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MEMORANDUM

Date: 24 March 2021

To: Jon Bell & Ella Whale

Of: Horizons Regional Council

SUBJECT: **OHAU RIVER – GRAVEL RESOURCE – REVIEW**

PAGES 1 + 3 + 5 Figures

Introduction

The gravel resources and gravel extraction activities along the lower plains reaches of the Ohau River have been re-assessed, with the most recent survey of the river cross-sections being undertaken in 2018.

In 2008 a scheme review was undertaken, which included investigations of channel capacity and river channel behaviour, channel and stopbank alignment, the effects of gravel extraction, and measures that could reduce the deposition of gravel and silt materials. As part of these investigations, a hydraulic model of the scheme reach was set up, and the capacity effects of channel changes and stopbank raising were investigated. A full re-survey of the river cross-sections was carried out in 2006/2007, and the changes in mean bed levels and bed material volumes were calculated for the inter-survey differences of the 1971, 1994/1995 and 2006/2007 surveys.

This study builds on these earlier investigations, using repeat cross-section surveys of 2011 and 2018. The comparison between the surveys concentrates on the reach from upstream of the river mouth (XS 15) to just upstream of Muhunoa Road Bridge (XS 60). Gravel bed material has been extracted upstream of this reach, however, there is not the repeat survey data to make any volume change comparisons.

The channel management implications of channel changes over time and extraction rates and locations, has been considered, based on the survey comparisons and the general characteristics of the river reach, as outlined in the report on the 2008 investigations. Recommendations cover extraction activities and any implications for the channel alignment and cross-section shape.

Background

The surveyed cross-sections are at intervals along the river, and the surveys are infrequent, with time spans of 5 to 10 years apart. The river channel is relatively stable over most of its length to above the Muhunoa Road Bridge, but channel re-working and meander migration alters the active width at any particular (cross-section) location, and this affects the comparability of surveys.

The analysis of the survey data can be undertaken in different ways, depending on the aim and the variability of the river channel over time. The important area for gravel movement and extraction activities is the area where bed material transport takes place, and generally includes the low flow channel(s) and the clear bar or beach areas of gravel bed material. The area is then the active width of the surveyed cross-section.

The mean bed level of this active bed width is determined to look at changes over time in the actively worked area of sediment transport and extraction activities, in terms of section-by-section variations, and more importantly reach trends of bed aggradation or degradation.

Channel volume calculations that estimate volume changes along the river, based on cross-sectional area differences at the cross-sections and the length between sections, are undertaken to assess bed material transport effects, through erosion and deposition, taking into account bank erosion supply to the river as well as bed scouring. In this case wider limits are used at the cross-sections to cover bank erosion and beach deposition/widening, but excluding berm siltation or other variations.

Determining these volume estimates in a comparable way is more difficult, and different limits may have to be used for different surveys.

Where the channel is relatively stable and a common width can be applied across all surveys, then an end-area analysis can be used, where the difference in area across the defined width (of left and right bank limits) between surveys is used. Where there are significant channel shifts or changes in width at cross-sections, then a width-averaging method can be used. In this case, the varying widths are averaged to give a common width and then this width is multiplied by the difference in mean bed level (height) to give an area, which is then used with profile distances to give volume changes, as with the end-area method.

For the analysis in 2007, the width-averaging method was adopted after initial investigations, and applied to all cross-sections. This time a common width was applied to most cross-sections, and the end-area method used, but with the width-averaging approach taken at a few cross-sections where there were the most pronounced shifts in the active channel between surveys.

The width-averaging only gives changes in the bed from scour and deposition, and not additions from bank erosion or beach deposition that goes out of the active working area. Hence where limits can be applied to incorporate bank erosion while not including berm changes from siltation or other reasons (including surveying), the end-area approach is the better method.

Assessment

The Ohau River rises in the Tararua Range, and after leaving the ranges flows within a terraced valley before crossing a wide alluvial fan downstream of the State Highway and the Main Trunk Railway. The river must then bend around sand dunes and pass through a sequence of dunes to the sea. There is a change in the river grade at the State Highway, and then again where the river first bends around the sand dunes and has formed double S bends. At this major loss of grade the river naturally deposits its gravel bed load, as well as suspended material on the berm land between the stopbanks. There are significant gravel beaches at these bends, but downstream the gravel beaches soon peter out.

These changes in grade are shown on the longitudinal profile plot of the 2018 surveyed length of the river on Figure 1. The bed material of the river then tends to drop out as the grade, and hence carrying capacity of the river, decreases. The natural aggradation zones are, thus, downstream of the State Highway, and then again at and downstream of the Burnell-Cattey double S bends. Here the river crosses a relatively wide alluvial plain, and naturally would have flooded this plain with changes of course through channel migration and break-outs.

The more recent gravel extraction has been concentrated in this reach of the river, although earlier there was substantial extraction above the bridges. There has also been a move upstream, with substantial extraction in the upper reaches of the river, above the surveyed length of the river.

The changes in mean bed levels and bed material volumes have been calculated for the common widths most applicable to all surveys, and for the active width of the most recent 2018 survey. Using the 2018 widths gives an indication of changes in volumes of bed material over time within the active width of the present river position (or of the most recent survey).

The changes in volume at each cross section up to the Muhunoa Road Bridge are given in Figure 2 for the common width calculations, and in Figure 3 for the 2018 widths. The changes with both sets of bed limits are very much the same, indicating that the results are not that sensitive to the limits used.

Overall there has been an accumulation of bed material along the lower reaches, up to the Burnell-Catley bends, with the amount over the earlier period of comparison (of 12 years from 1994/1995 to 2006/2007) being less than over the later period (of 12 years from 2006/2007 to 2018). In the earlier period bed levels are maintained through the bends area, with some degradation at XSs 40 and 41, and thereafter some accumulation to above the bridges (to XS 50) and then some degradation again around XSs 57 to 59.

In the later period there is a more significant degradation trend above the bends, with some recovery upstream of the bridges, before there is a substantial and continuous degradational trend.

The overall trends are very similar with the 2018 limits, but with less accumulation below the bends and a more continuous degradation trend above the bends

Around XSs 48 to 50 there were significant changes in the location of the active bed, and around XSs 55 to 57 there was a lateral shift in the active channel.

The overall trends are shown graphically in the cumulative volume plots of Figures 4 and 5, where the cumulative change from section to section up the river are plotted.

These changes in the river channel are affected by changes in the channel level and shape through the actions of flood events and of river management measures. They are also affected by the direct removal of bed material, through gravel extraction activities.

The impact of extraction on the channel trends is shown graphically on Figure 6. The amounts of extraction, taken from extraction records for reaches of the river, have been spread along the record reaches, and a cumulative plot of extraction superimposed on the calculated channel changes from survey data. This extraction records has then been added to the channel change volumes, to indicate overall trends if the extraction had not taken place. This shows that there would have been a substantial amount of aggradation along the reach of the bends up to XS 41. Thereafter the trends remain nearly the same, as there had been minimal extraction up to XS 60 since the 1994/1995 survey.

The extraction totals (in m3) are given in Table 1 below.

EXTRACTION VOLUMES Table 1

PERIOD	SCHEME REACH (XS 15 to XS 60)	UPPER SURVEYED REACH (XS 61 to XS 75)	ABOVE SURVEY (Upstream of XS 75
1994/95 to 2006/07	131,000	59,000	44,000
2006/07 to 2018	187,000	36,000	93,000

The extraction above the survey reach, where the river channel is less confined immediately below the ranges, and with easy access from a road, has more than doubled over the two 12 year intervals of the surveys.

Conclusions

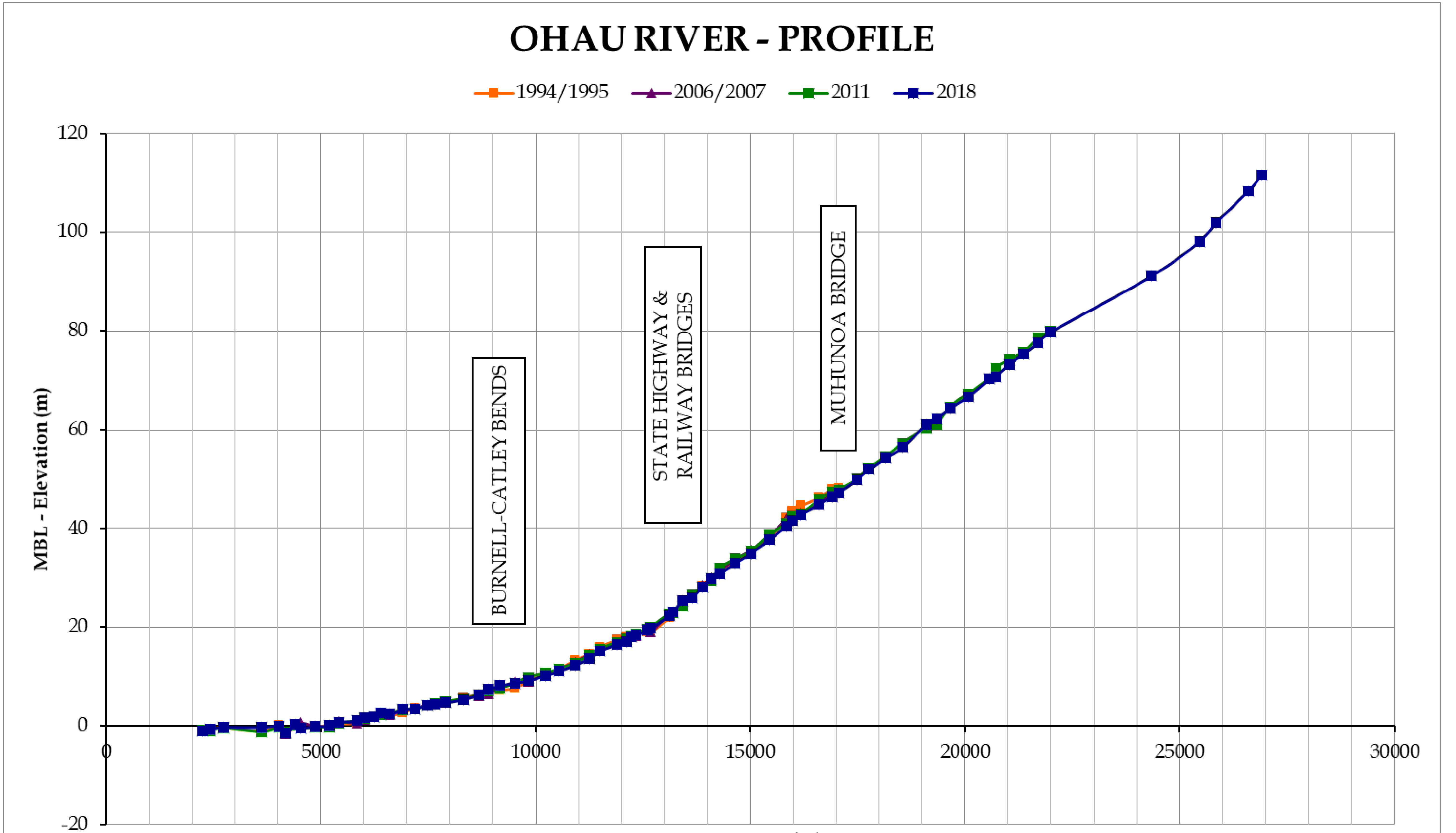
The river channel has been relatively stable along the scheme reach, up to XS 60. However, despite little extraction above the State Highway and Railway bridges the river bed has continued to degrade, with a consistent degradation trend along the reach from XS 48 to XS 60. The confinement of the river along this steeper reach of the river, due to past extraction, is continuing the channel degradation, with only minor further extraction.

Between the 2011 and 2018 surveys that cover the reach above the Muhunoa Road Bridge, there has been a mix of deposition and scouring at the cross-sections, with some significant degradation upstream of Kimberley Reserve. There is no survey information along the uppermost extraction area, but bed degradation is likely to be occurring because of the extraction.

The extraction below the bridges down to the Burnell-Cattey bends can continue at around the same rate, or a little less, to maintain flood capacity without generating channel degradation. The extraction should be carried out on the existing beaches, while maintaining the overall shape of the beach, with a higher central area that slopes down to the edge of the low flow channel. This is the approach recommended in the previous 2008 review. An annual extraction rate for this reach would then be around 10,000 m3.

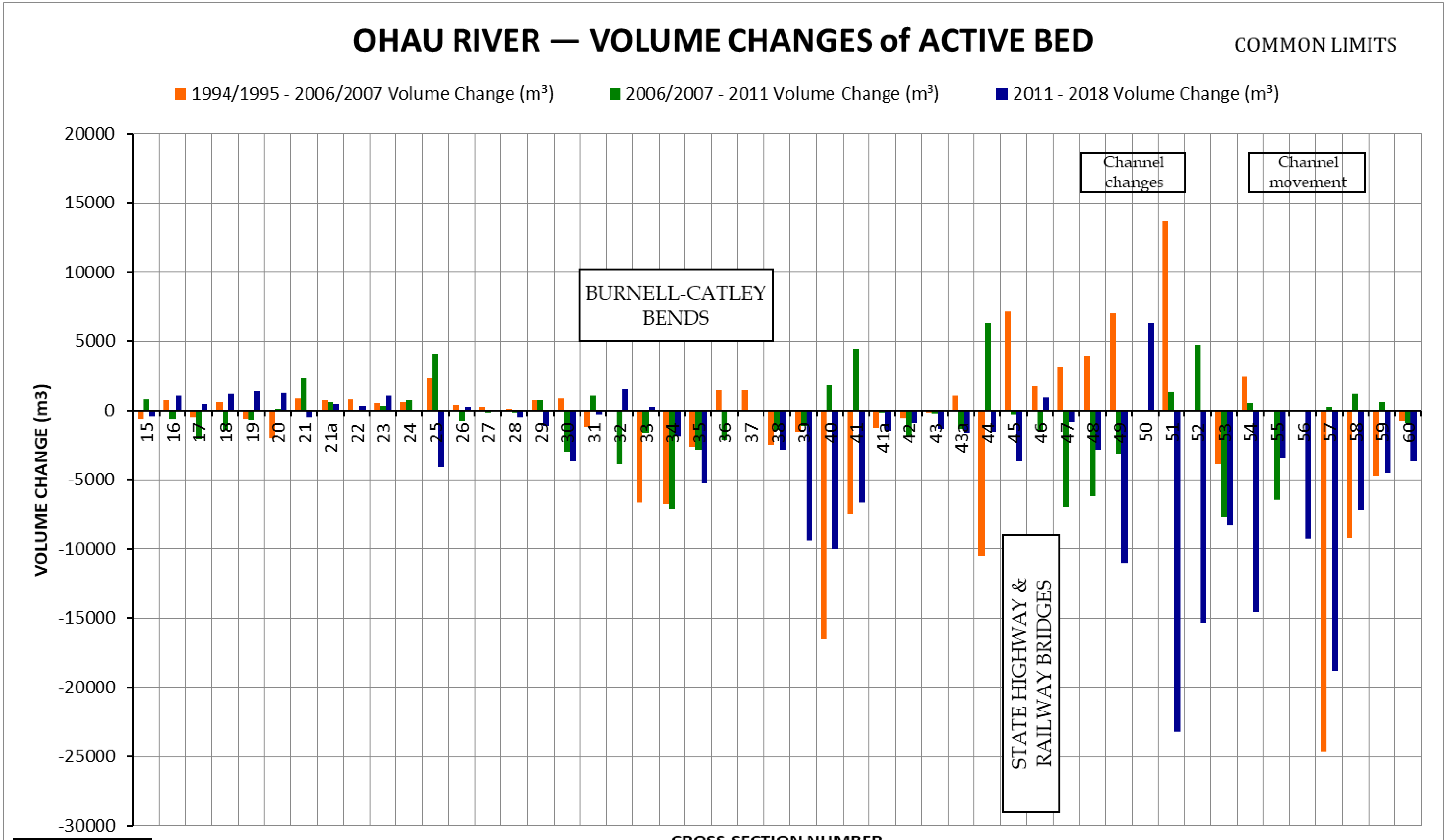
Extraction upstream of the bridges should not be undertaken within the active channel area, as this will add to the degradational trend along the terraced reaches of the river above the bridges. Any extraction should be of gravel deposits that have become redundant in terms of sediment transport, and unlikely to be re-worked in the longer term. This could include some high beach areas on the inside of tight bends, where there is channel splitting and aggrading side channels, as well as extraction for river management purposes where this will assist other management measures.

Gary Williams



OHAU RIVER - PROFILE
1994/1995
2006/2007
2011
2018
MBL - Elevation (m)
120
100
80
60
40
20
0
-20
0
5000
10000
15000
20000
25000
30000
DISTANCE (m)
BURNELL-CATLEY BENDS
STATE HIGHWAY &
RAILWAY BRIDGES
MUHUNOA BRIDGE

FIGURE 1



OHAU RIVER — VOLUME CHANGES of ACTIVE BED
COMMON LIMITS
1994/1995 - 2006/2007 Volume Change (m³)
2006/2007 - 2011 Volume Change (m³)
2011 - 2018 Volume Change (m³)
VOLUME CHANGE (m3)
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
BURNELL-CATLEY BENDS
Channel changes
Channel movement
STATE HIGHWAY & RAILWAY BRIDGES
15 16 17 18 19 20 21 21a 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 41a 42 43 43a 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60
CROSS-SECTION NUMBER

FIGURE 2

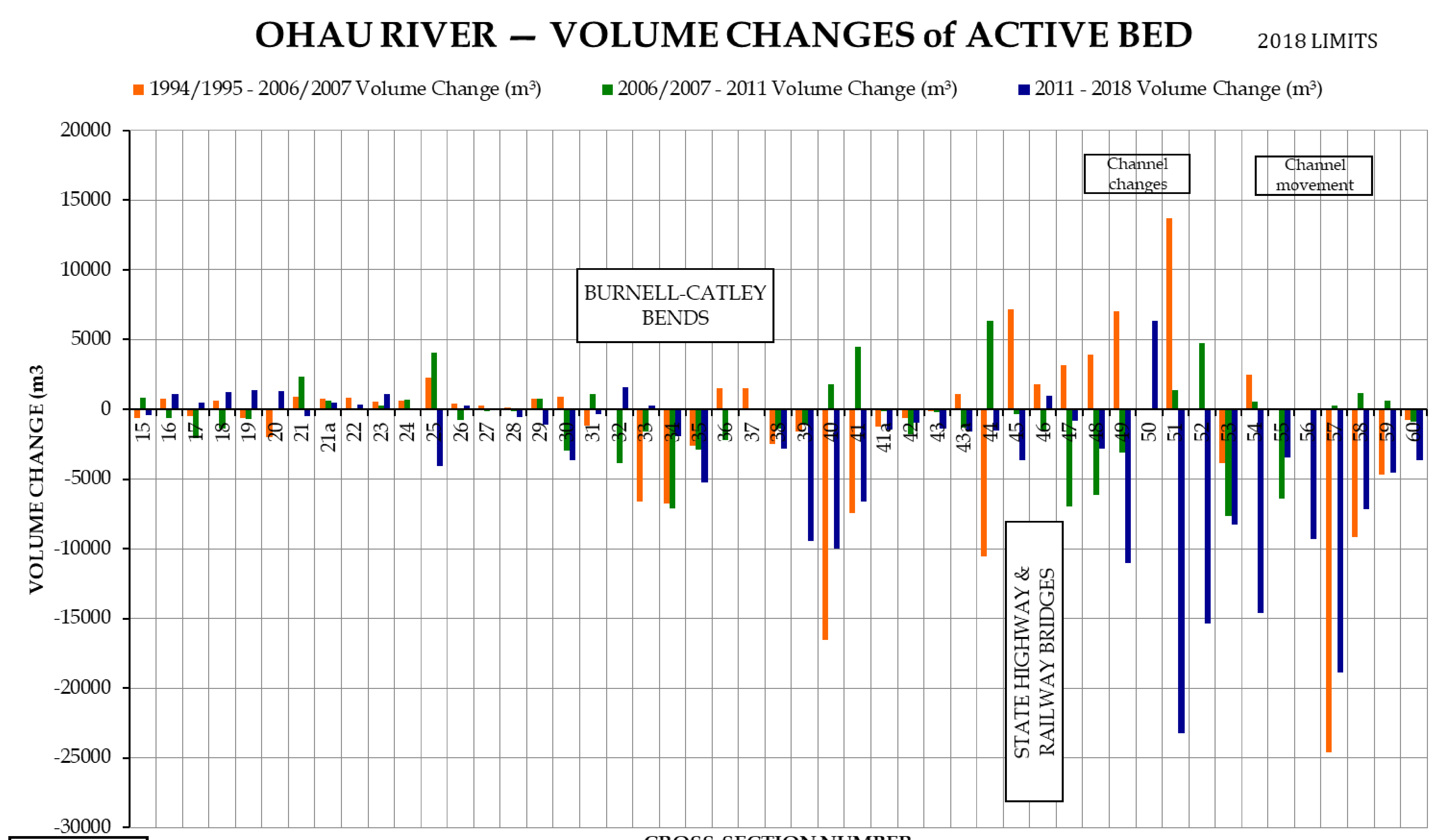
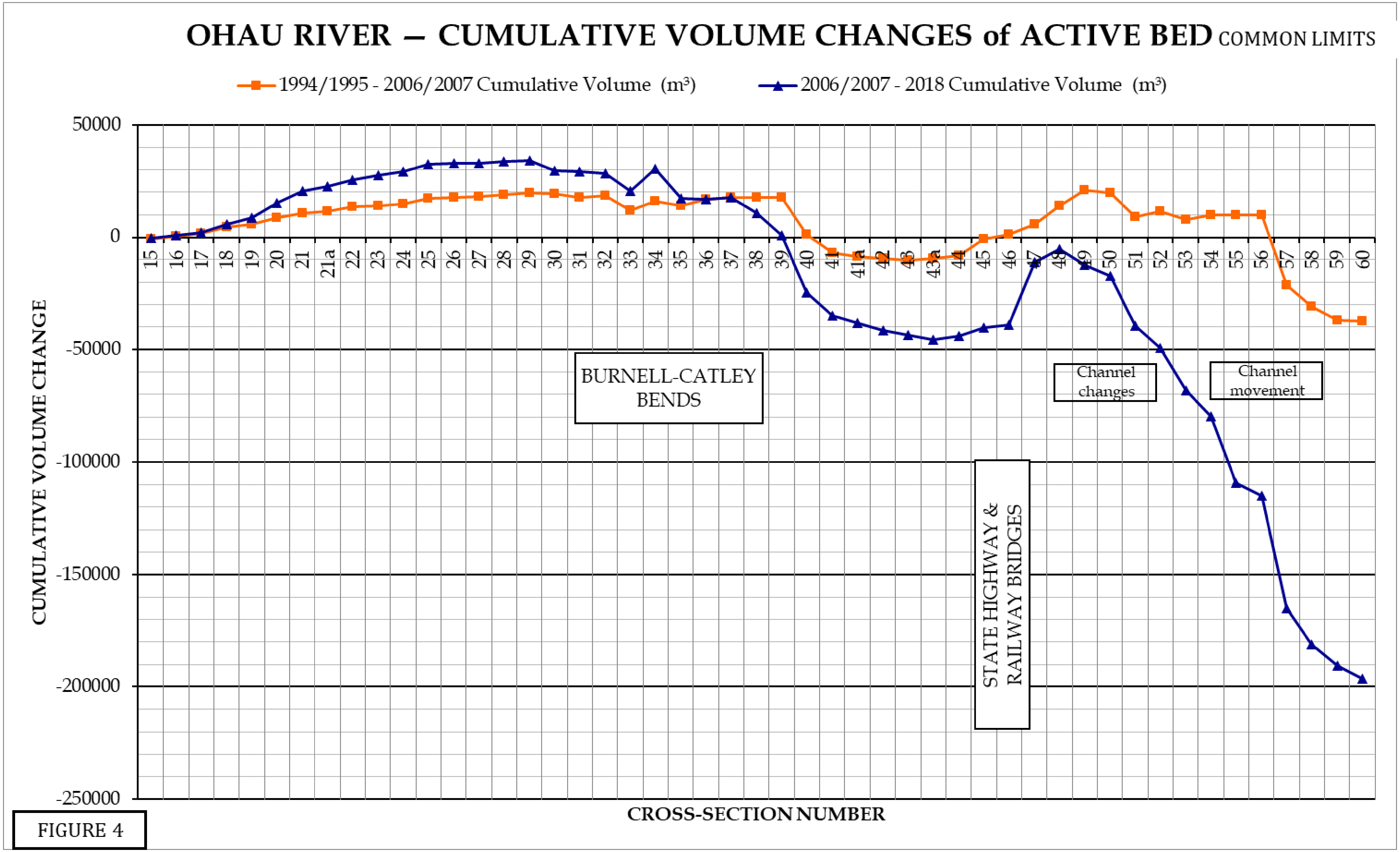
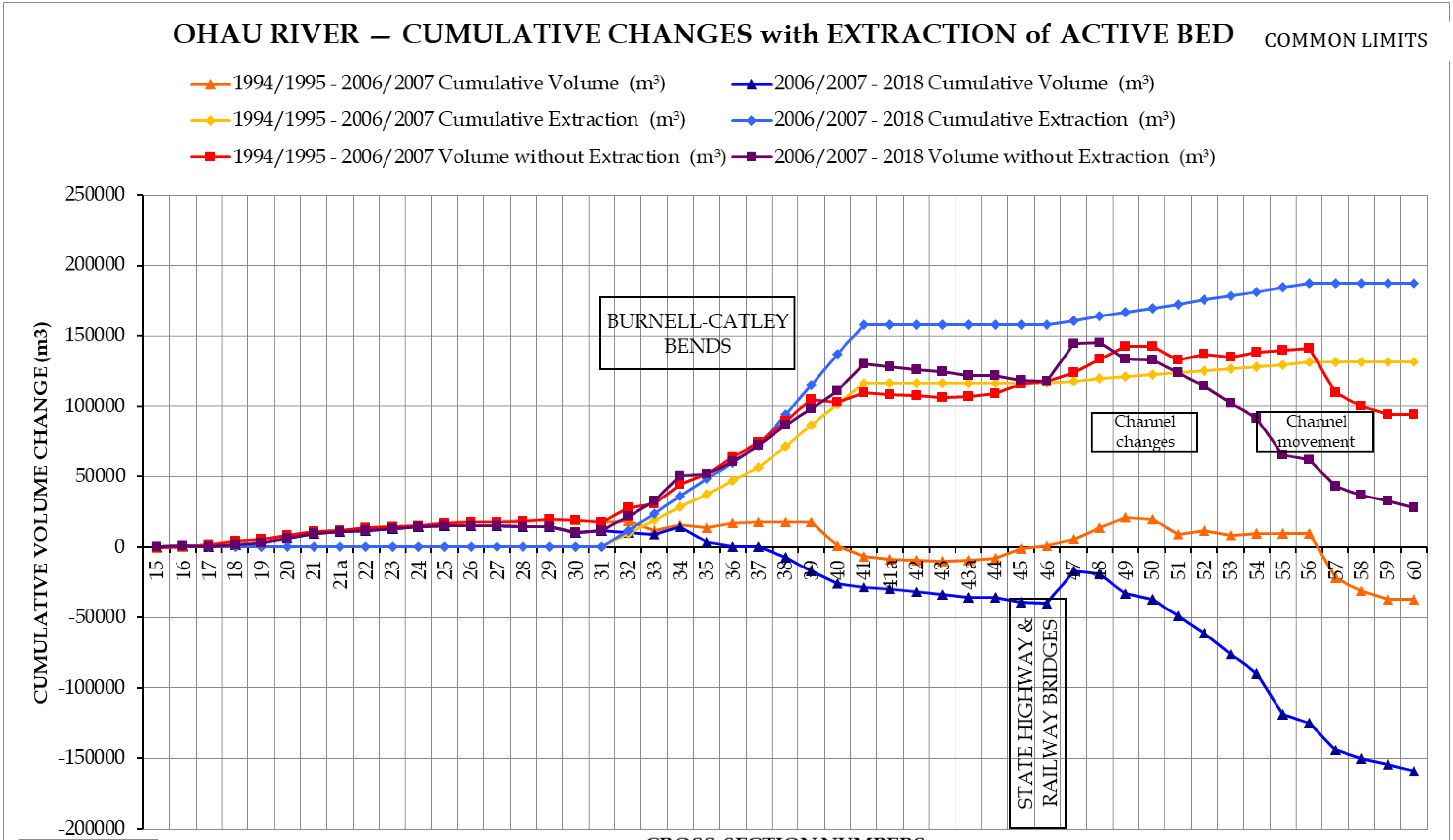

OHAU RIVER – VOLUME CHANGES of ACTIVE BED
2018 LIMITS
1994/1995 - 2006/2007 Volume Change (m³)
2006/2007 - 2011 Volume Change (m³)
2011 - 2018 Volume Change (m³)
VOLUME CHANGE (m3
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
BURNELL-CATLEY BENDS
Channel changes
Channel movement
STATE HIGHWAY & RAILWAY BRIDGES
15
16
17
18
19
20
21
21a
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
41a
42
43
43a
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
CROSS-SECTION NUMBER

FIGURE 3


OHAU RIVER – CUMULATIVE VOLUME CHANGES of ACTIVE BED COMMON LIMITS
1994/1995 - 2006/2007 Cumulative Volume (m³)
2006/2007 - 2018 Cumulative Volume (m³)
CUMULATIVE VOLUME CHANGE
50000
0
-50000
-100000
-150000
-200000
-250000
15
16
17
18
19
20
21
21a
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
41a
42
43
43a
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
BURNELL-CATLEY BENDS
Channel changes
Channel movement
STATE HIGHWAY & RAILWAY BRIDGES
CROSS-SECTION NUMBER
FIGURE 4



OHAU RIVER – CUMULATIVE CHANGES with EXTRACTION of ACTIVE BED
COMMON LIMITS
1994/1995 - 2006/2007 Cumulative Volume (m³)
2006/2007 - 2018 Cumulative Volume (m³)
1994/1995 - 2006/2007 Cumulative Extraction (m³)
2006/2007 - 2018 Cumulative Extraction (m³)
1994/1995 - 2006/2007 Volume without Extraction (m³)
2006/2007 - 2018 Volume without Extraction (m³)
CUMULATIVE VOLUME CHANGE (m3)
CROSS-SECTION NUMBERS
BURNELL-CATLEY BENDS
Channel changes
Channel movement
STATE HIGHWAY & RAILWAY BRIDGES

FIGURE 6