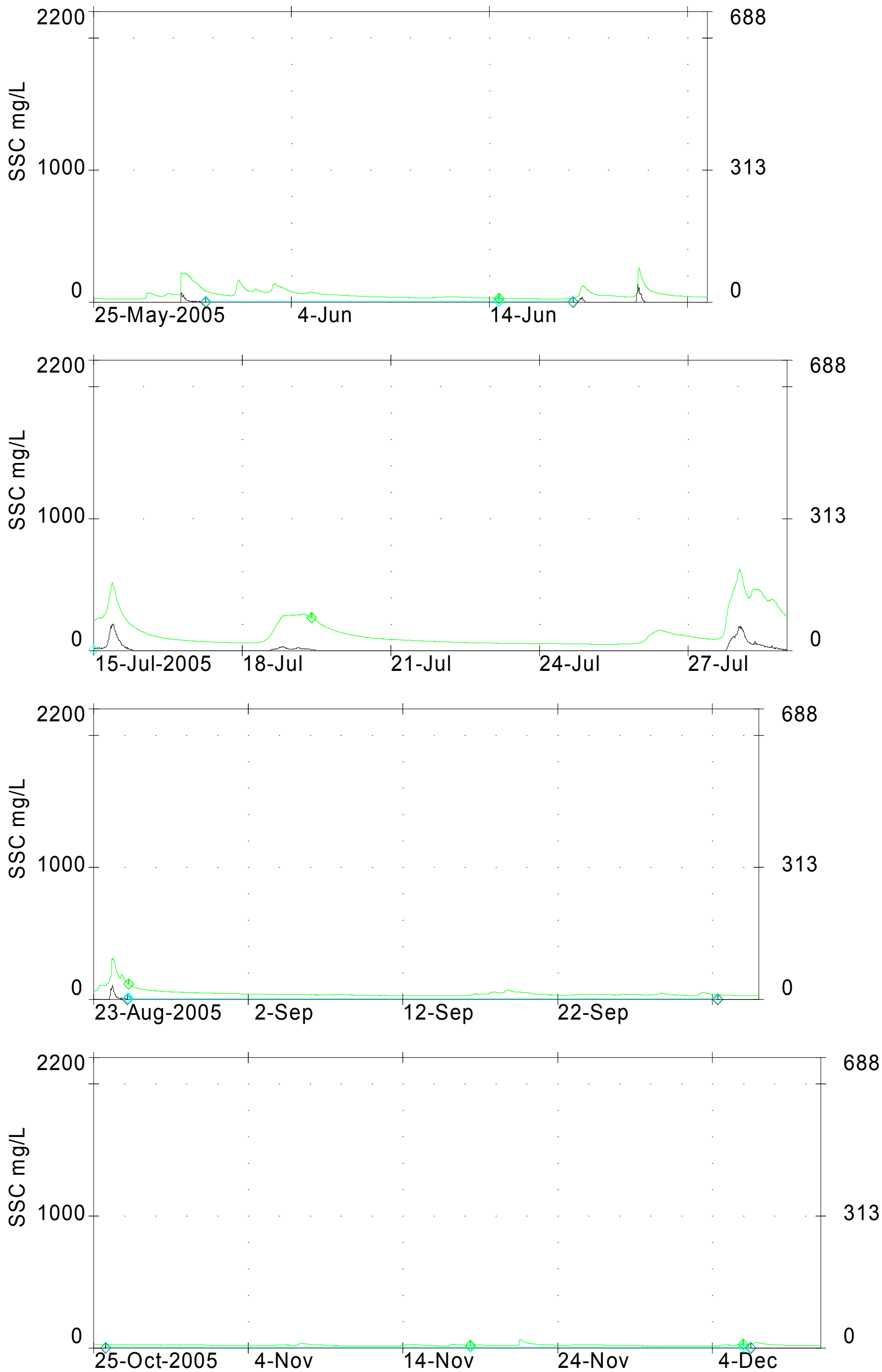


Figure A5.5: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for Wangapeka at Walter Peak.

Appendix 6: Motupiko at Christie's Bridge derived SSC and discharge plots

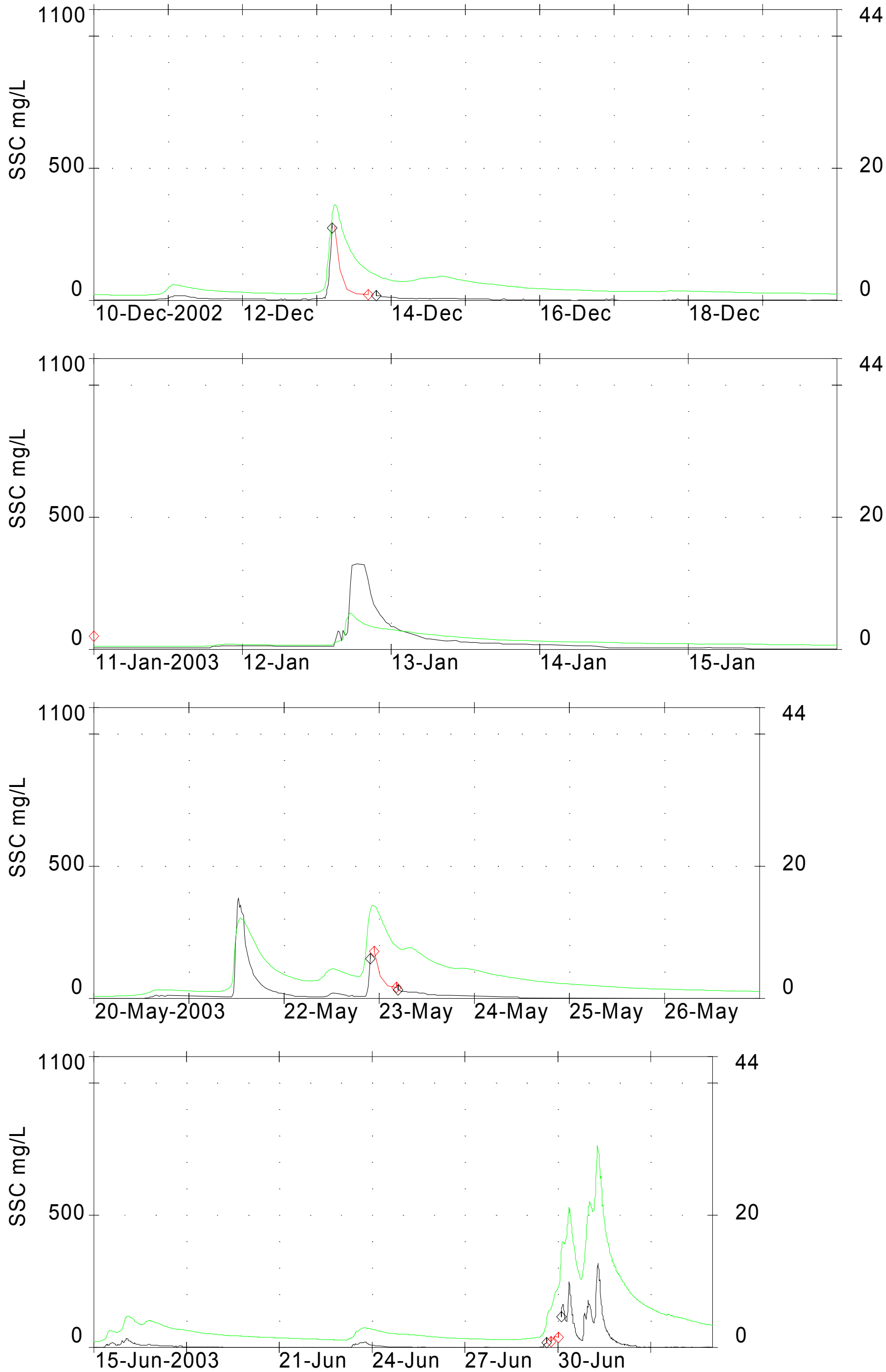


Figure A6.1: **Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motupiko at Christie's Bridge.**

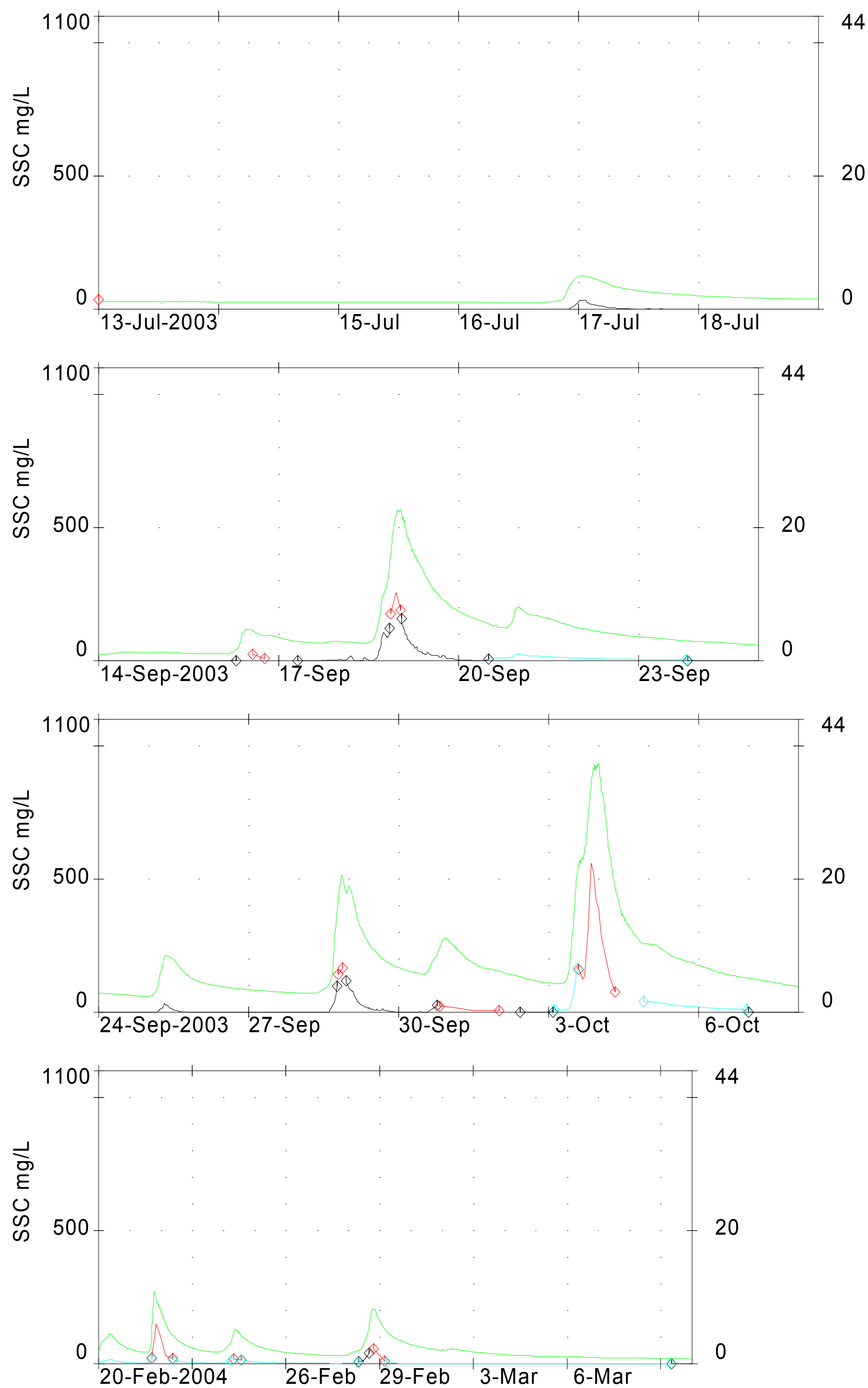


Figure A6.2: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motupiko at Christie's Bridge.

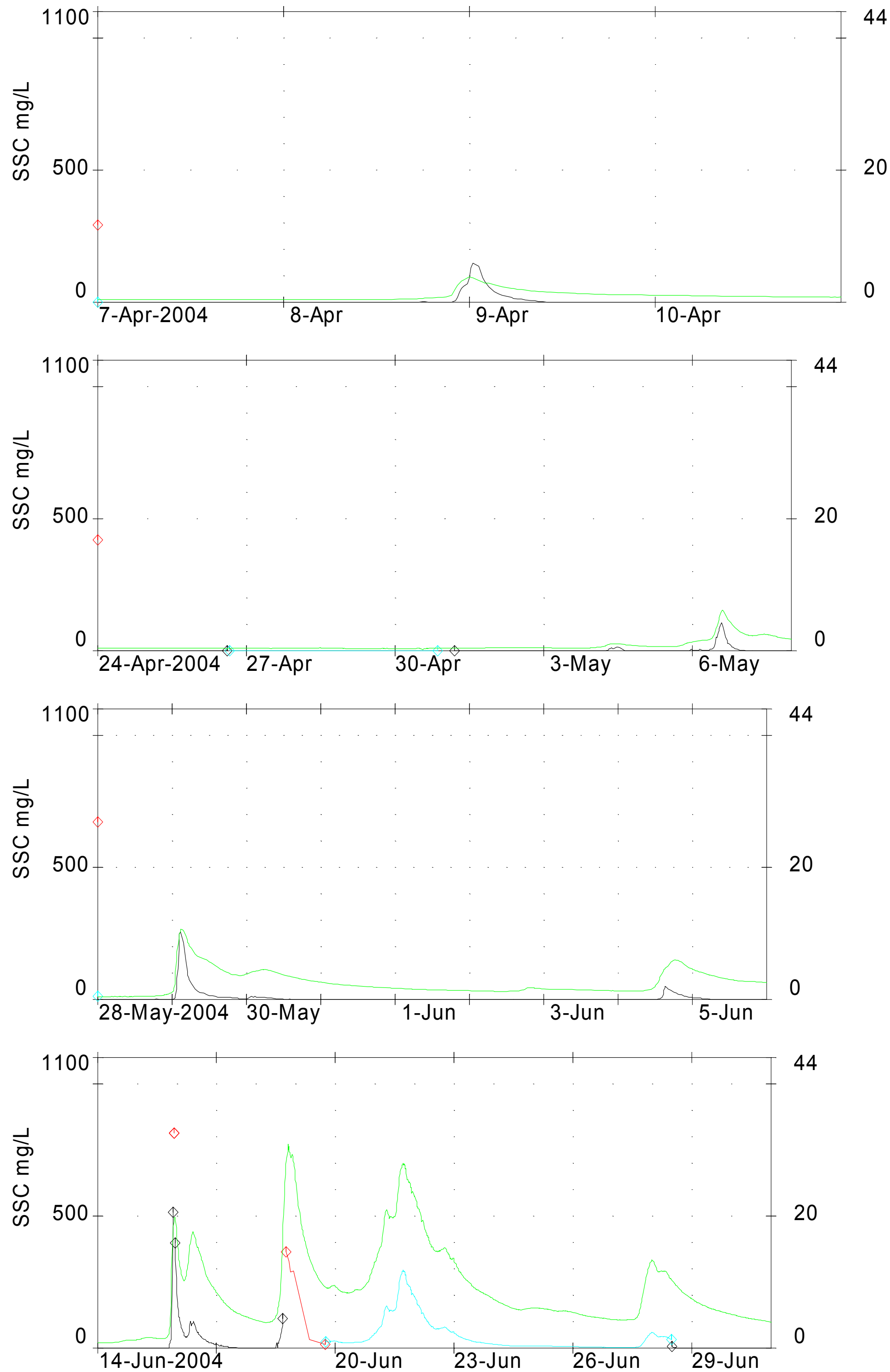


Figure A6.3: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motupiko at Christie's Bridge.

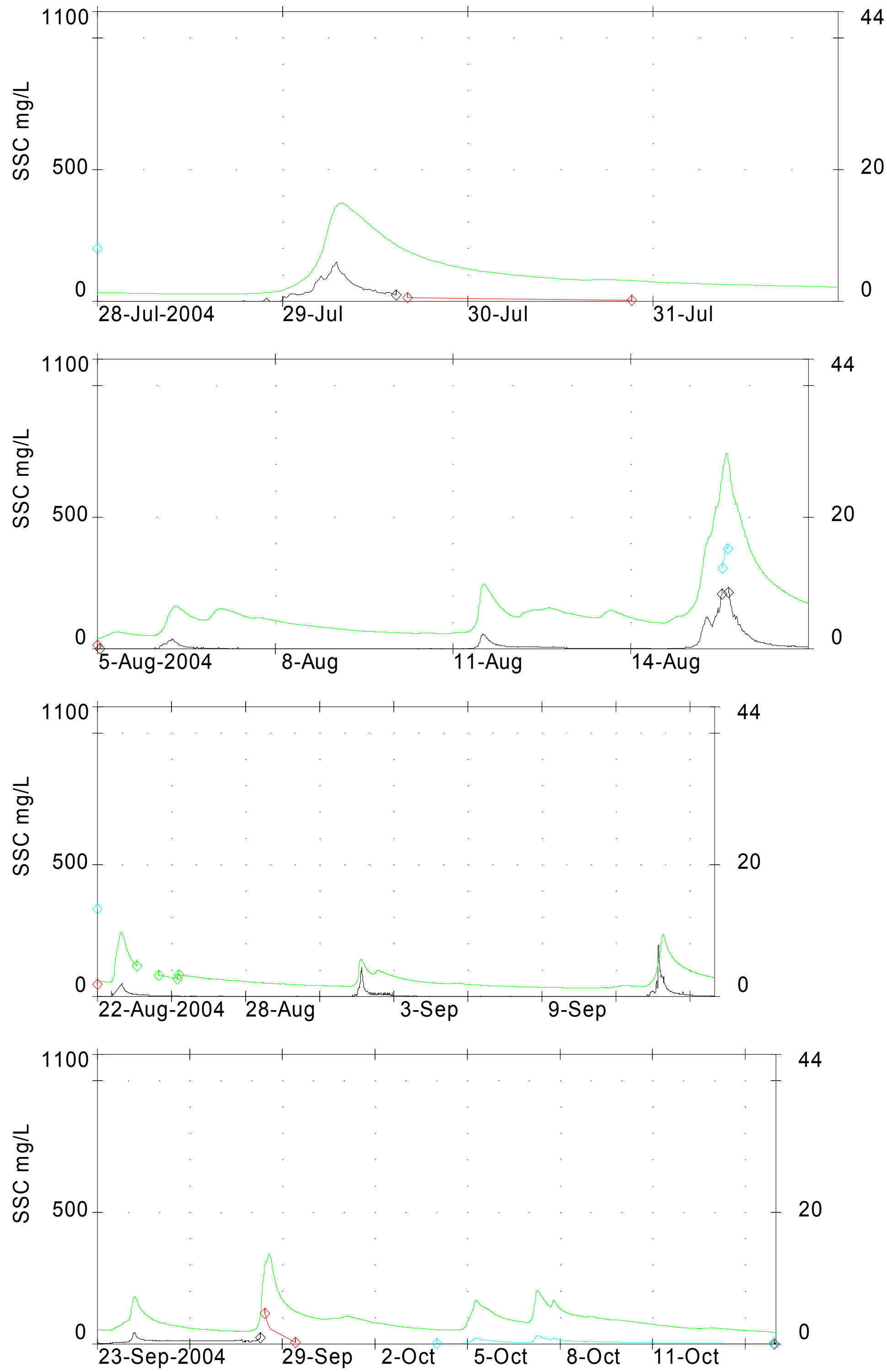


Figure A6.4: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motupiko at Christie's Bridge.

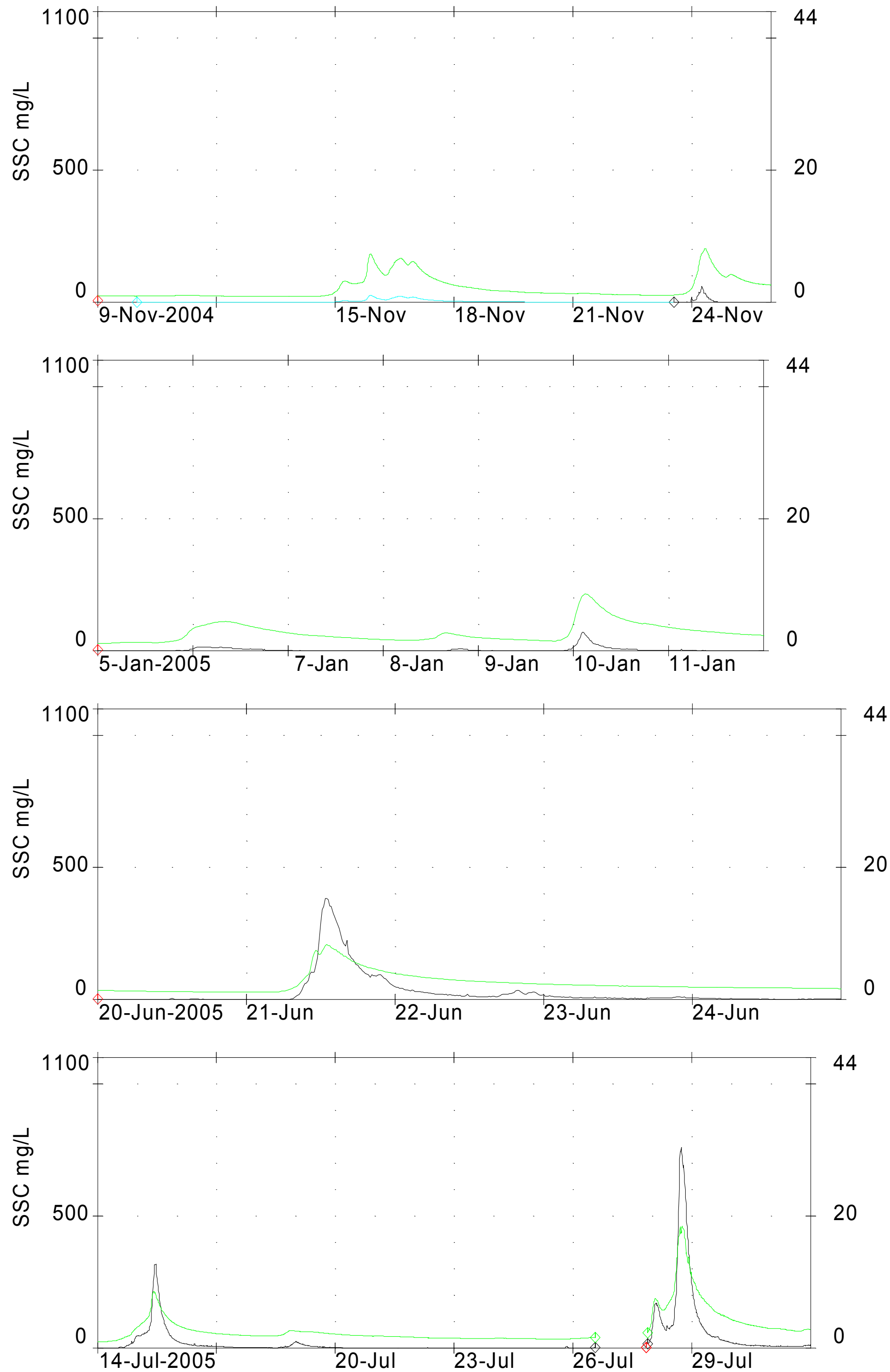


Figure A6.5: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motupiko at Christie's Bridge.

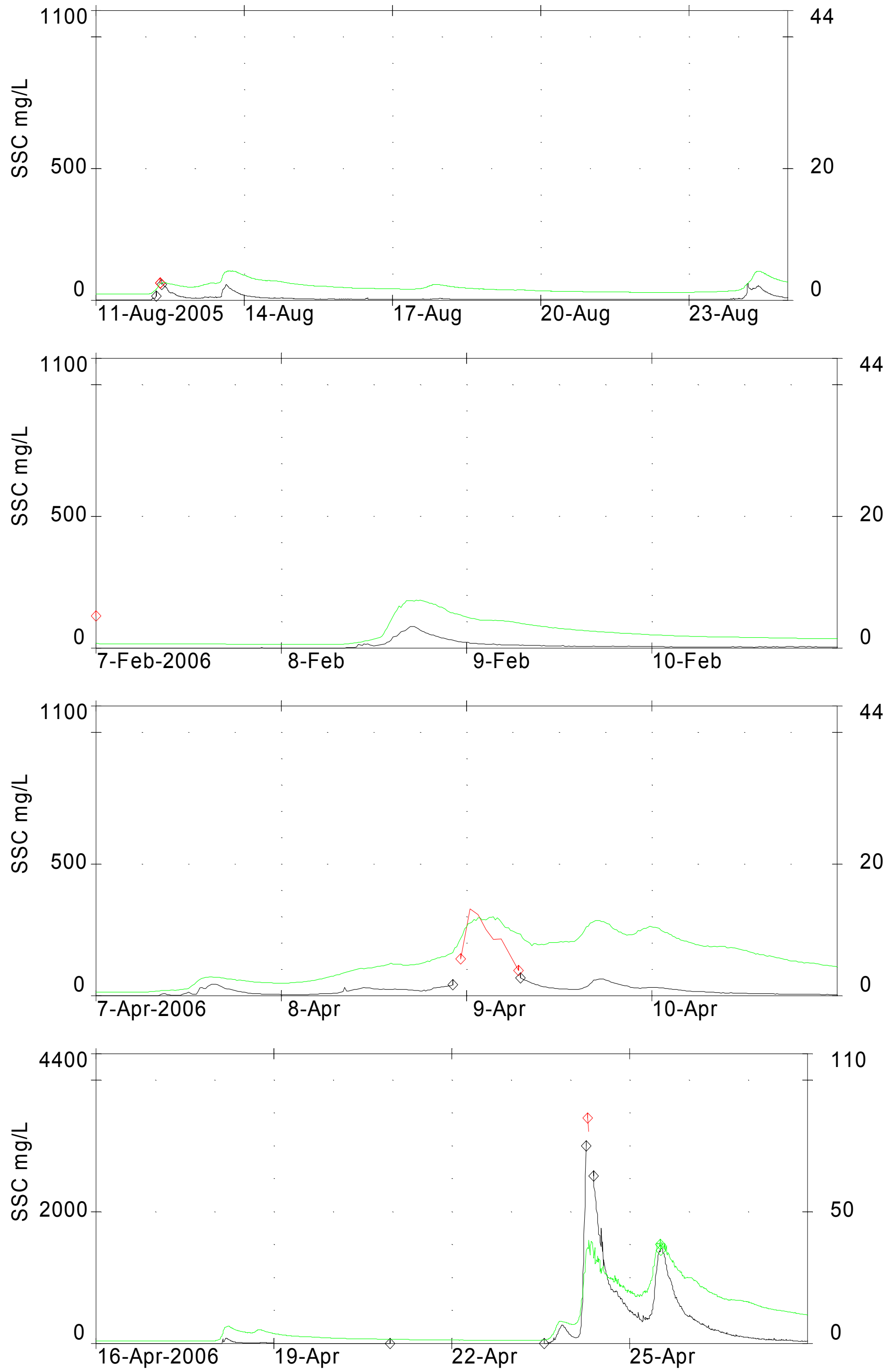


Figure A6.6: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motupiko at Christie's Bridge. Note: scale for bottom graph is different.

Appendix 7: Motueka at Gorge derived SSC and discharge plots

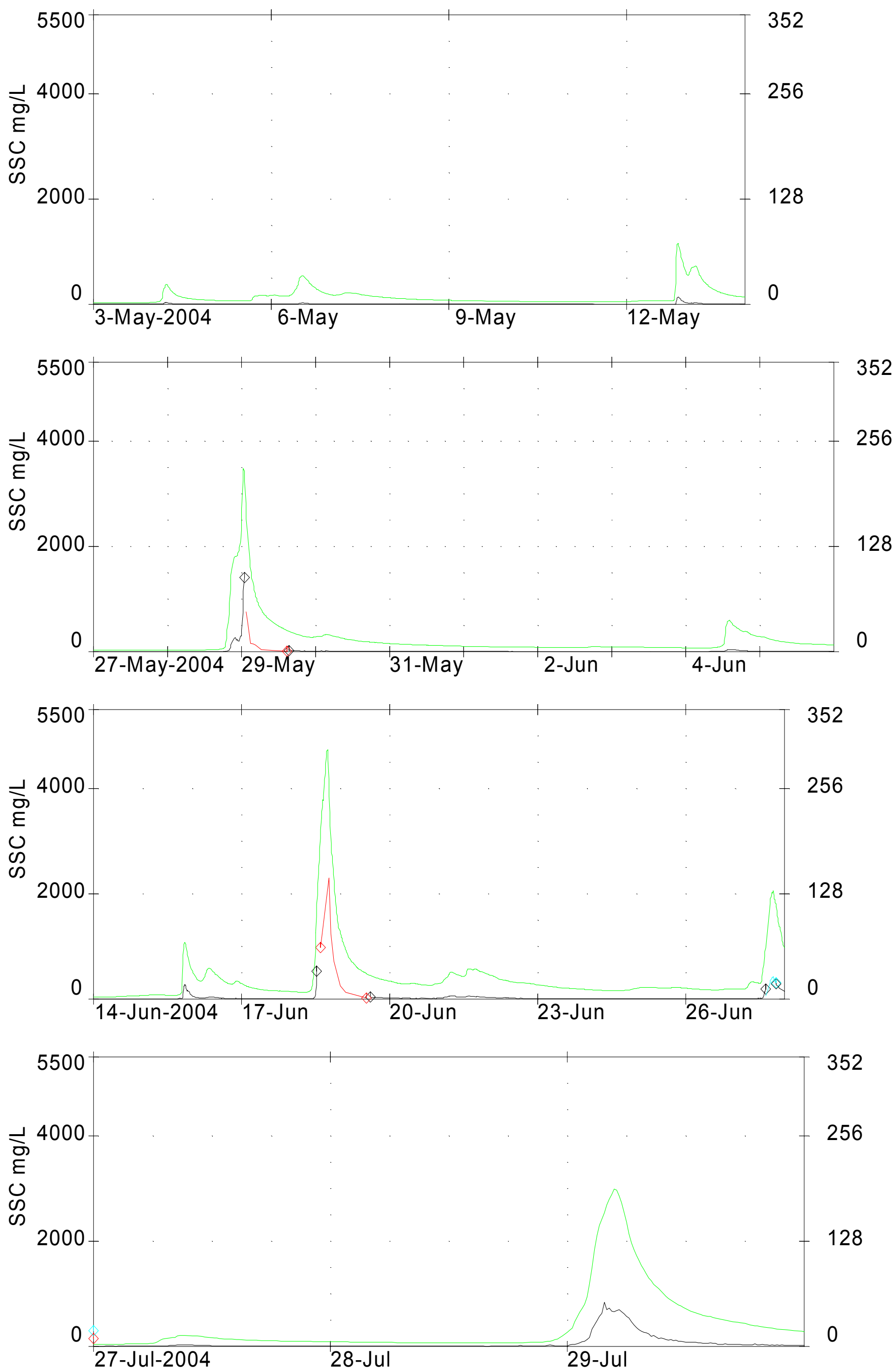


Figure A7.1: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Gorge.

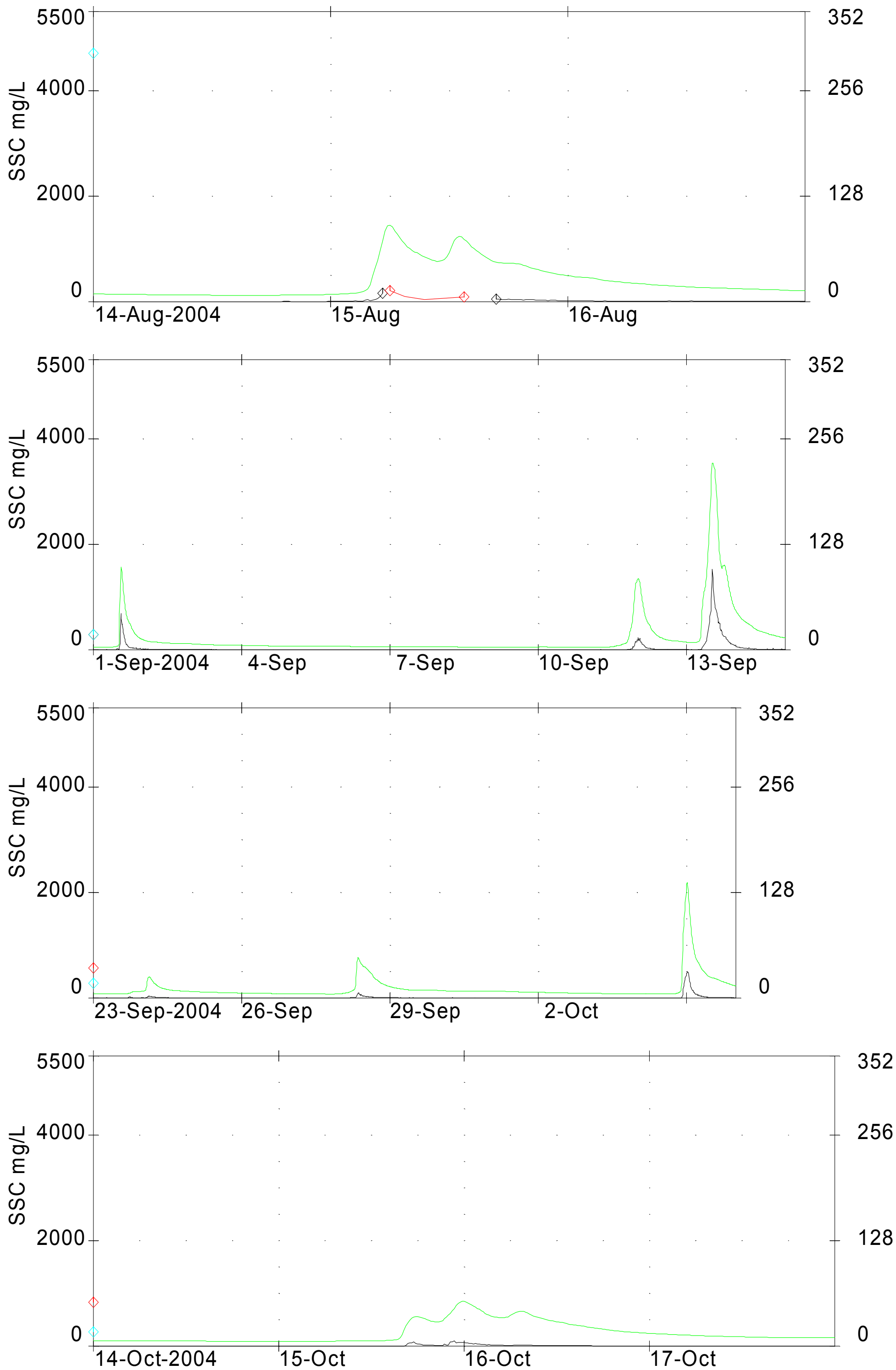


Figure A7.2: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Gorge.

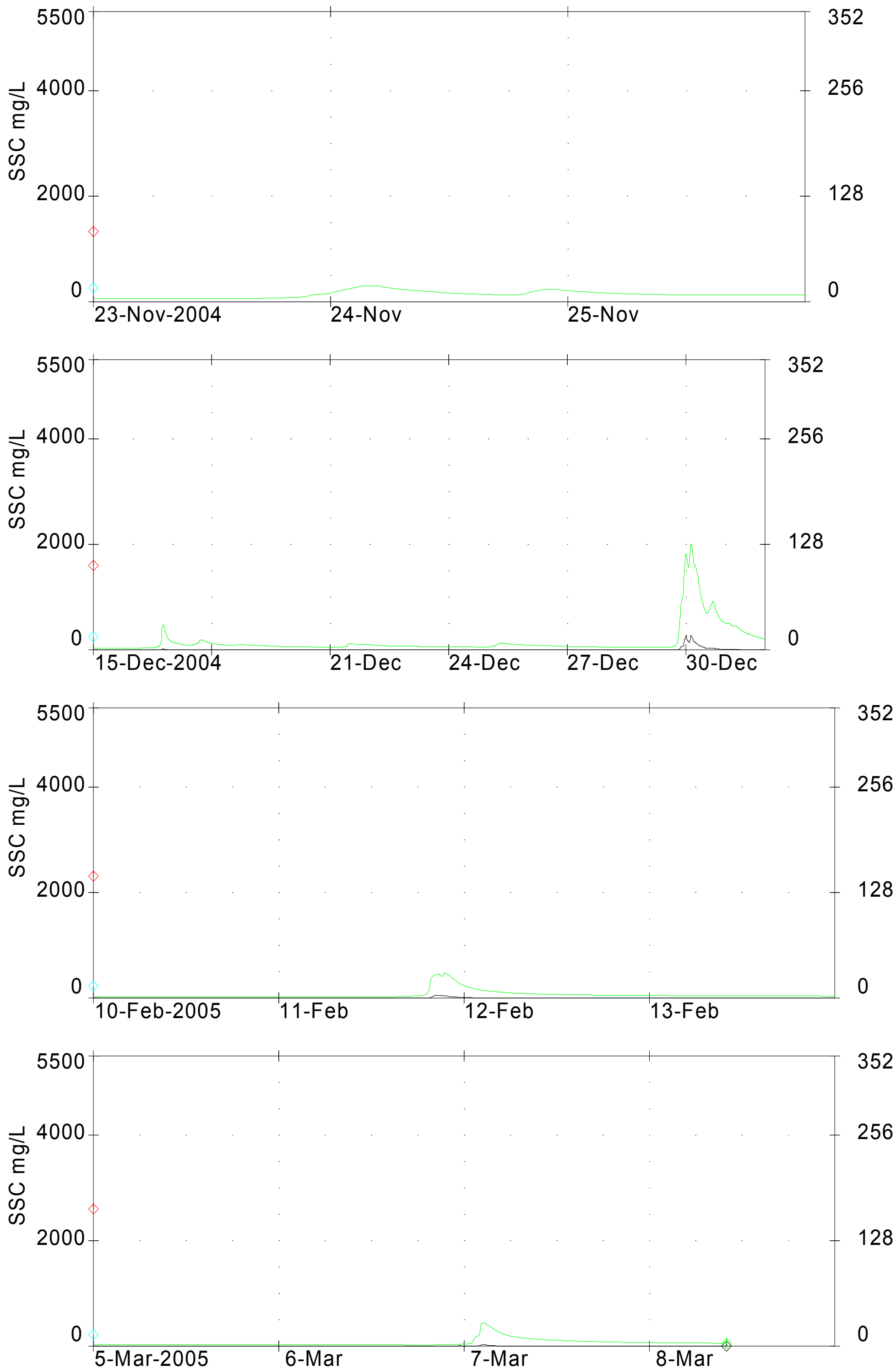


Figure A7.3: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Gorge.

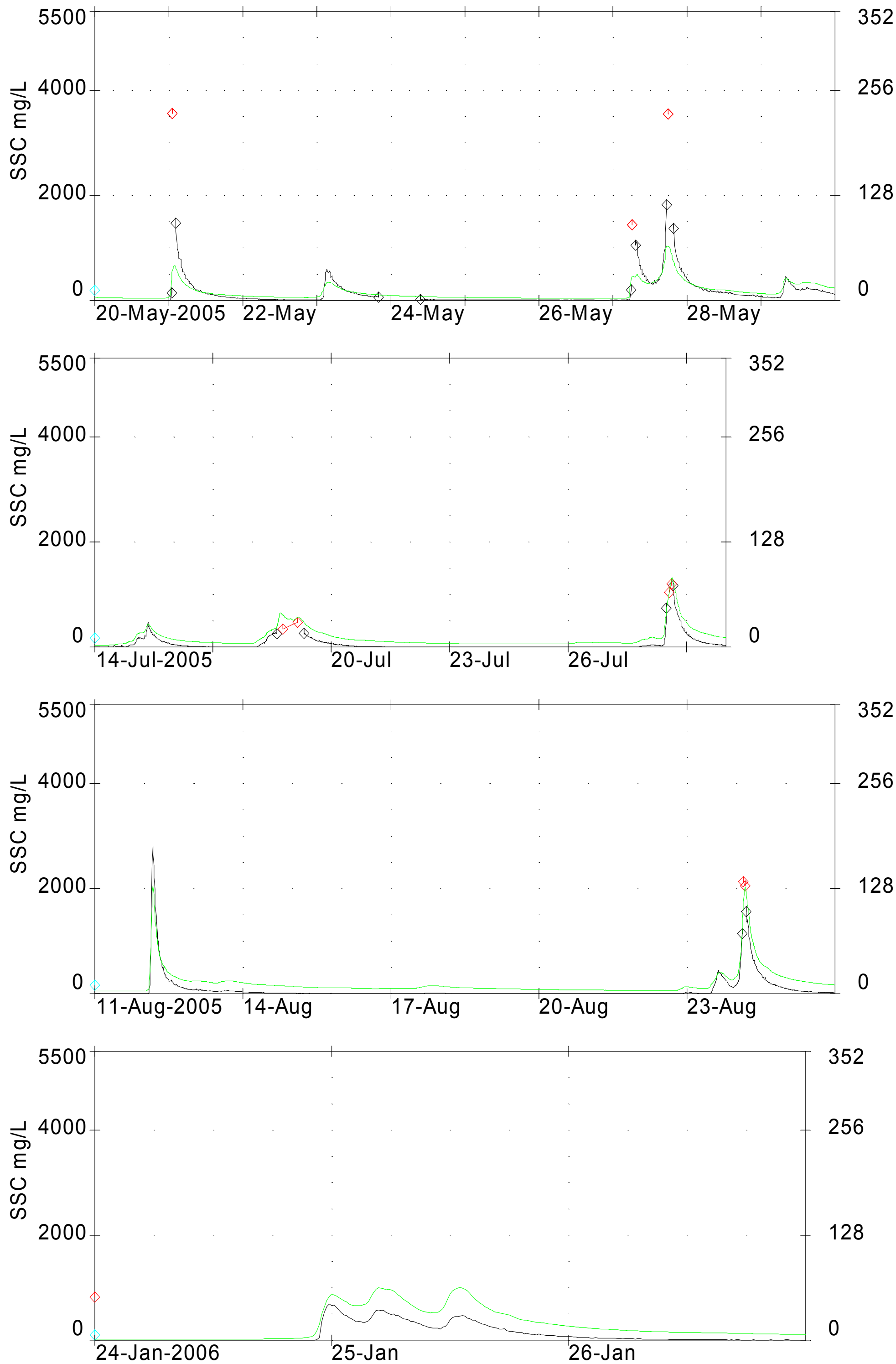


Figure A7.4: Water discharge (green, m³/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Gorge.

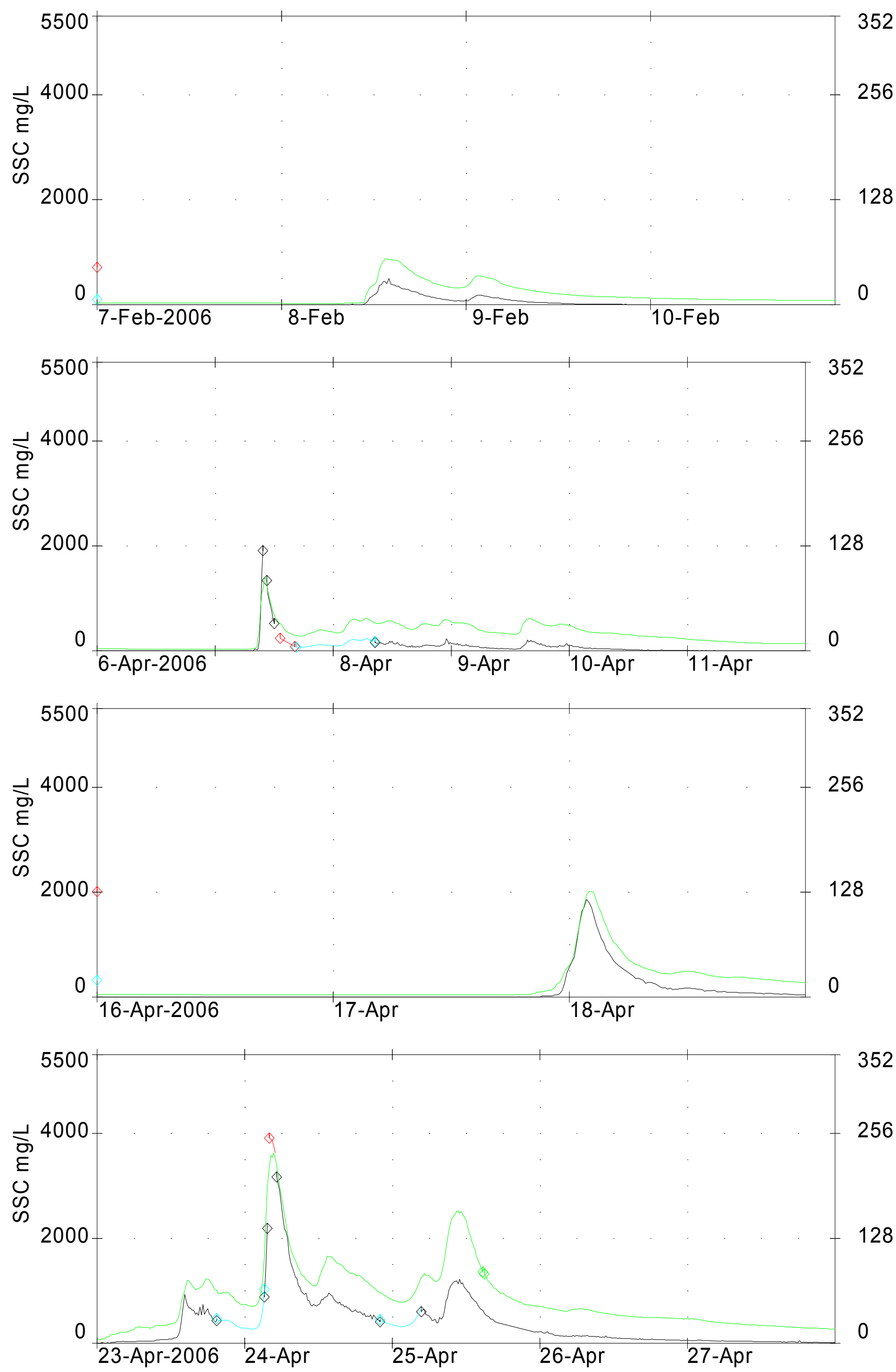


Figure A7.5: Water discharge (green, m^3/s) and SSC derived time series 'components' – autosamples (red), NTU/SSC relationship (black), discharge/SSC relationship (blue) for events at Motueka at Gorge.

Appendix 8: Final SSC time series

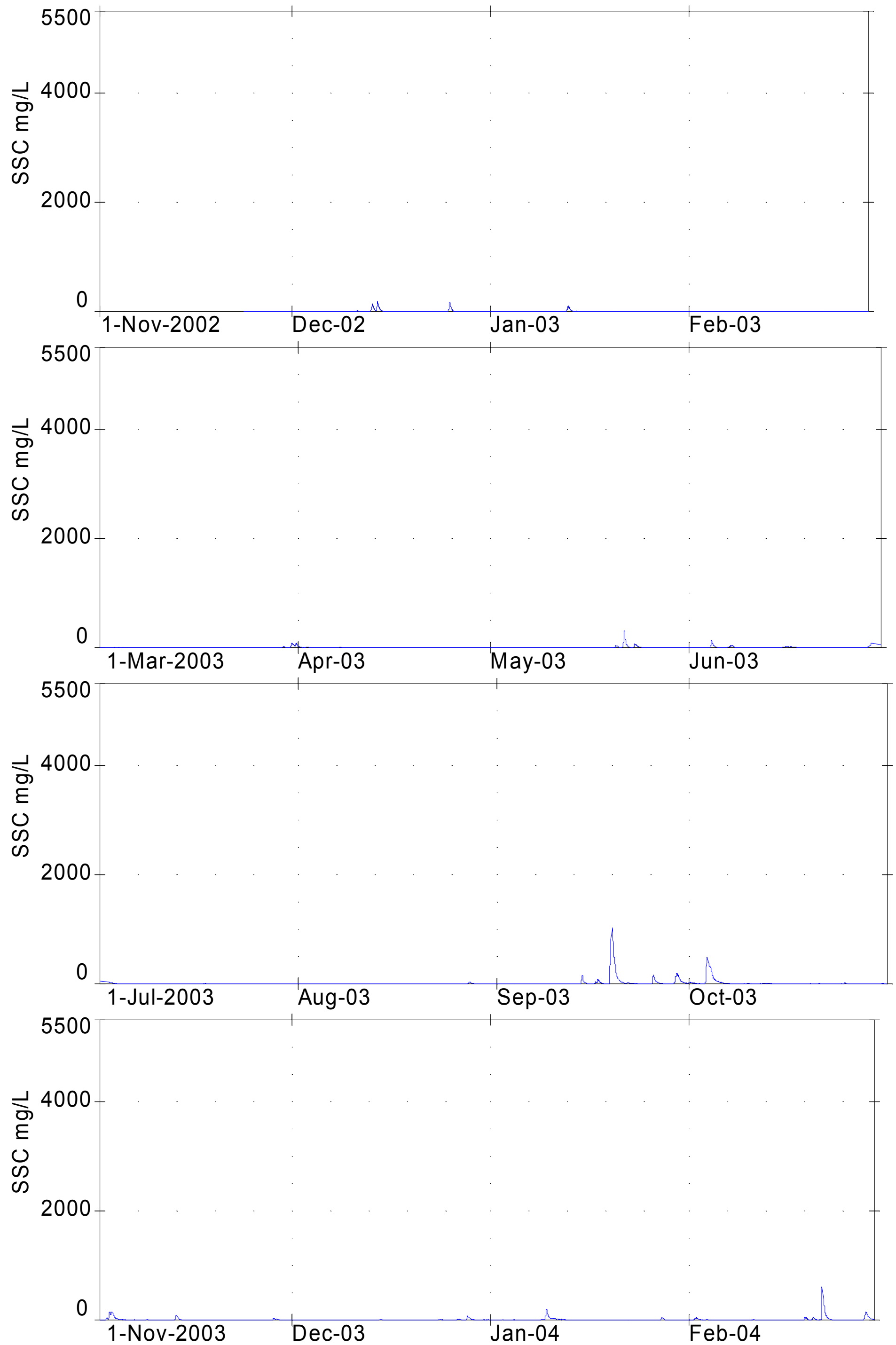


Figure A8.1: Derived suspended sediment concentration (SSC, mg/L) record, November 2002 to 1 March 2004 at Motueka at Woodman's Bend.

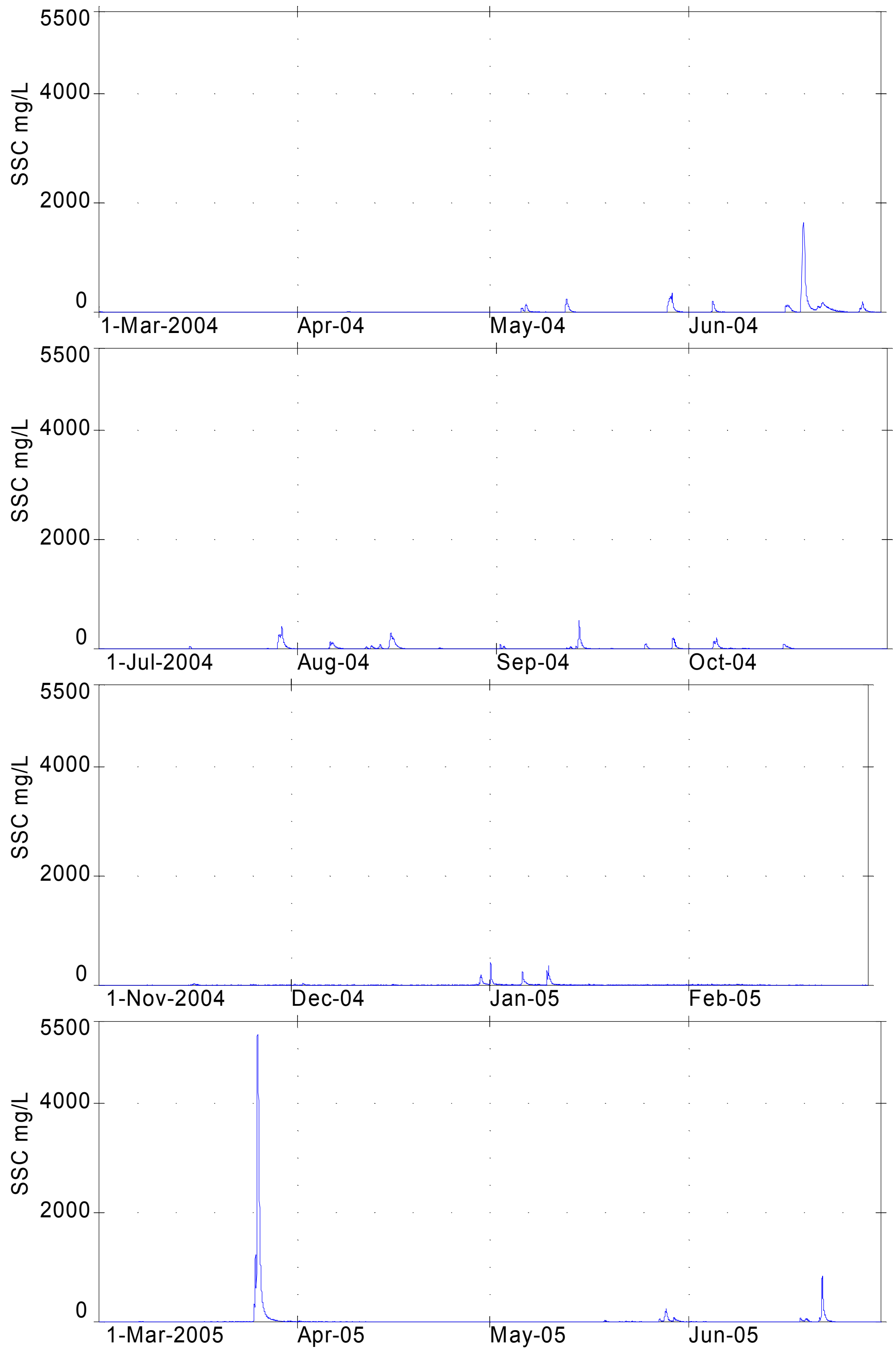


Figure A8.2: Derived suspended sediment concentration (SSC, mg/L) record, 1 March 2004 to 1 July 2005 at Motueka at Woodman's Bend.

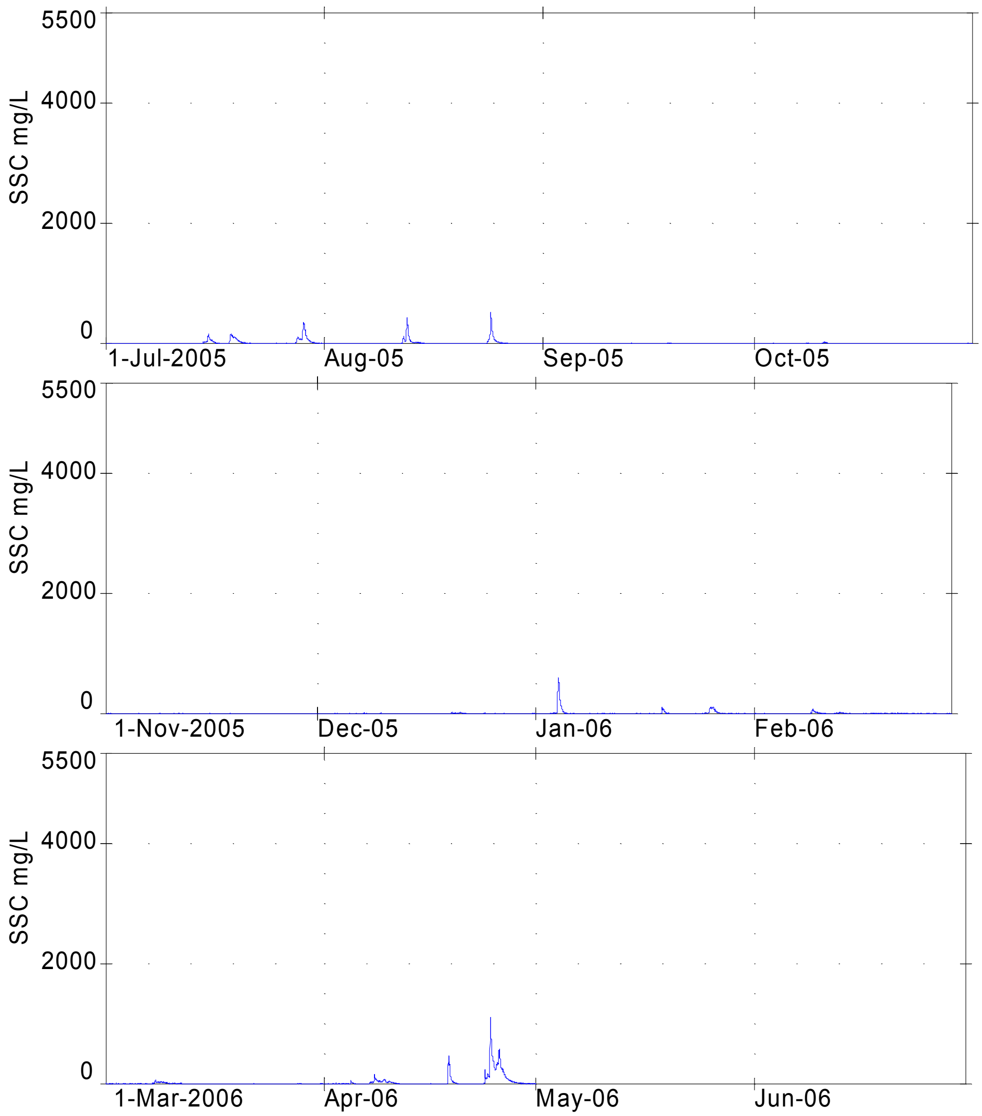


Figure A8.3: Derived suspended sediment concentration (SSC, mg/L) record, 1 July 2005 to 1 May 2006 at Motueka at Woodman's Bend.

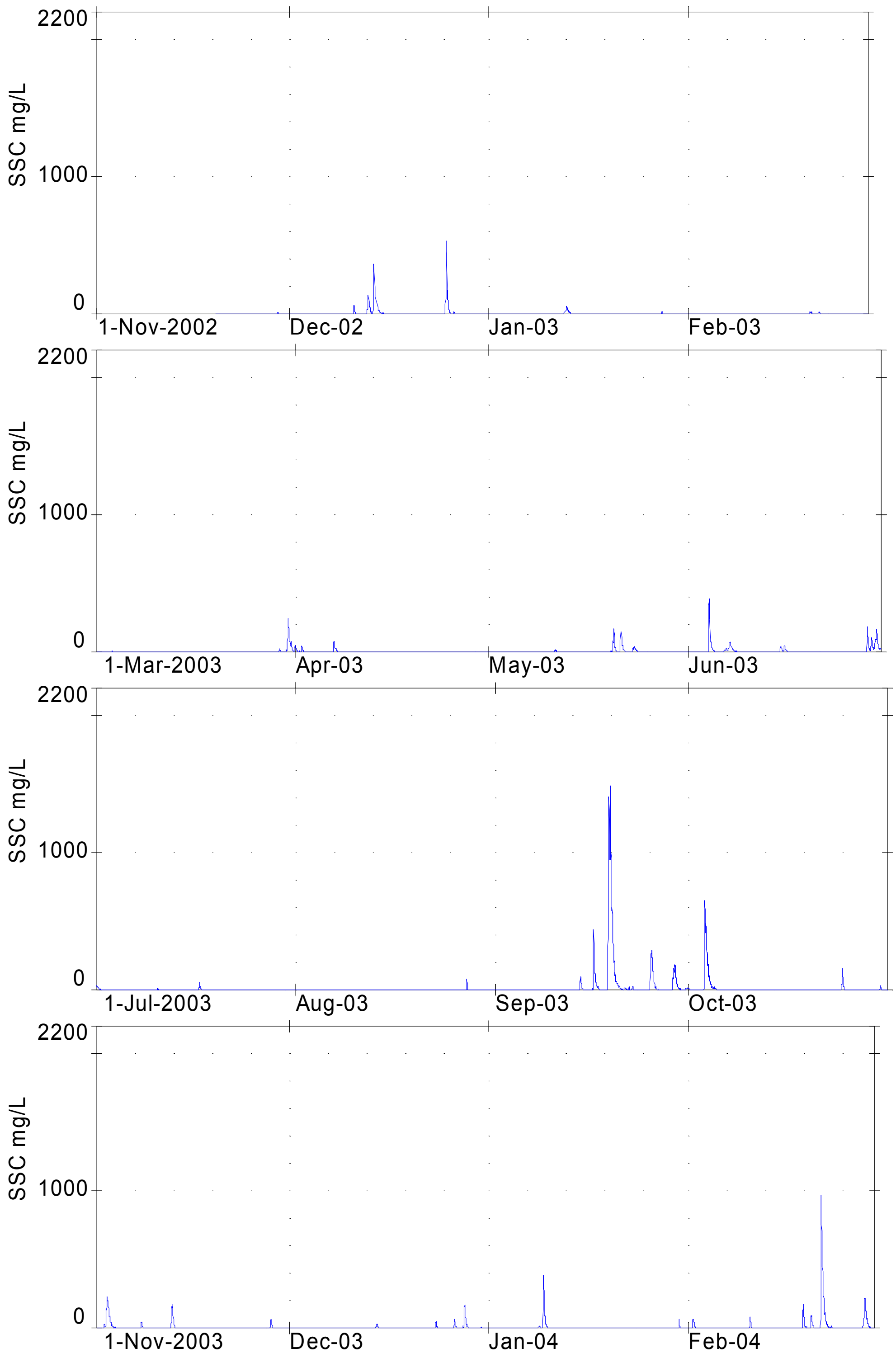


Figure A8.4: Derived suspended sediment concentration (SSC, mg/L) record, 1 November 2002 to 1 March 2004 at Wangapeka at Walter Peak.

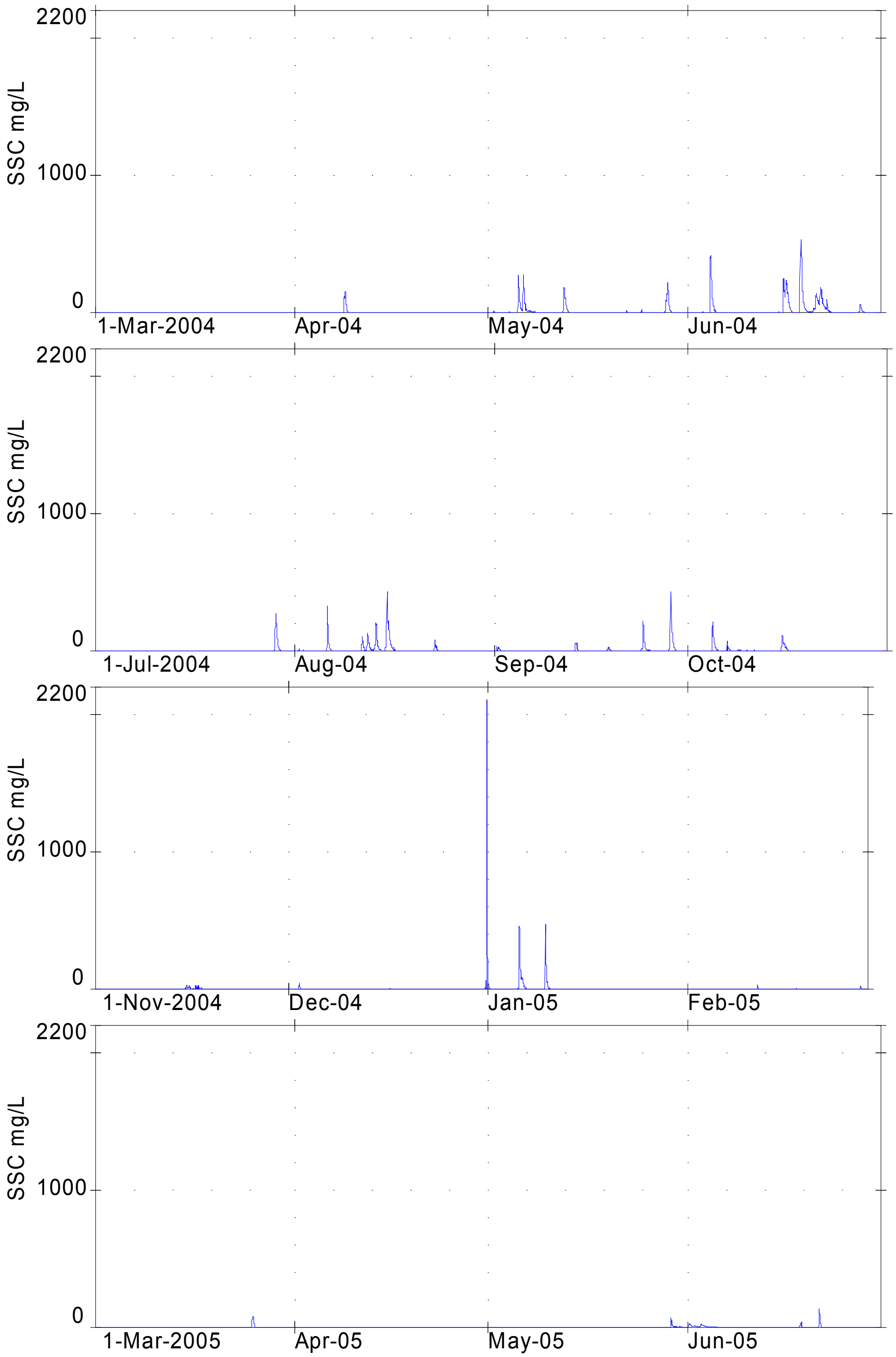


Figure A8.5: Derived suspended sediment concentration (SSC, mg/L) record, 1 March 2004 to 1 July 2005 at Wangapeka at Walter Peak.

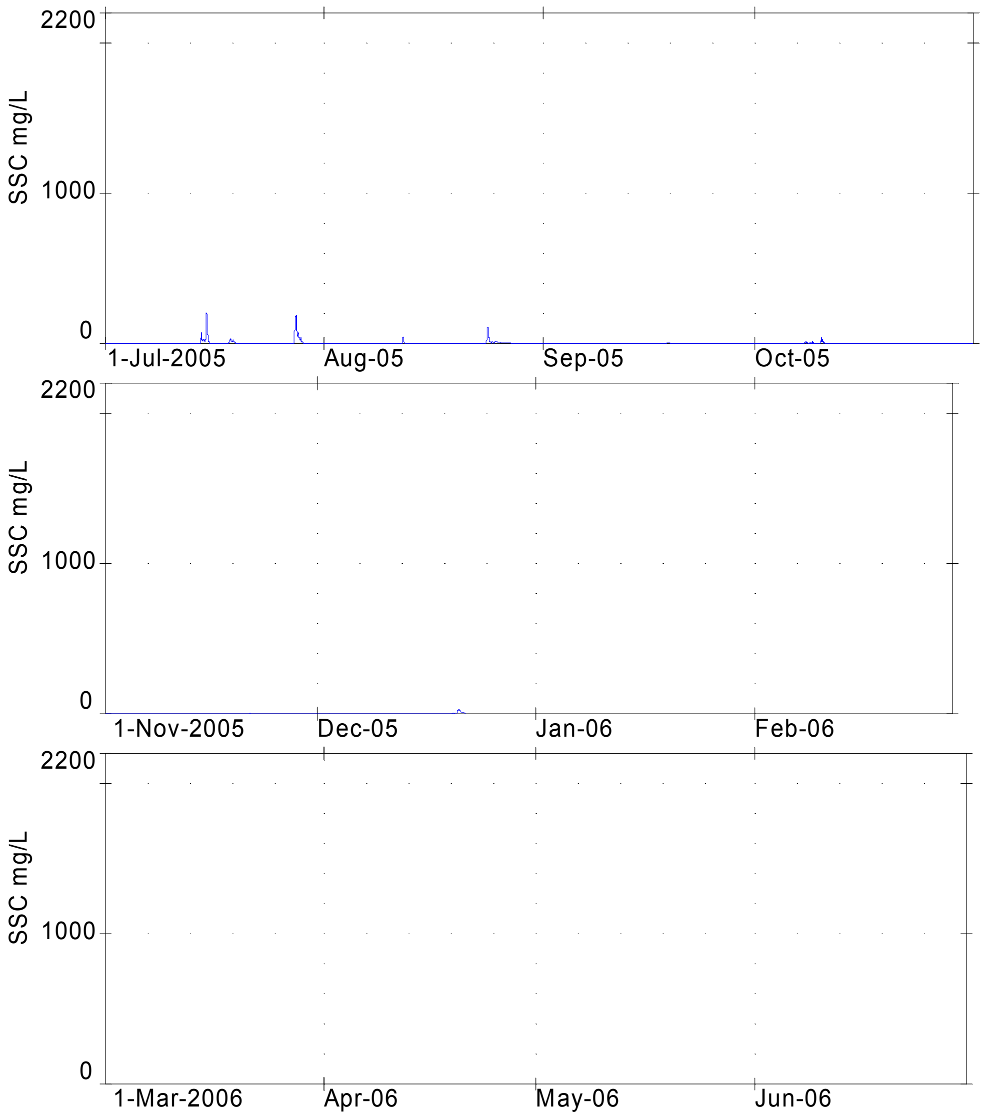


Figure A8.6: Derived suspended sediment concentration (SSC, mg/L) record, 1 July 2005 to 1 May 2006 at Wangapeka at Walter Peak.

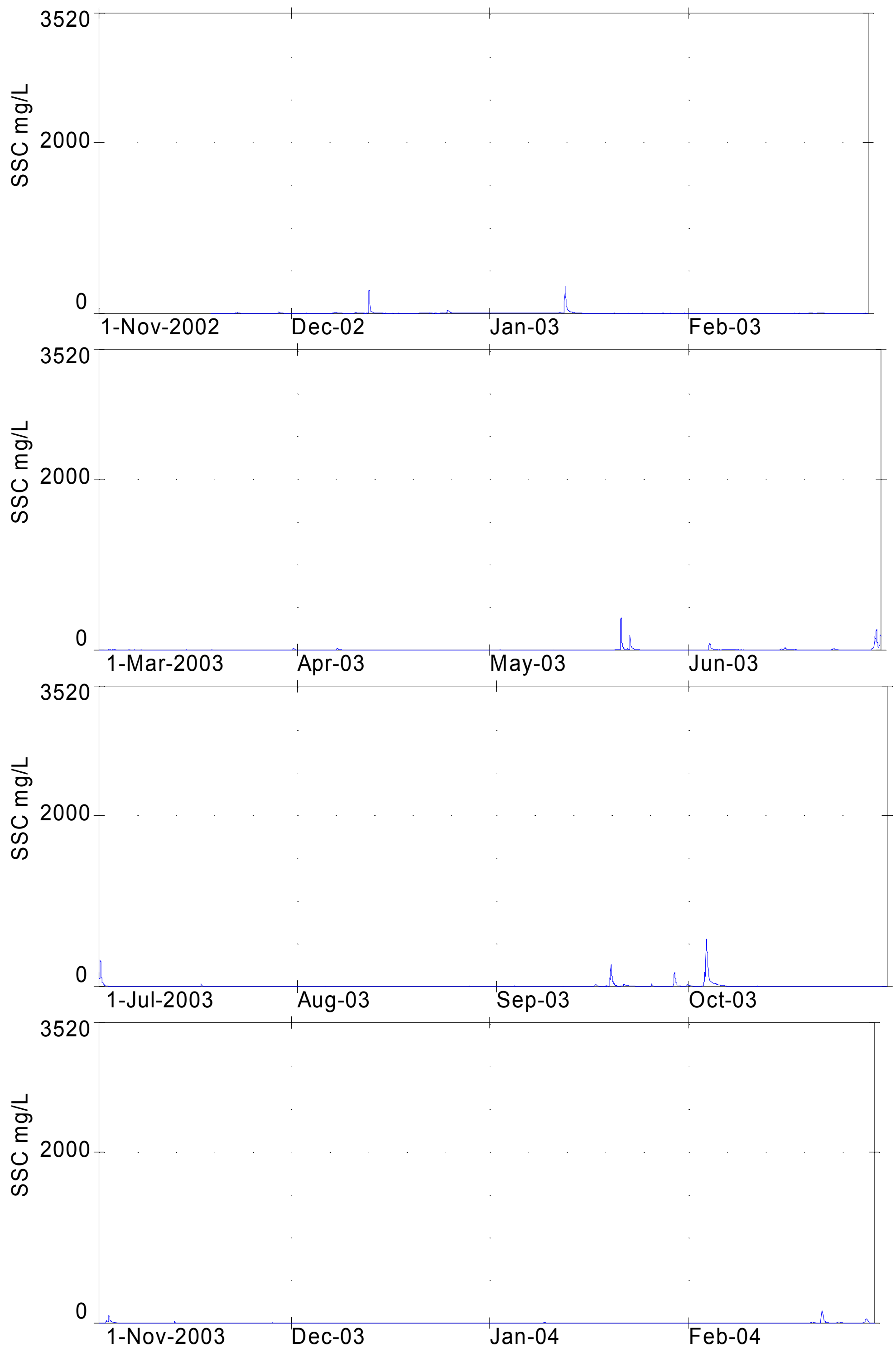


Figure A8.7: Derived suspended sediment concentration (SSC, mg/L) record, 1 November 2002 to 1 March 2004 at Motupiko at Christie's Bridge.

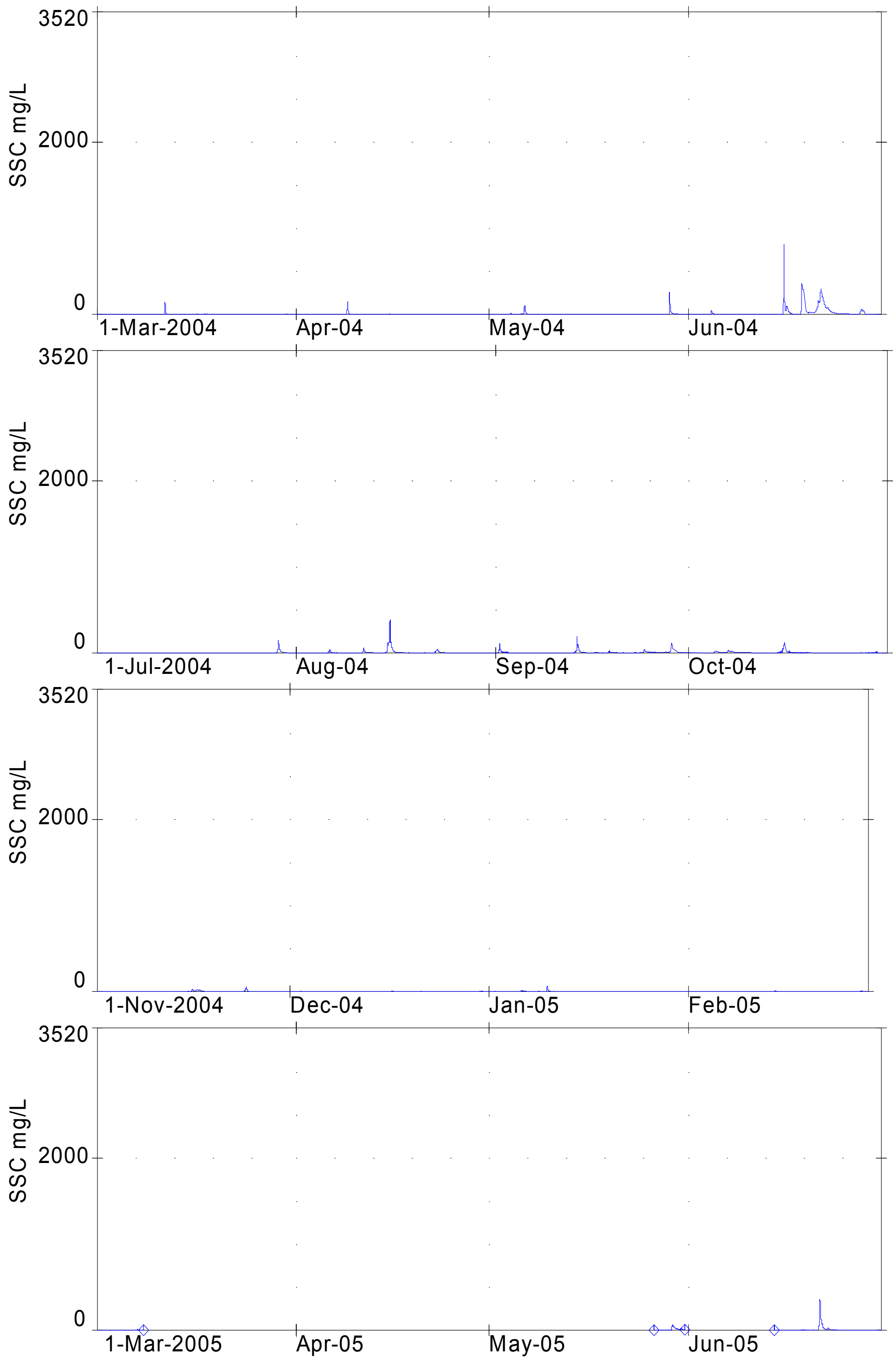


Figure A8.8: Derived suspended sediment concentration (SSC, mg/L) record, 1 March 2004 to 1 July 2005 at Motupiko at Christie's Bridge.

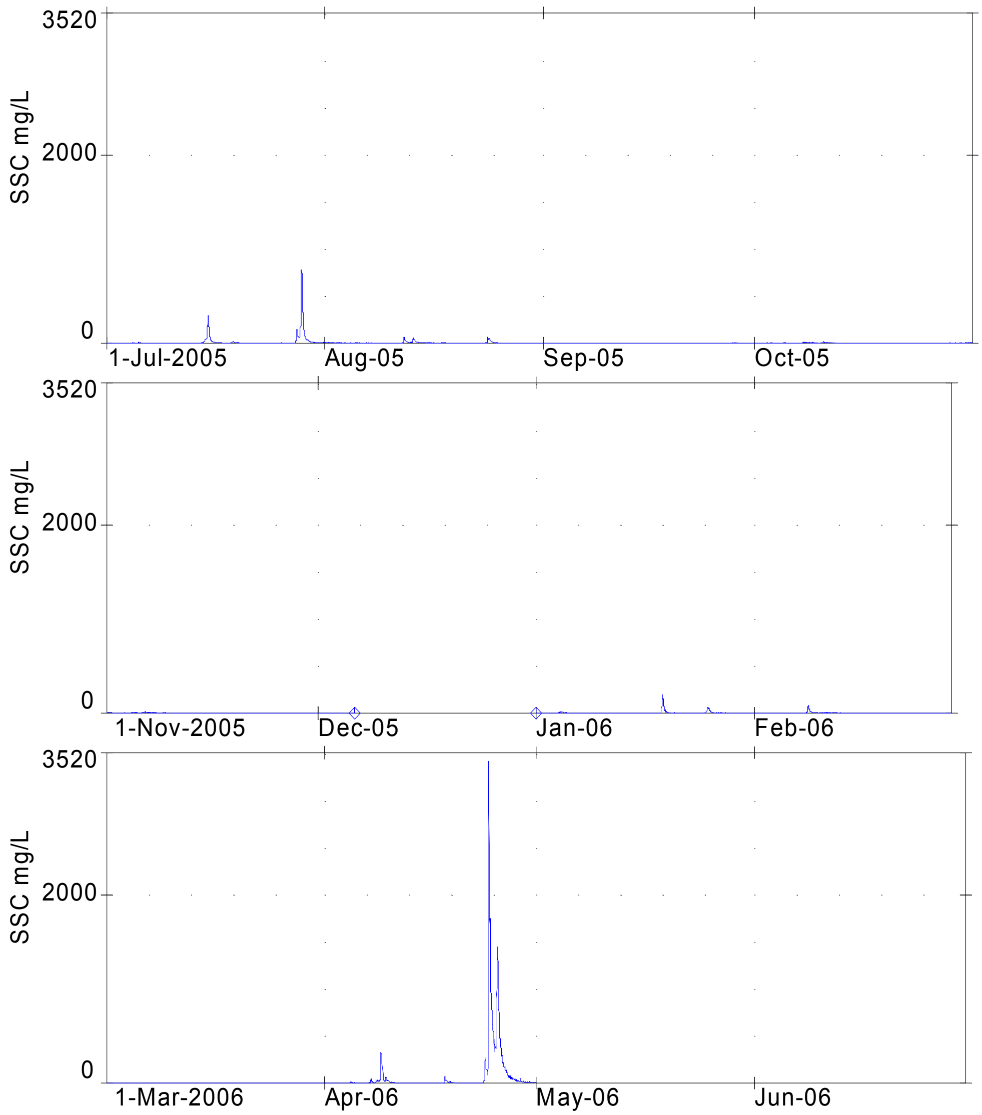


Figure A8.9: Derived suspended sediment concentration (SSC, mg/L) record, 1 July 2005 to 1 May 2006 at Motupiko at Christie's Bridge.

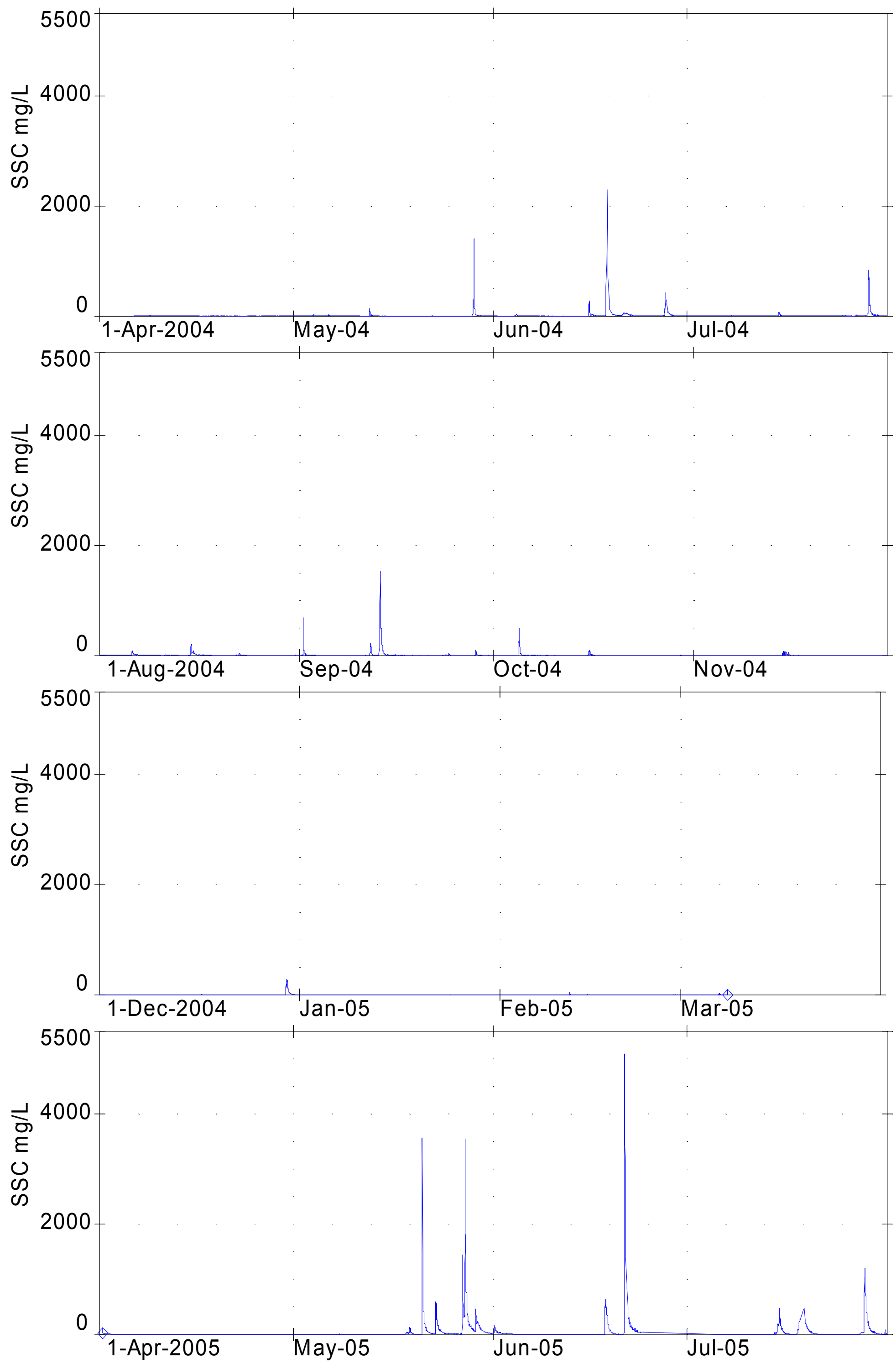


Figure A8.10: Derived suspended sediment concentration (SSC, mg/L) record, 1 April 2004 to 1 August 2005 at Motueka at Gorge.

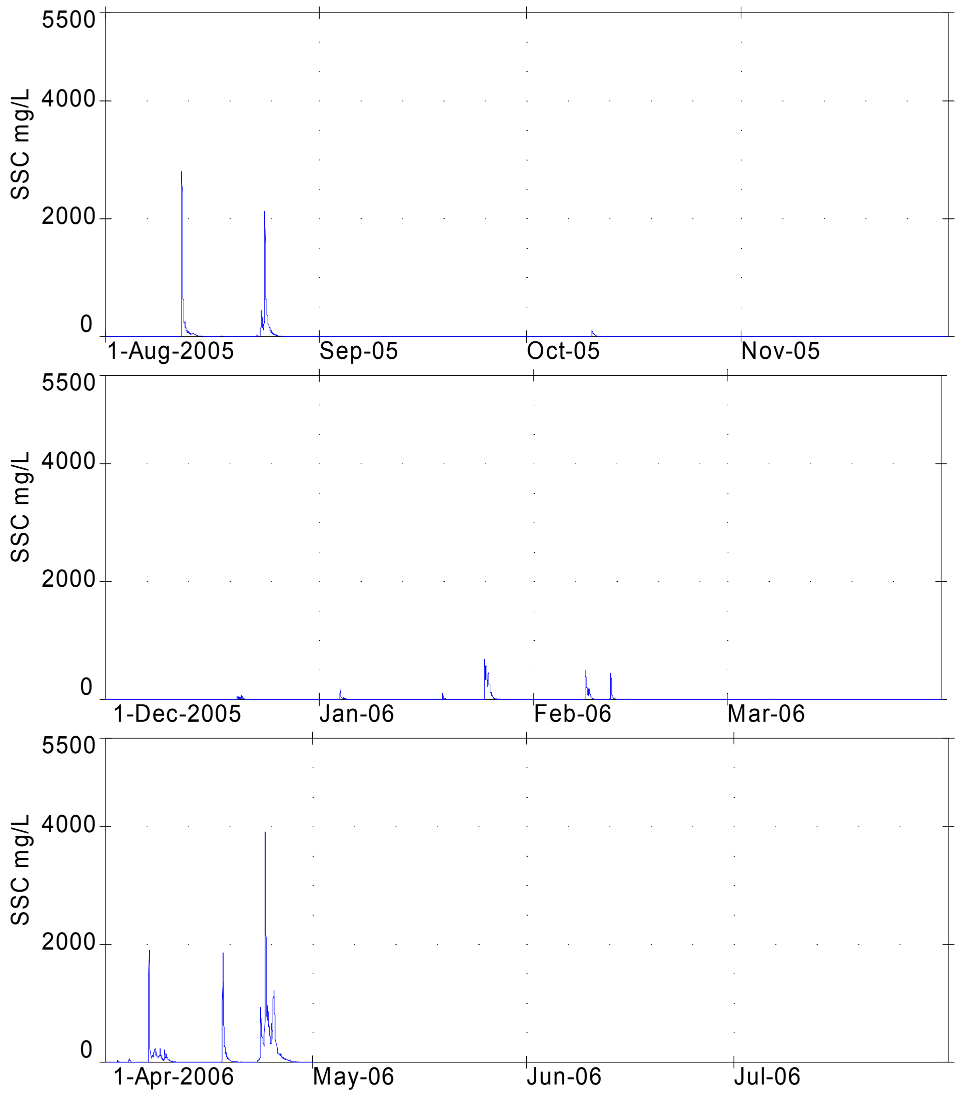


Figure A8.11: Derived suspended sediment concentration (SSC, mg/L) record, 1 August 2006 to 1 May 2006 at Motueka at Gorge.