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Forsmark site investigation

Manual discharge measurements in brooks, April 2002–April 2005

Per-Olof Johansson, Artesia Grundvattenkonsult AB

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Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

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Keywords: Brooks, Discharge measurements, Manual, Float, AP PF 400-02-07, AP PF 400-03-36, AP PF 400-03-66.

Summary

Manual discharge measurements have been performed in brooks at eight locations, starting in 2002. The measurements were performed 1–5 times per month, except for periods when the brooks were dry, covered with ice, or the flow was too small to allow for measurements.

The manual discharge measurements were started to get rough information on the discharge in the brooks at the surface water sampling points waiting for the installation of permanent automatic gauging stations.

The manual discharge measurements were performed by the float method. The equipment used was a float, a stop watch and a measuring tape. A 150 mL plastic bottle, filled to 2/3 by water, was used as a float.

The discharge measurements at the measuring points east of Lake Gunnarsboträsket, at the inlet to Lake Bolundsfjärden, in the brook from Lake Gällsboträsket and at the outlet of Lake Eckarfjärden are considered to give a good indication of the variations in the discharge. However, the comparison of the manual measurements and the automatic discharge measurements by long-throated flumes at the same locations clearly indicates that the manual measurements heavily overestimate the actual discharge, usually by more than a factor two. This means that the manual discharge measurements should not be used, even as a rough estimate of the discharge, without corrections.

For the measuring points where long-throated flumes have been installed, regression analysis of data from overlapping time periods can be used for correction of the manual measurements. It is recommended that additional manual measurements are performed at these points to get a better basis for the regression analysis.

At one measuring point, at the outlet of Lake Bolundsfjärden, by-pass flow at high discharges were observed. In the brook south of the Eckarfjärden point it was not possible to perform any measurements, while only single measurements were possible at the outlet of Lake Fiskarfjärden and south of Lake Bredviken.

Sammanfattning

Manuella flödesmätningar har utförts i åtta bäckar med start under 2002. Mätningarna har gjorts 1–5 gånger per år utom under perioder då bäckarna har varit torra, istäckta eller mätningarna omöjliggjorts av för låga flöden.

De manuella flödesmätningarna startades för att erhålla ungefärliga flödesvärden från bäckarna i de punkter där vattenprover för kemiska analyser togs i avvaktan på installation av permanenta, automatiska mätstationer.

Mätningarna har gjorts med hjälp av en flytkropp, ett tidtagarur och ett måttband. En 150 mL plastflaska, till 2/3 fylld med vatten, användes som flytkropp.

Mätningarna i bäckarna öster om Gunnarsboträsket, vid inflödet till Bolundsfjärden, i bäcken från Gällsboträsket och i utflödet från Eckarfjärden bedöms ge en god bild av flödesvariationerna. En jämförelse mellan de manuella mätningarna och mätningarna i de installerade mätrännorna indikerar emellertid att flödena överskattas grovt vid de manuella mätningarna, vanligen med mer än en faktor två. Detta betyder att de manuella mätningarna inte kan användas, ens som grova uppskattning av flödena, utan att korrigeras.

I de mätpunkter där mätrännor har installerats kan regressionsanalys med hjälp av data från överlappande mätperioder användas för korrektion av de manuella mätningarna. Det rekommenderas att ytterligare manuella mätningar utförs i dessa mätpunkter för att få ett bättre underlag för regressionsanalysen.

I en av mätpunkterna, i utflödet från Bolundsfjärden, observerades ett läckage förbi mätstället vid höga flöden. I bäcken söder om Eckarfjärden har inga mätningar kunnat utföras, medan endast ett fåtal mätningar har varit möjliga i utflödet från Fiskarfjärden och söder om Bredviken.

Contents

1 Introduction

This document reports the results gained by manual discharge measurements in brooks, which is one of the activities performed within the site investigation at Forsmark. In Table 1-1 the SKB internal controlling documents for performing this activity are listed.

Manual discharge measurements have been performed in the brooks at eight locations starting in 2002 in connection with surface water sampling (approximately 20 times/year). Since July 2003 additional discharge measurements have been performed at these locations to obtain weekly manual measurements until the start of the continuous measurements at the four permanent gauging stations in December 2004 /see Johansson, 2005/ for location and design of the automatic permanent discharge gauging stations). The results from the manual discharge measurement connected to the surface water sampling for the period March 2002 to March 2004 have been earlier reported in /Nilsson et al. 2003; Nilsson and Borgiel, 2004/.

The locations of the measurement points are shown in Figure 1-1 and in Table 1-2. The manual discharge measurements were performed 1–5 times per month, except for periods when the brooks were dry, covered with ice, or the flow was too small to allow for measurements.

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Ytvattenprovtagningar 2002	AP PF 400-02-07	1.0
Ytvattenprovtagningar 2003	AP PF 400-03-36	1.0
Enkla flödesmätningar I vattendrag	AP PF 400-03-66	1.0

Table 1-2. Coordinates for the brook discharge measurements (RT90 2.5 gon W 0:–15).

Idcode	Northing	Easting
PFM000066	6699064	1629343
PFM000067	6699753	1631859
PFM000068	6698735	1631641
PFM000069	6698440	1631510
PFM000070	6697319	1632061
PFM000071	6696533	1631944
PFM000072	6696708	1634151
PFM000073	6698073	1635004

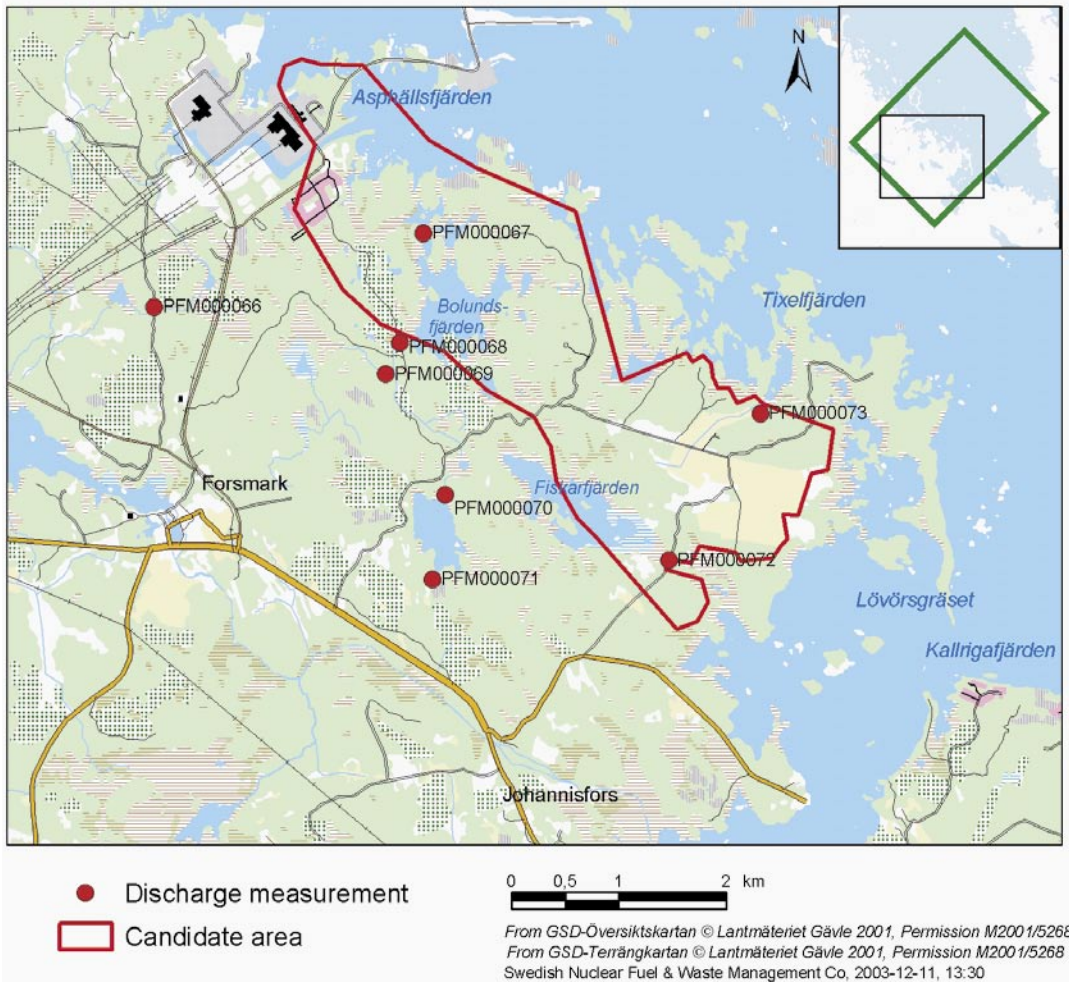


Figure 1-1. *Locations for manual discharge measurements.*

2 Objective and scope

The manual discharge measurements were started to get rough information on the discharge in the brooks at the surface water sampling points waiting for the installation of permanent automatic gauging stations. The objective of these measurements was to enable the inclusion of discharge as a factor in the analysis of the chemical data time series and to provide a basis for rough mass balance calculations. Initially, these measurements were carried out approximately 20 times/year in connection with the water sampling. Due to a delay of the installation of the four automatic gauging stations it was decided to perform weekly manual discharge measurements from July 2003 until the start of the automatic measurements to get better information on the discharge and its variation.

3 Equipment and execution

The discharge measurements were performed by the float method. The equipment used was a float, a stop watch and a measuring tape. A 150 mL plastic bottle, filled to 2/3 by water, was used as a float. The time (T) required for the bottle to float a known distance (L) between two points in the water course was measured, see Figure 3-1. This procedure was repeated 5 times, and the average value of T was calculated. Based on the average width (W) and depth (D) of the brook over the measured distance, the discharge Q was estimated as

$$Q = \frac{L \times W \times D}{T}$$

where all parameters except L are average values.

The measurements were performed in accordance with activity plans AP PF 400-02-07, AP PF 400-03-36, AP PF 400-03-66 and Method description MD 364.008 (SKB internal controlling documents).

At most of the measurement points, measurements were impossible for extensive periods because the brooks were dry, covered by ice, or the flow was too small to allow for measurements.

The field data were stored in Excel worksheets where the discharge values were calculated. The calculated discharge values were delivered to and stored in SKB's SICADA database where the data are traceable by the number of the activity plan.

Figure 3-1. *Schematic illustration of the float method used for the manual discharge measurements (PFM000073 South of Bredviken) /From Nilsson et al. 2003/.*

4 Results

Location, catchment area, measurement period and number of measurements for the presented manual discharge measurements are summarized in Table 4-1.

A map of the catchment areas and graphs of the time series for all measurement stations, except for PFM000071 where no measurements could be performed, are presented in Figure 4-1 and Appendix 1, respectively.

Discharge measurements were mostly possible at PFM000066–PFM000070. However, at PFM000067 it was observed that a significant by-pass flow occurred when the discharge was large. With some exceptions, the measured discharge was zero or too low to allow for measurements at the stations PFM000071–73 (at PFM000071 no measurements could be performed). The lowest recorded non-zero discharges varied widely between the stations due to the type of cross-section; from 0.9 L/s at PFM000069 to 89 L/s at PFM000073. Sometimes also the wind made measurements impossible.

For three of the measuring points with manual measurements, PFM000066, PFM000068 and PFM000070, overlapping automatic discharge measurements by long-throated flumes exist from the same locations; PFM002669 (Dec 2004–May 2005), PFM005764 (May 2004–May 2005) and PFM002668 (Dec 2004–May 2005), respectively. From these measurements it is obvious that the manual measurements heavily overestimate the discharge. In Figure 4-2 linear regressions are shown for the manual and automatic discharge measurements for these three stations. For PFM000066 and PFM000070 only four manual discharge measurements were available, while 13 manual measurements were available for PFM000068.

Table 4-1. Summary of the manual discharge measurements.

Id code	Location	Catchment area (km^2)	Measurement period (YYYY-MM-DD)	Number of measurements
PFM000066	East of Gunnarsboträsket	2.83	2002-04-15 – 2005-05-09	60
PFM000067	Lillputtsundet	8.00	2002-11-26 – 2004-11-02	48
PFM000068	Kungsträsket	5.59	2002-04-15 – 2005-05-09	54
PFM000069	Bolundsskogen	3.00	2002-04-17 – 2005-05-09	65
PFM000070	North of Eckarfjärden	1.30	2002-04-02 – 2005-05-10	53
PFM000071	South of Eckarfjärden	–*	2002-04-16 – 2004-11-02	33
PFM000072	Flottbron	2.93	2002-04-15 – 2004-11-02	31
PFM000073	South of Bredviken	0.63	2002-04-15 – 2004-11-02	39

* The catchment area was not determined since no discharge measurements could be performed.

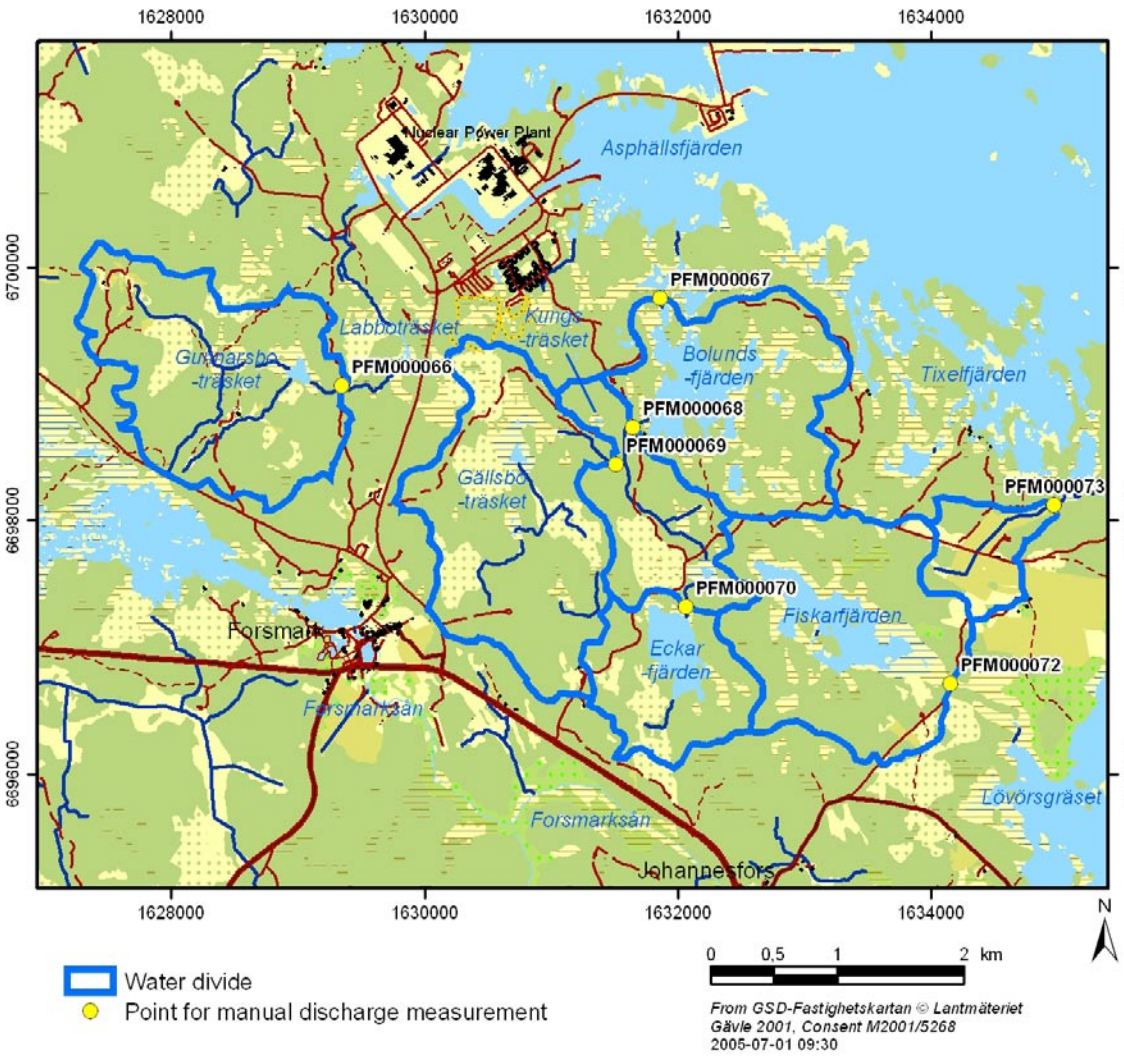
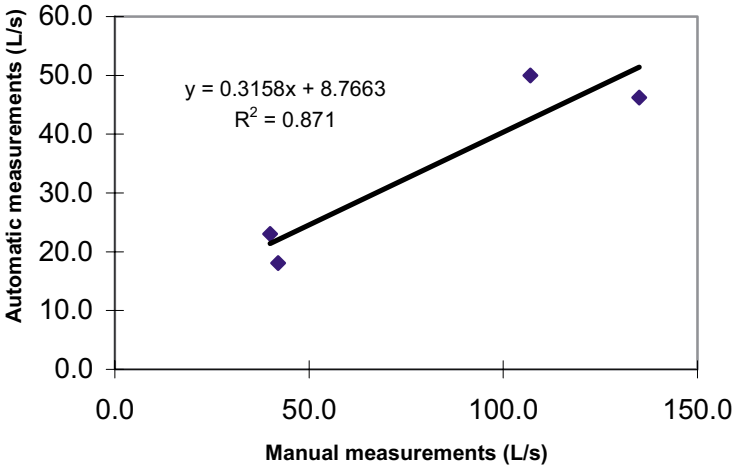
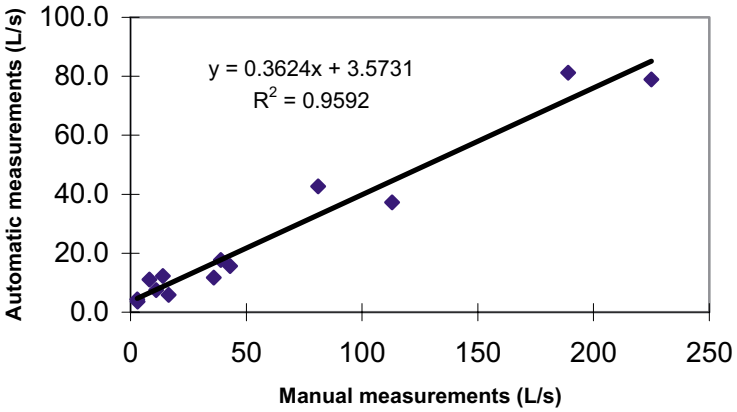


Figure 4-1. *Catchment areas for the manual discharge measurement points. (PFM000071 excluded since no measurements could be carried out).*





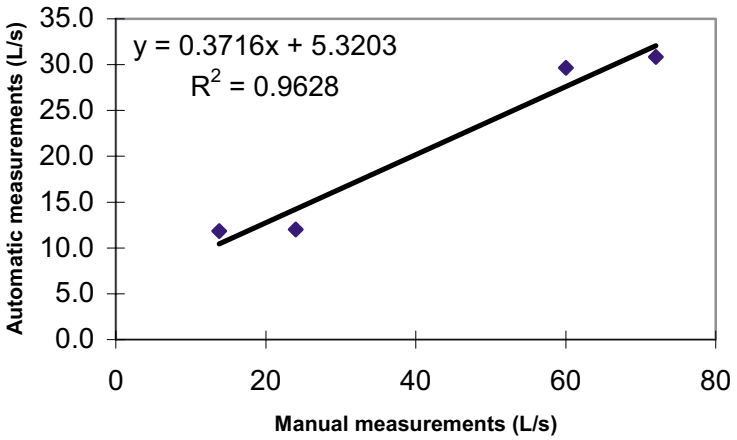


Figure 4-2. *Comparison of manual and automatic discharge measurements at the same locations: top) PFM000066 and PFM002669, middle) PFM000068 and PFM005764, and bottom) PFM000070 and PFM002668.*

The largest recorded manual discharge during the period March 2002–October 2004 was 283 L/s at PFM000068 (May 5, 2003). According to the linear regression with the automatic measurements, this corresponds to an actual discharge of 106 L/s. In Figure 4-3 a comparison is shown between manually measured values and the corresponding values obtained from the linear regression. It should be emphasised that the measurements are sparse, and that even larger discharges likely would have been observed if more measurements had been performed. In the figure, data points are connected with a solid line if the time period between consecutive measurements is 14 days or less.

If the total runoff is calculated by creating a continuous time series by linear interpolation between consecutive measurements, average discharges of 83 and 30 l/s are obtained for the two hydrological years of Sep 2002–Aug 2004 from the actually measured values and the values from the linear regression, respectively. The value of 30 l/s for the 5.6 km^2 large catchment area of PFM000068, corresponding to a specific discharge of approximately 5.5 L/s/km^2, is in relative good agreement with the long-term mean specific discharge of 6.5 L/s/km^2 estimated from regional data. The somewhat low value may be explained by the obvious risk for missing peak discharges due to the relatively long interval between the measurements.

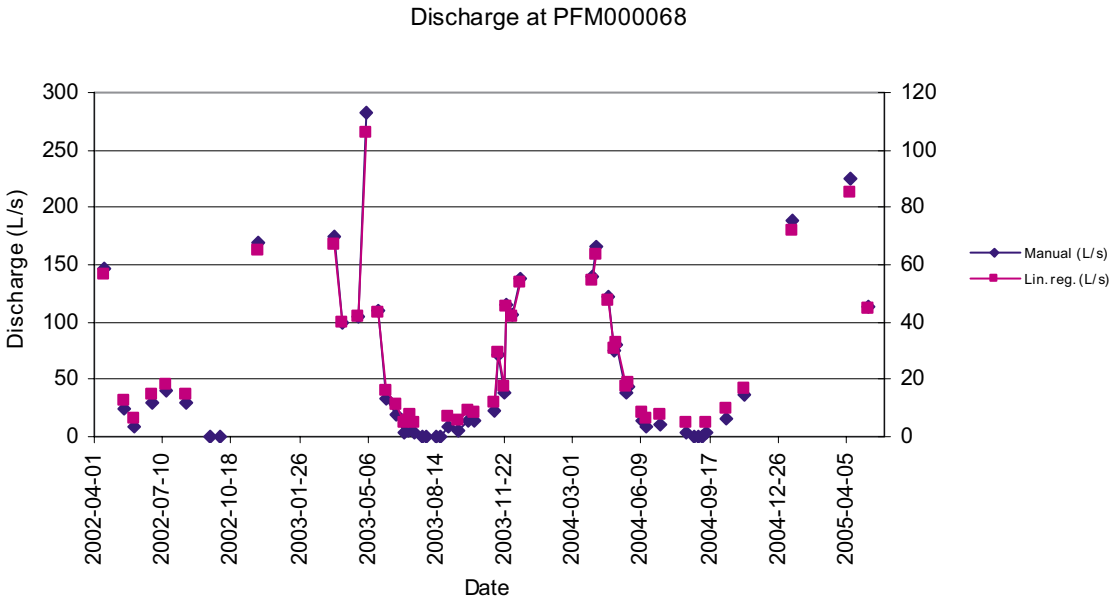


Figure 4-3. *Results from the manual discharge measurements (left vertical axis) at PFM000068 compared with the corresponding discharge obtained from the linear regression with the automatic measurements (right vertical axis).*

5 Discussion and conclusion

The manual discharge measurement at PFM000066 and PFM000068–PFM000070 are considered to give a good indication of the variations in the discharge. However, the comparison of the manual measurements and automatic discharge measurements by long-throated flumes at the same locations clearly indicates that the manual measurements heavily overestimate the actual discharge, usually by more than a factor two. This means that the manual discharge measurements should not be used, even as a rough estimate of the discharge, without corrections.

For the measuring points where long-throated flumes have been installed, regression analysis of data from overlapping time periods can be used for correction of the manual measurements. It is recommended that additional manual measurements are performed at these points, especially for PFM000066 and PFM000070, to get a better basis for the regression analysis.

At PFM000067 by-pass flow at high discharges were observed. At PFM000071 it was not possible to perform any measurements, while only single measurements were possible at PFM000072 and PFM000073.

References

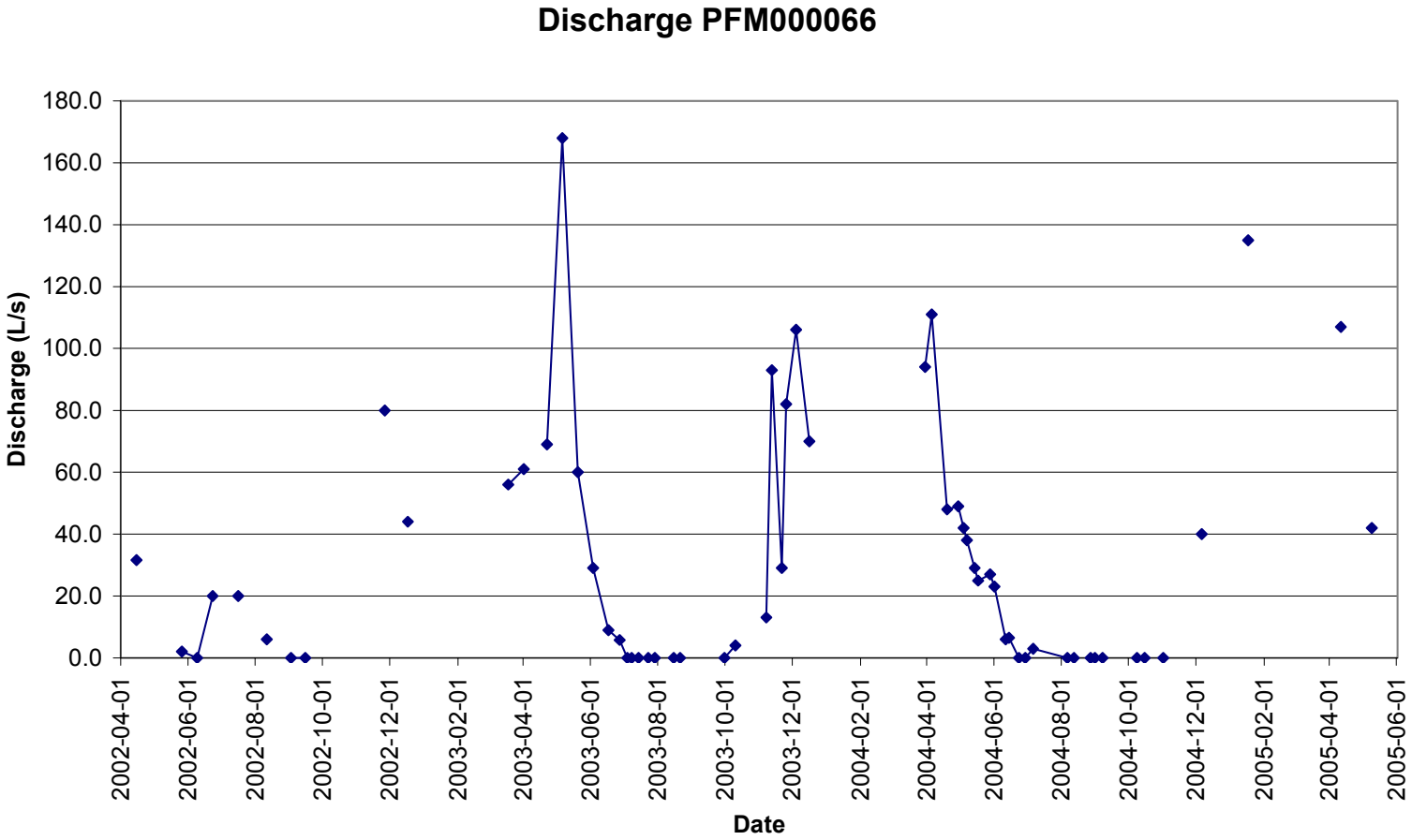
Nilsson A-C, Karlsson S, Borgiel M, 2003. Forsmark site investigation. Sampling and analyses of surface waters. Results from sampling in the Forsmark area, March 2002 to March 2003. SKB P-03-27. Svensk Kärnbränslehantering AB.

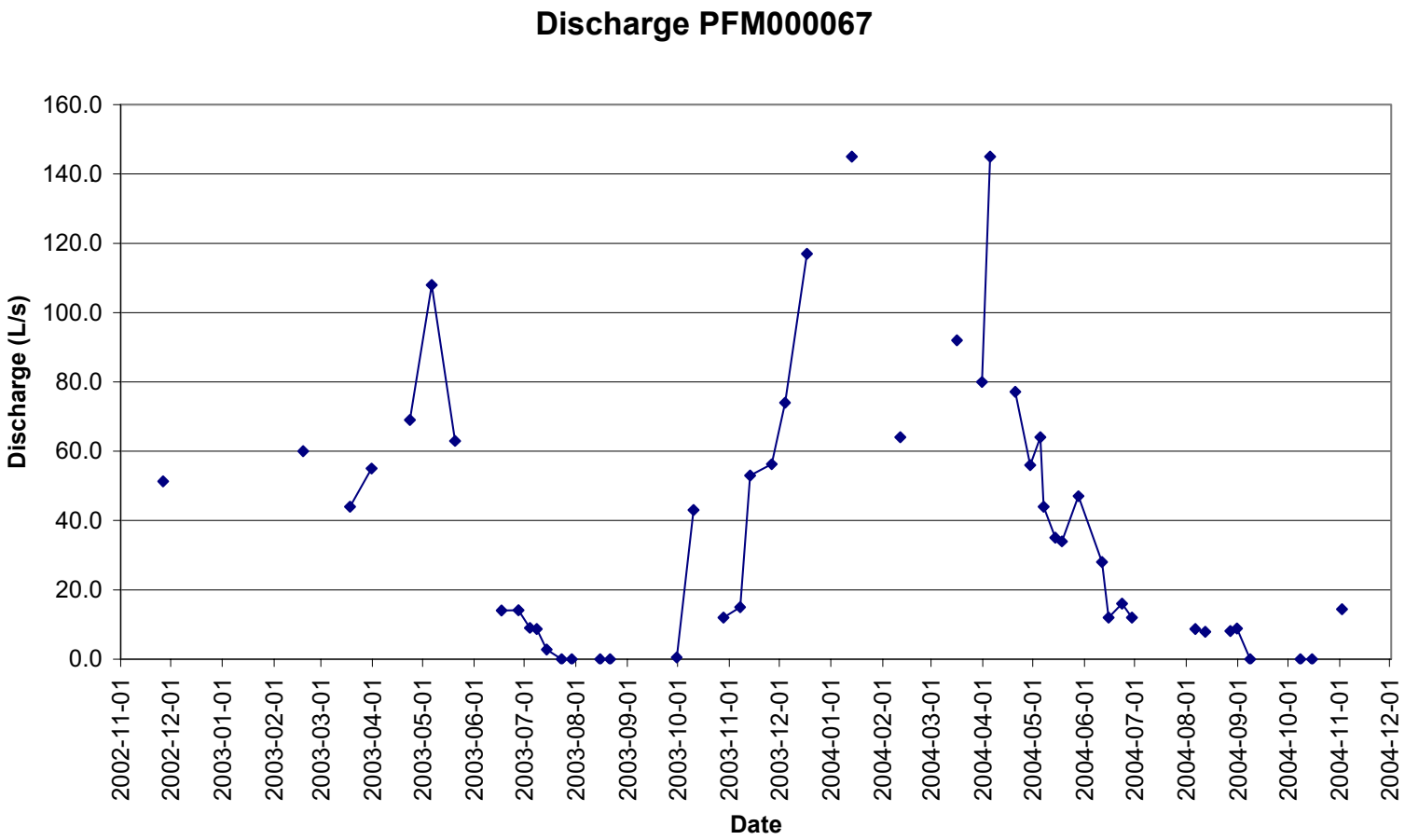
Nilsson A-C, Borgiel M, 2004. Forsmark site investigation. Sampling and analyses of surface waters. Results from sampling in the Forsmark area, March 2003 to March 2004. SKB P-04-146. Svensk Kärnbränslehantering AB.

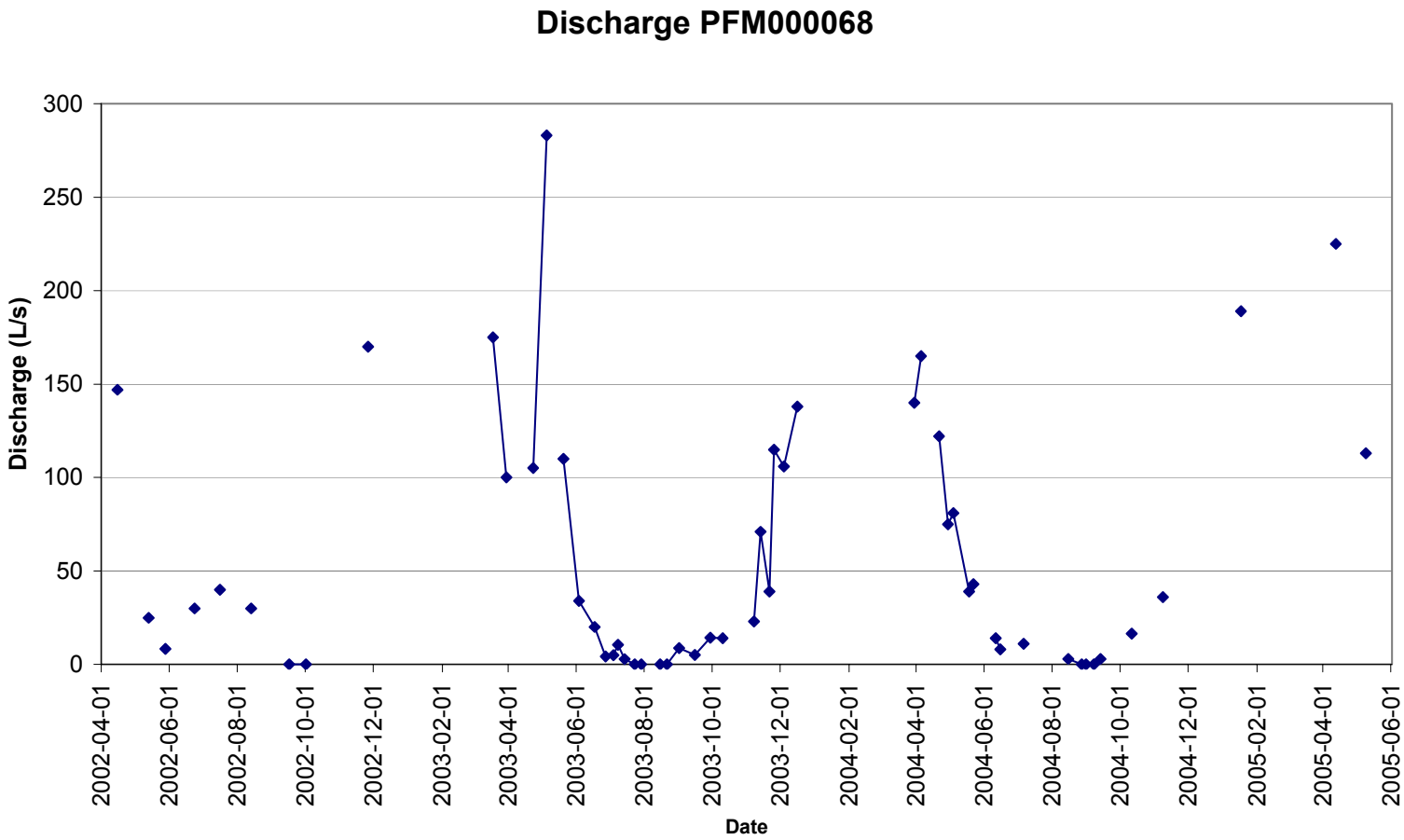
Johansson P-O, 2005. Forsmark site investigation. Installation of brook discharge gauging stations. SKB P-05-154. Svensk Kärnbränslehantering AB.

Time series from the manual discharge measurement points

(data points are connected with a solid line if the time period between consecutive measurements is 14 days or less)




Discharge PFM000067
Discharge (L/s)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2002-11-01
2002-12-01
2003-01-01
2003-02-01
2003-03-01
2003-04-01
2003-05-01
2003-06-01
2003-07-01
2003-08-01
2003-09-01
2003-10-01
2003-11-01
2003-12-01
2004-01-01
2004-02-01
2004-03-01
2004-04-01
2004-05-01
2004-06-01
2004-07-01
2004-08-01
2004-09-01
2004-10-01
2004-11-01
2004-12-01
Date


Discharge PFM000068
Discharge (L/s)
300
250
200
150
100
50
0
2002-04-01
2002-06-01
2002-08-01
2002-10-01
2002-12-01
2003-02-01
2003-04-01
2003-06-01
2003-08-01
2003-10-01
2003-12-01
2004-02-01
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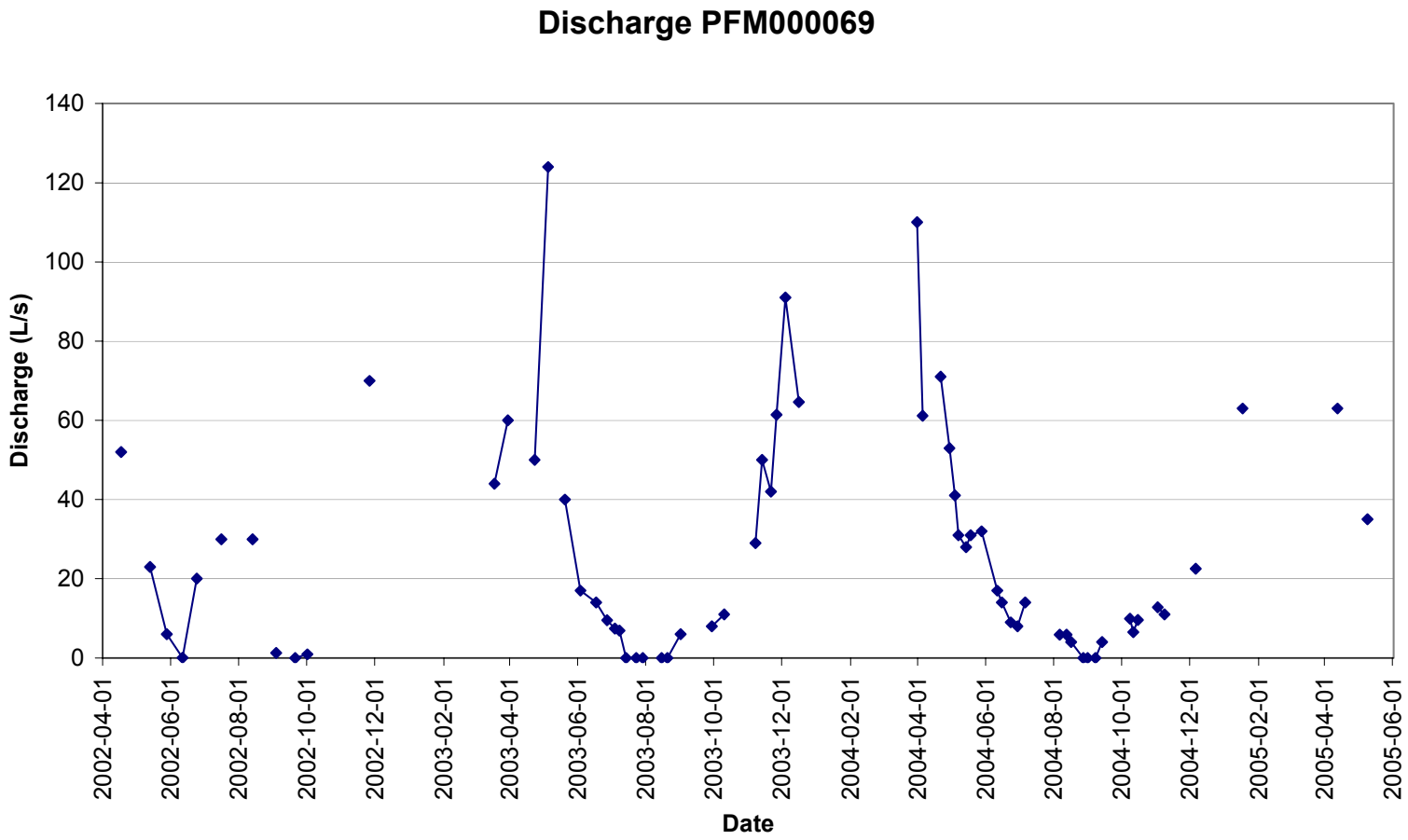
2005-02-01
2005-04-01
2005-06-01
Date


Discharge PFM000069
Discharge (L/s)
140
120
100
80
60
40
20
0
2002-04-01
2002-06-01
2002-08-01
2002-10-01
2002-12-01
2003-02-01
2003-04-01
2003-06-01
2003-08-01
2003-10-01
2003-12-01
2004-02-01
2004-04-01
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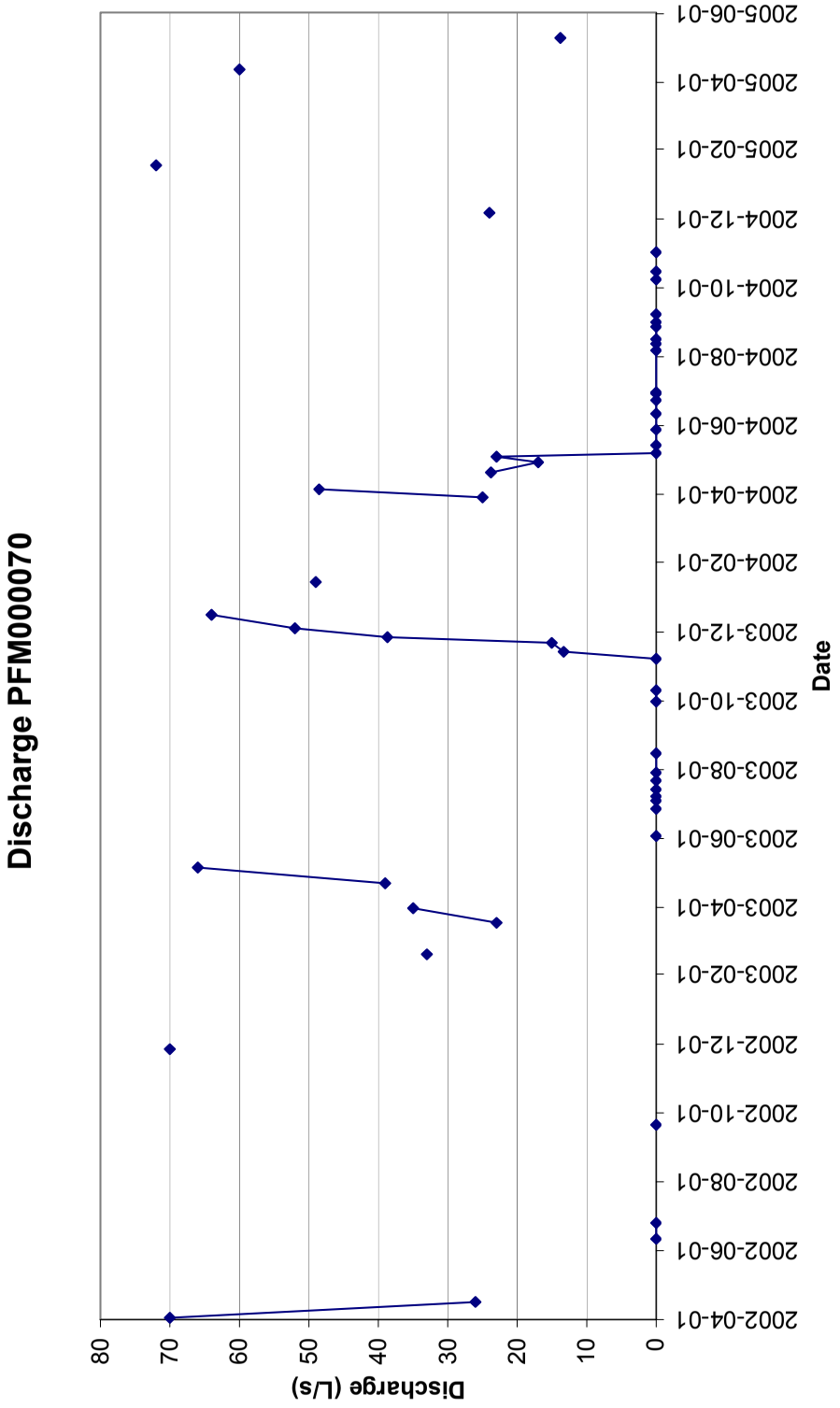
2004-08-01
2004-10-01
2004-12-01
2005-02-01
2005-04-01
2005-06-01
Date


Discharge PFM000070
Discharge (L/s)
0
10
20
30
40
50
60
70
80
Date
2002-04-01
2002-06-01
2002-08-01
2002-10-01
2002-12-01
2003-02-01
2003-04-01
2003-06-01
2003-08-01
2003-10-01
2003-12-01
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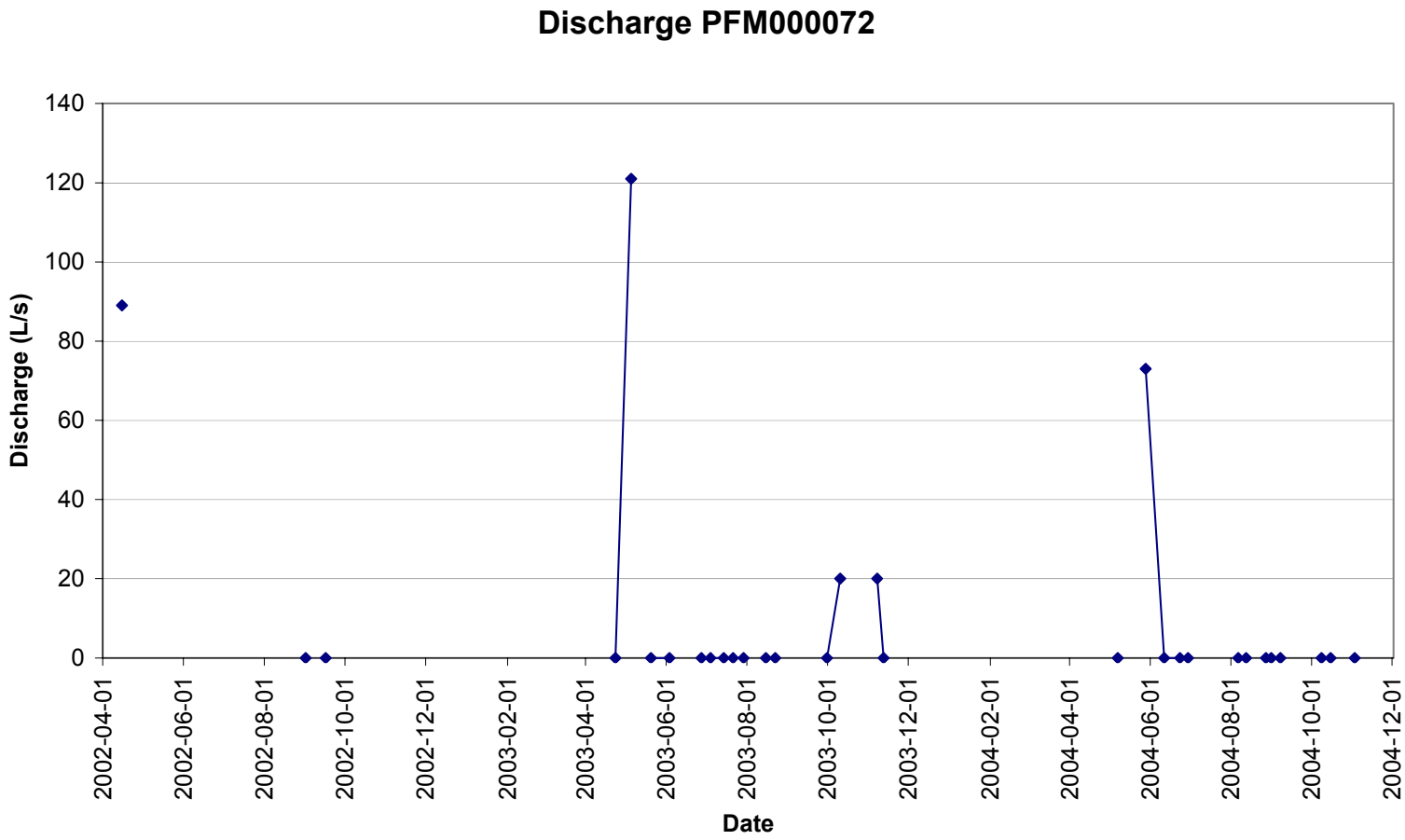
2004-12-01
2005-02-01
2005-04-01
2005-06-01


Discharge PFM000072
Discharge (L/s)
140
120
100
80
60
40
20
0
2002-04-01
2002-06-01
2002-08-01
2002-10-01
2002-12-01
2003-02-01
2003-04-01
2003-06-01
2003-08-01
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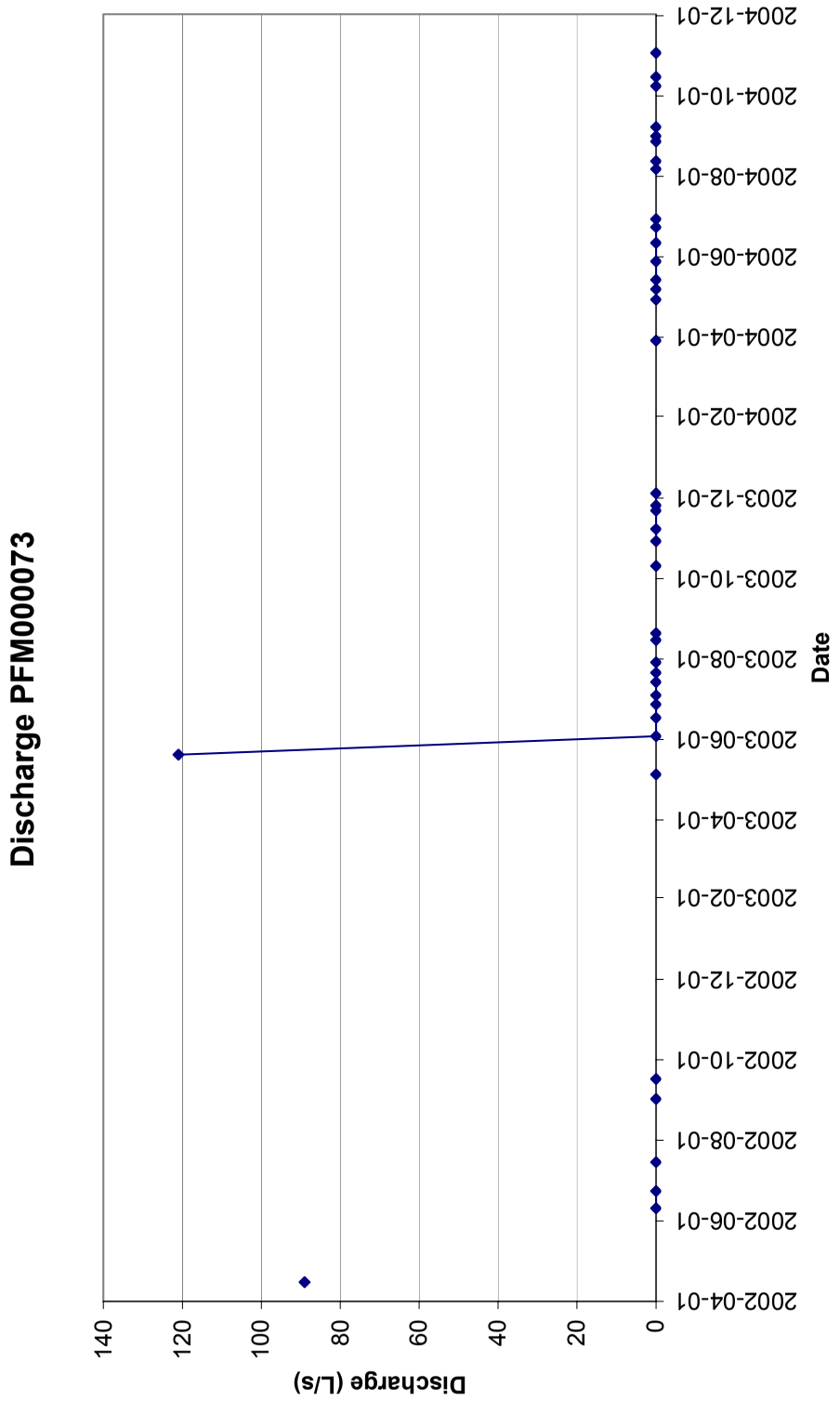
2004-12-01
Date


Discharge PFM000073
Discharge (L/s)
0
20
40
60
80
100
120
140
Date
2002-04-01
2002-06-01
2002-08-01
2002-10-01
2002-12-01
2003-02-01
2003-04-01
2003-06-01
2003-08-01
2003-10-01
2003-12-01
2004-02-01
2004-04-01
2004-06-01
2004-08-01
2004-10-01
2004-12-01