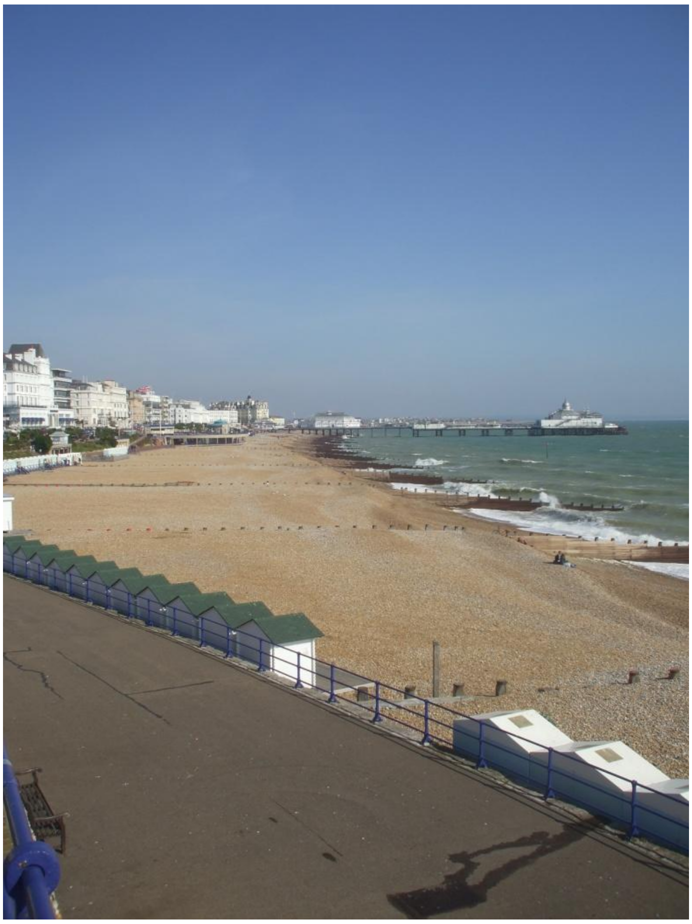
Engineering Services
Military Road
Canterbury
CT1 1YW

Client: Environment Agency
Project: Regional Shingle Sediment Budget Report

Eastbourne to Rye Harbour



Canterbury City Council
Strategic Monitoring
Military Road
Canterbury
Kent
CT1 1YW

Tel: 01227 862535
Fax: 01227 784013
e-mail: Strategic.Monitoring@canterbury.gov.uk
Web Site: www.se-coastalgroup.org.uk
www.channelcoast.org

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Author:	**A. Dane**
Checked By:	**J. Clarke**
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01	-	Draft Report for Consultation	J. Clarke
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Summary

A shingle sediment budget for Eastbourne to Rye Harbour was generated to gain an understanding of sediment movements through the frontage. The entire frontage is characterised by persistent longshore transport in a northerly/easterly direction.

- Eastbourne is a heavily managed frontage where overall beach volumes have remained stable, which mask that the frontage is naturally erosive. The export of sediment is addressed by a capital recharge scheme in 2011 and by occasional recycling as in 2009.

- The frontage from Sovereign Harbour to Cooden, Bexhill, shows a net export of sediment in the order of 28,000m^3/year. This export is explained by an annual recharge of 20,000m^3/year and bypassing of material around Sovereign Harbour. The natural longshore transport rate is higher than the export due to the open nature of the beaches and so is addressed through recycling in the order of 60,000m^3/year.

- Bexhill-on-Sea gains around 17,500m^3 each year from the input of the updrift frontage but still passes 10,000m^3/year onto the Bulverhythe frontage. The areas of accumulation have expanded downdrift over the last 10 years. It is suggested that the frontage is now largely saturated making it likely that output into the Bulverhythe frontage is likely to increase in the future.

- Bulverhythe is a frontage dominated by transit of material, passing 6,700m^3/year onto the Hastings frontage. This export is fuelled by small scale recharge in front of the rock revetment, which it struggles to retain.

- Hastings shows an accretion of 4,000m^3/year which is focussed at the harbour arm. Beach levels have built up so high over the past 10 years that around 2,000m^3 is passed eastwards into the Fairlight Cove frontage.

- The cliffs at Fairlight are fronted by a small beach fed by sedimentary input from cliff falls. This material is quickly moved on through the unit to cliff end, where 20,500m^3 is transported into the Winchelsea frontage.

- The gain at Winchelsea (18,500m^3/year) is almost equivalent to the loss at Fairlight (19,500m^3/year) showing that the frontage is dependent on the input of material from the cliffs. Sediment transport rates are typically high at between 15,000-20,000m^3/year due to the open nature of the beaches.

These trends are analysed over various temporal and spatial scales in the following report.

1.0 Introduction

This report details the regional shingle sediment budget for Eastbourne to Rye Harbour. A sediment budget is essential in defining longshore sediment transport rates, sediment pathways and areas of erosion and accretion, within defined boundaries, over a given period in time (Kana, 1995). The budget provides transparent and quantitative evidence of beach losses, gains and sediment pathways, in combination with both natural and artificial movements of beach grade material. The outcomes of this report will feed into Beach Management Plans (BMP). The report primarily focuses on the shingle sediment movement, as this has the most significance to beach management operations.

The data used for this report has been sourced from the Strategic Regional Coastal Monitoring Programme (SRCMP). The topographic beach data has been extensively collected since 2003 using ground based GPS measurements, LiDAR and bathymetric surveys. This data is analysed and reported over small management units, with very little regional analysis undertaken. Therefore, this report will take the local analysis to the regional scale to gain a greater insight into beach behaviour over interconnected sediment sub-cells.

The sediment budget is analysed over a range of spatial scales. Each spatial scale has been assigned a level relating to how much detail is provided, as shown below:

Level 1 – Very-fine analysis polygons
Level 2 – Fine analysis polygons
Level 3 – Coarse Sediment Budget
Level 4 – Regional Sediment Budget

The method for the production of the shingle sediment budget is discussed in detail in Appendix A. The transparent and repeatable methods will allow future budgets to be conducted and analysed using the same techniques developed here. The limitations and solutions in the methodology have been highlighted at the relevant stages and justifications made wherever possible.

2.0 Study Area

Throughout the entire sediment budget analysis, the frontage has been split into 8 sections (or cells) which broadly coincide with SRCMP survey units (Table 3.1). This also serves to maintain the boundaries between different beach management organisations which allows for easy accounting of the anthropogenic management on the individual frontages. As the dominant drift direction is from West to East, management units are always considered with the most westerly unit first.

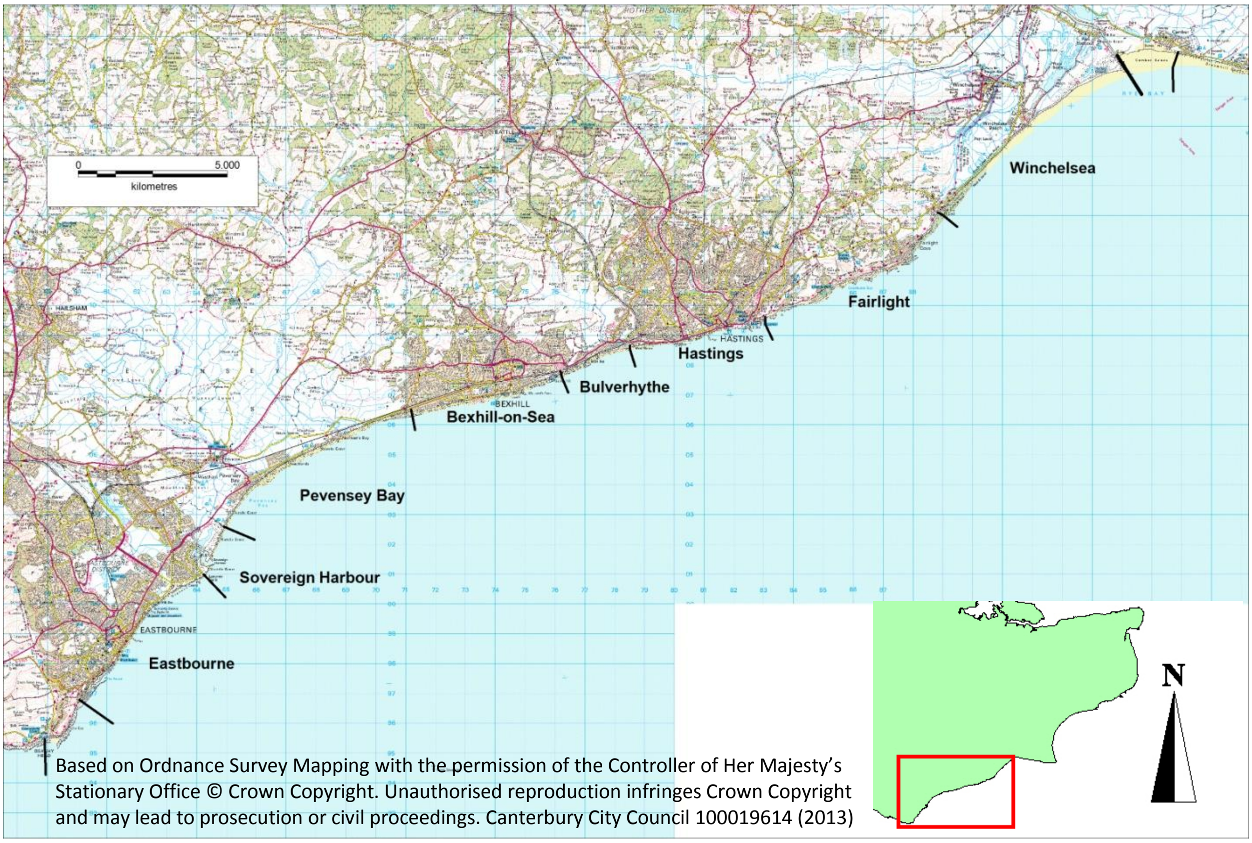


Figure 2-1 Location of study area

2.1 Eastbourne

Eastbourne is the most westerly extent of the study site and predominantly consists of a shingle beach with a sandy foreshore. Any beach material input from the Cliffs along the Seven Sisters and Beachy Head is considered to be relatively small. Human intervention has cut off the sediment supply from west of Seaford due to the presence of a terminal structure (South Foreland to Beachy Head SMP, 2010). A natural transport barrier for material coming from the west exists since the cliff fall at Beachy Head in 2000. Longshore transport is reduced from a natural rate due to the dense timber groyne field. Nevertheless there is a tendency for redistribution of beach material towards Sovereign Harbour from where material is either recycled (in 2009) or bypassed onto the Pevensey frontage. A capital replenishment of over 160,000m^3 was carried out in 2011.

2.2 Sovereign Harbour

Sovereign Harbour was built in 1992, creating a barrier to longshore transport which acts to capture sediment arriving from the Eastbourne frontage. Consequently, the eastern area of Sovereign Harbour is highly susceptible to erosion. While the immediate eastern side is protected by a rock revetment, regular recycling and replenishment works are undertaken to keep the coast at its current position and provide material to feed the longshore transport.

2.3 Pevensey Bay

Following the disintegration of the timber groyne field, Pevensey Bay, in contrast to Eastbourne, has been managed since 2000 as an ‘open beach’ with few longshore transport control structures. By default, following an initial increase in beach volume, total beach volume is kept constant, addressing local redistribution through recycling. The management contract prescribes that on average, 16,000m^3 should be allowed to leave the frontage eastwards requiring an annual addition of the same amount through both recharge from offshore and bypassing from the Eastbourne frontage. The shoreline orientation changes within Pevensey leading to an increase in wave exposure towards the east.

2.4 Bexhill-on-Sea

Bexhill-on-Sea is again characterised by a dense timber groyne field and with material entering from the west, very little management has been carried on the now largely buried groynes.

2.5 Bulverhythe

Bulverhythe has undergone a significant amount of beach management over the last 10 years as a result of low beach levels in the 1990s and early 2000s. In 2006, a 450m rock revetment was constructed together with rock groynes either side. In addition a 60,000m^3 capital replenishment scheme was undertaken to build up beach levels. Although beach material does not stay in large volumes in front of the revetment, small amounts of recharge material (5,000 to 15,000m^3) have been brought into the area over the last four years.

2.6 Hastings

Since the 14th century, the eastern area of Hastings has been accreting due to the development of a breakwater and small fishing harbour (South Foreland to Beachy Head SMP, 2010). Land has been reclaimed and built out onto the accretion zone, creating a significant beach at this location. Hastings has a dense groyne field of relatively short and low groynes. Material passing through the groyne field has continued to be collected against the harbour breakwater which has started to let material onto frontages further east. Imbalances in beach width particularly to the east of the Pier resulted in a new short rock groyne and beach recycling in 2009.

2.7 Fairlight

Comprising Fairlight Cove and Glen, the cliffs at Fairlight are predominately made up of sandstone, sandy shales, silts and clays (South Foreland to Beachy Head SMP, 2010). They are fronted by a small sand and gravel beach which extends to the foreshore. The cliffs are actively landsliding providing a potential source of beach grade material although the actual volume from each slide is considered to be low. A rock revetment was constructed in 1990 to protect a rapidly eroding stretch of cliff at Fairlight Cove, since then material has been filling interstitial voids in the defence structure.

2.8 Winchelsea

A large shingle barrier beach forms the final unit of the sediment budget, which switches between being groyned in the west and open in the east. The eastern beach has historically shown significant accretion as shingle is trapped by the terminal structure at Rye Harbour. Shingle is recycled (20,000m^3/year) from the sink at the Harbour wall to Cliff end, where the beach struggles to retain the sediment.

3.0 Methodology

3.1 Source data

In order to undertake the sediment budget a review of all topographic data was conducted (Table 3.1). This review was focussed on the topographic survey data from both ground based GPS and aerial LiDAR sources, over the 2003-2011 period, the longest available timescale since regular monitoring began. Where both LiDAR and GPS measurements were available, GPS was preferentially chosen due to the tailored nature of the surveys. This data was used in the formulation of the sediment budget explained below. For more information, refer to Appendix A.

Table 3-1 Available DTM's and Difference Models for Frontages

Frontage	Management Organisation	SRCMP Survey Units (Phase II)	Available DTM's	Data Type	Difference models
Eastbourne	Eastbourne Borough Council	4cMU29	2003-2011	Ground Based GPS	All years
Sovereign Harbour	Pevensey Coastal Defence Ltd	4cMU28	2003-2005, 2007, 2009-2011	Ground Based GPS	2003-2004, 2004-2005, 2005-2007, 2007-2009, 2009 onwards
Pevensey Bay	Pevensey Coastal Defence Ltd	4cMU27	2003-2005,2007-2011	Ground Based GPS	2003-2004, 2004-2005, 2005-2007, 2007 onwards
Bexhill –On-Sea	Rother District Council	4cMU26	2003-2011	Ground Based GPS	All years
Bulverhythe	Environment Agency	4cMU25	2003-2011	Ground Based GPS	All years
Hastings	Hastings Borough Council	4cMU24	2003-2011	Ground Based GPS	All years
Fairlight	Hastings Borough Council/Rother District Council	4cMU23-19	2005 (patchy), 2006 (patchy) 2007 (patchy) 2009-2011	LiDAR	2005-2006, 2006-2007, 2007-2009, 2009 onwards
Winchelsea	Environment Agency	4cMU17	2003, 2005-2011	Ground Based GPS	2003-2005, 2005 onwards

3.2 Generation of the Sediment Budget (Level 3 and 4)

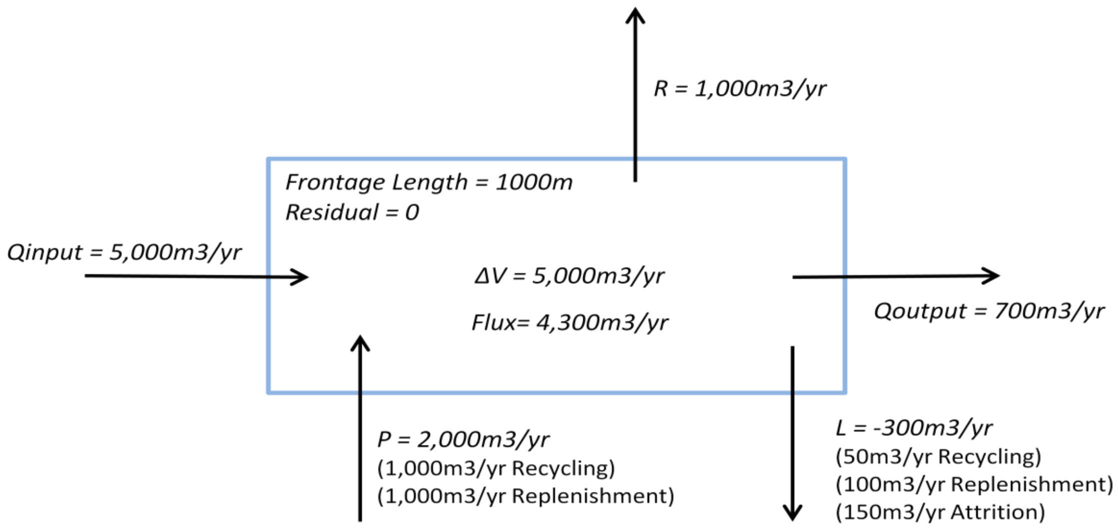
A sediment budget presents a quantitative model of the magnitude of volumetric change, sediment transport rates and losses and gains within a self-contained coastal cell, in a defined period of time (Rosati and Kraus, 1999). At its most basic, using the principles of conservation of mass (volume), it is an attempt to balance all inputs into a cell with all outputs leaving a cell as shown in Equation 1 below (Adapted from Rosati and Kraus, 1999):

$$\sum Qinput - \sum Qoutput - \Delta V + P - R + L = Residual \qquad (1)$$

Where:

- Q_{input} - Volume input from the updrift cell
- Q_{output} - Volume output into the downdrift cell
- ΔV - Volumetric change within the cell (as surveyed)
- P - The material placed into the cell e.g. beach replenishment
- R - The material removed from the cell e.g. beach recycling
- L - The losses to attrition and material lost during placement.

The Residual is the volume of the cell remaining or the degree to which the cell is balanced. In a balanced sub-cell the residual should near 0 or be no larger than the combined error in the data collection.



Residual = ΣQinput - ΣQoutput -ΔV + P – R + L
Residual = 5000 - 700 - 5000 + 2000 – 1000 + -200
Residual = 0

Figure 3-1 Sample balanced sediment cell

Volumetric change in each SRCMP polygon was calculated through analysis of the difference models shown in Table 3.1. Different methods for calculating *ΔV* were explored in depth provided in Appendix A. All replenishment and recycling logs were collated and *P* and *R* were calculated for each polygon.

Losses expected on this frontage can be broadly split into three categories, attrition losses, replenishment losses and recycling losses. Offshore losses are not considered significant due to the predominance of coarse grained sediments and the topography and geomorphology of the beaches. The losses applied to each cell are shown in the table below, with justification for the figures applied provided in Appendix A.
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Table 3-2 Losses to a sediment cell

Source of Loss	Loss	Reference
Attrition	$0.15m^3$/m/year	Dornbusch et al. 2003
Losses during replenishment	10%	Clarke and Brooks 2008
Losses during recycling	5%	Clarke and Brooks 2008

While the SRCMP polygons (Level 2) are useful in providing detailed losses and gains over a management unit, they are too fine when considering the regional view of the sediment budget. Polygons exhibiting similar coastal behaviour were grouped together to create a coarser system of sub-cells, or the Level 3 analysis sub-cells. This set of sub-cells now contained values for $\Delta V, P, R \text{ and } L$. Using these figures, the average annual flux can be calculated through:

$$Flux = \Delta V - P + R - L \qquad (2)$$

The flux can be thought of as the volume of sediment added (when flux is negative) or removed (when flux is positive) of the sediment system. This is an important parameter for working out what volume of sediment is actually being exported out of the cell after all losses, extractions and placements have been excluded.

With the residual nearing 0 in a closed sub-cell, Equation 1 can be solved for Q_{input} *and* Q_{output}. Starting at the most western extent of Eastbourne where the sediment input from Beachy Head into the frontage is known to be minimal or $Q_{input} = 0$:

$$Qoutput = -(\Delta V - P + R - L) + Qinput \quad (3)$$

The Q_{output} of the updrift cell then feeds the downdrift cell as the Q_{input} and the next cell can be balanced. Examples of this can be found in Appendix A.iii. An overview budget was also developed helping to place the changes within the context of management frontages (Level 4). This can provide feedback on those frontages that are significantly gaining or losing material. Equation 1 can be applied over the whole sediment budget with the residual determining whether or not the cell can be thought of as a self contained sediment unit.

Finally, when using the Q_{output} figures to assess sediment transport rates it needs to be recognised that an *a priori* assumption of net transport direction has been made. In most areas along the study a distinct net transport direction prevails each year but is obviously composed of transport in either direction. For a large scale sediment budget covering several years, annual net transport is the crucial factor though locally and on operation time scales, actual rates are invariably different in both magnitude and direction.

3.3 Historic beach calculation

Historic beach DGMs were generated through an assumed relationship between the MHW, beach crest and beach toe elevation. MHW marks were mapped from historical images from the 1890's, 1910's and 1930's. For a more in depth methodology on the creation of historic DGMs from historical maps refer to Appendix C. The elevations used to generate the DGMs are shown below.

Table 3-3 Data used to generate Historic DTMs

Cell	Height (mAOD)					Distance from MHW (m)	
	Back of Beach**	Crest **	MHW*	Beach Toe **	MLW*	Beach Crest (L1)	Beach Toe (L2)
Eastbourne	6.1	6.1	2.75	-1.6	-2.25	12.5	35.0
Sovereign Harbour	6.1	6.1	2.75	-1.6	-2.25	12.5	35.0
Pevensey Bay	5.8	5.8	2.75	-1.8	-2.25	11.4	37.0
Bexhill-on-Sea	6.2	6.2	2.9	-1.6	-2.35	12.3	36.6
Bulverhythe	6.8	6.8	2.9	-0.4	-2.35	14.6	26.9
Hastings	6.6	6.6	2.9	-1.6	-2.35	13.8	36.6
Fairlight	Not applicable as MHW assumed to be back of beach		2.9	-0.6	-2.35	As before	28.5
Winchelsea	7.0	7.0	2.9	-0.6	-2.35	15.3	28.5

* Note: found from Admiralty tide curves; ** Found through analysis of SANDS profiles

4.0 Results

The results have been split into their various temporal and spatial scales. Note: Level 2 (SRCMP polygons) are not analysed, as this level was a processing level used to gain volumetric change values to feed into the Level 3 analysis. Level 2 was considered to be too fine to conduct a sediment budget analysis over a regional scale.

4.1 Level 1 - Volumetric Change per 50m Length

The year on year volumetric change has been analysed in the following pages to gain an insight on the variability around the mean volumetric change (ΔV) used in the sediment budget analysis in Section 4.2 and 4.3. The methodology for the production of the contour plots is explained in depth in Appendix A.

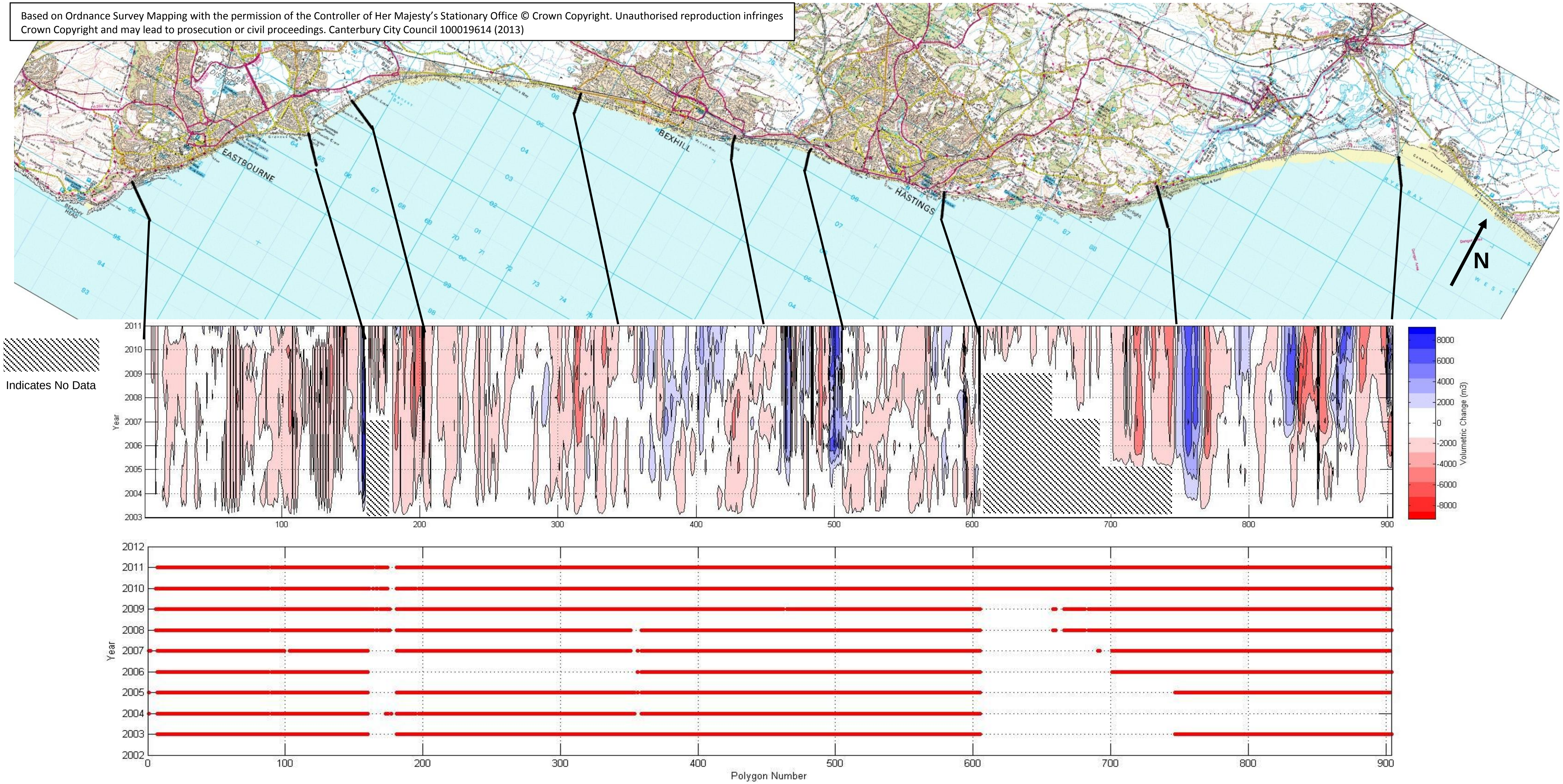
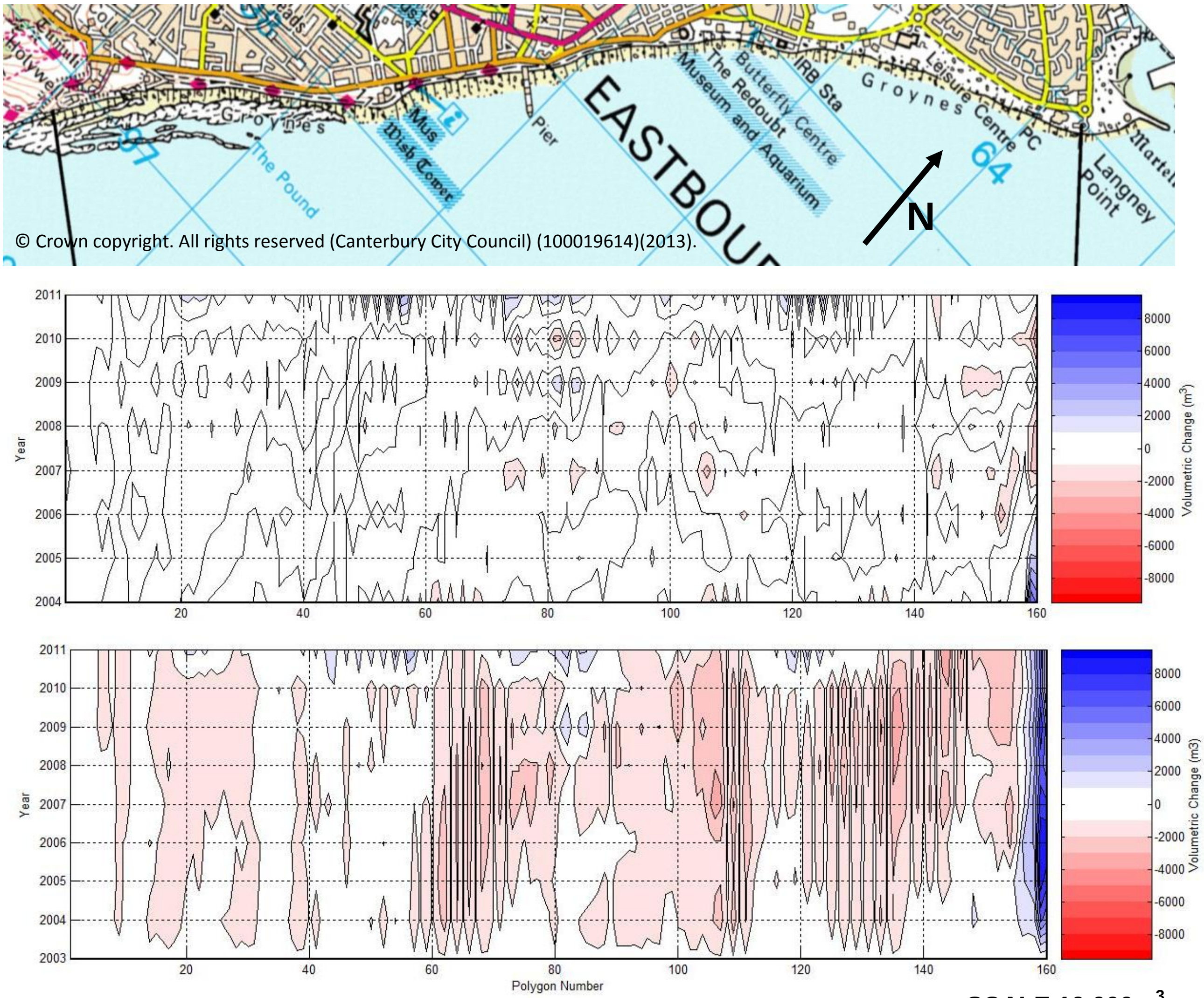


Figure 4-1 Cumulative contour plot of beach volumetric change since 2003 over the entire sediment budget

The contour plots show the volumetric change for each 50m stretch of coast over the whole budget. The X axis refers to the distance along shore from Eastbourne, and the Y axis refers to time. The Z axis is the volumetric change recorded for each 50m wide polygon over each monitoring period, calculated through analysis of the difference models. The data used to generate the plots are shown in the second plot, with a red dot representing a data point on the contour plot. Gaps in the data exist at Fairlight due to problems with access. Where there is missing data, change is interpolated from known points. On the whole, the frontage is characterised by large, relatively stable sections were there is little change through time (e.g. Eastbourne, Sovereign Harbour, Pevensey Bay and parts of Hastings). There is a section of gradually increasing beach volumes along the Bexhill frontage and a more rapid change noted in Bulverhythe due to management interventions. The frontages are explored in more depth in the following pages; each frontage has the year on year change in the top plot and the cumulative change in the bottom plot.

4.1.1 Eastbourne

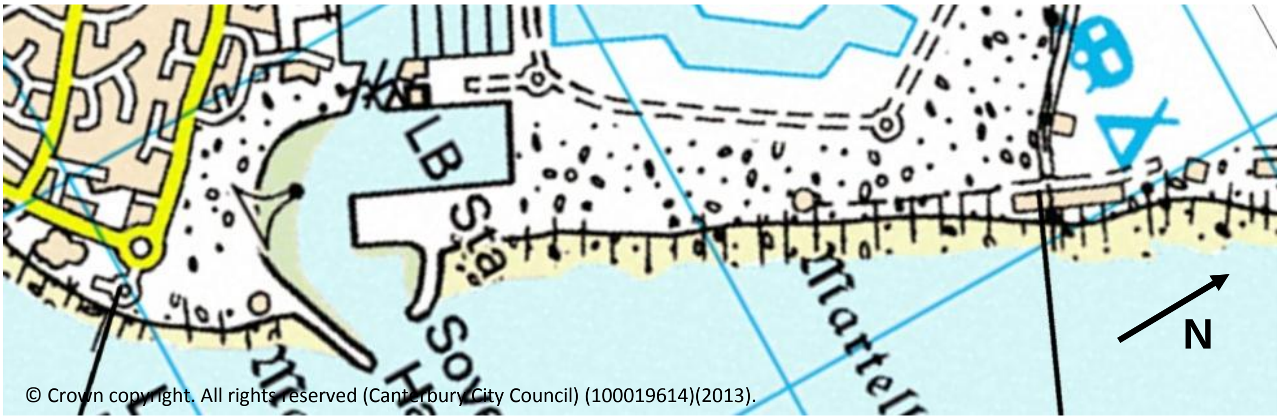


SCALE 10,000m^3

Figure 4-2 Year on year (top) and cumulative (bottom) contour plot for beach volumetric change in Eastbourne since 2003

Eastbourne is a relatively stable frontage with gradual reductions in volumes in the same locations compared to the 2003 data. Longshore transport through the system is accelerating towards the north in line with a decrease in protection from Beach Head and increased water depth at the beach toe. Longshore transport terminates at Sovereign Harbour where the volume is kept constant through removal and bypassing to north of the harbour. The recharge and recycling intervention in 2011 can be seen by the widespread increase in volume above the 2003 levels. The large increase shown in Polygons 158-160 in the cumulative contour plot is only due to a large increase between 2003 and 2005, after which the volumes remain relatively stable.

4.1.2 Sovereign Harbour



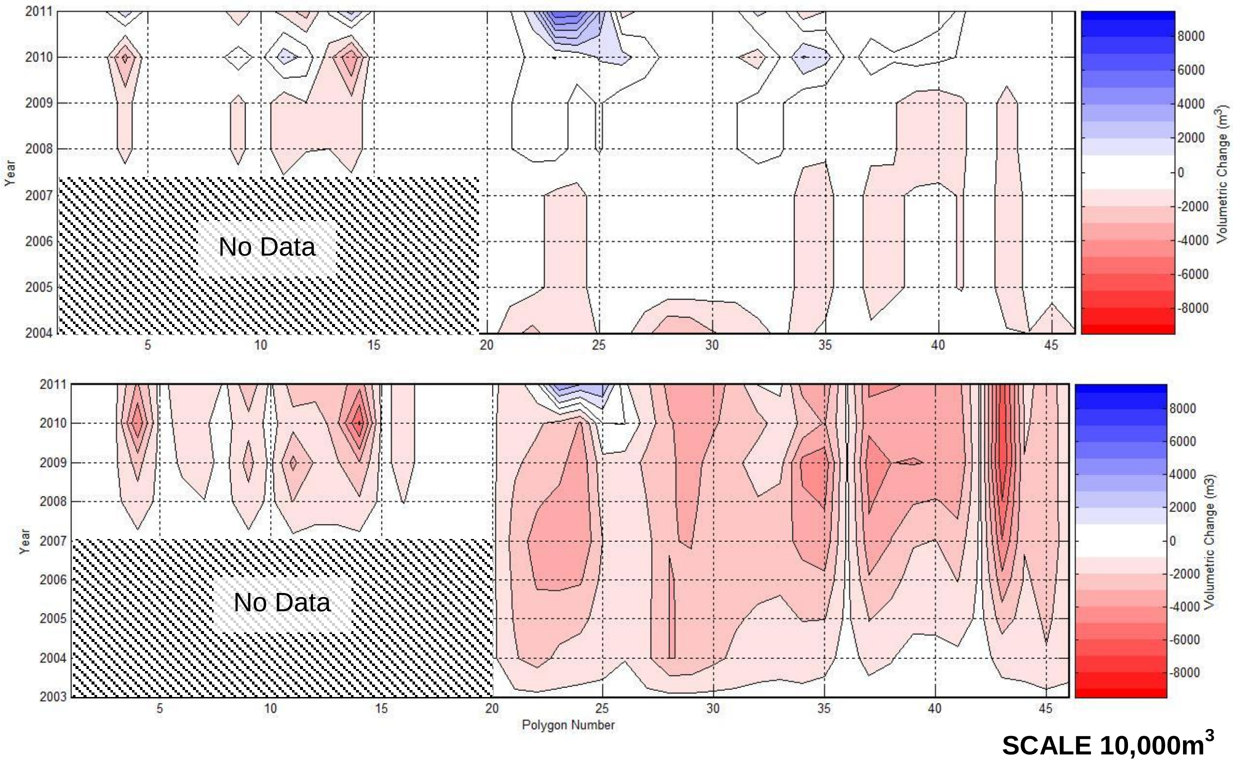


Figure 4-3 Year on year (top) and cumulative (bottom) contour plot for beach volumetric change for Sovereign Harbour since 2003

Surveys for south of the Harbour only started in 2007 by which time significant volumes of material had arrived from the Eastbourne frontage. The lower than 2007 values reflect the removal of material for bypassing and recycling. The northern frontage shows a reduction in material following the placement of large volumes in 2002, a volume that was unsustainable to hold. Despite recycling and recharge into the area volumes were difficult to maintain and since 2007, the requirements for the amount of material have been changed. Volumes have largely remained at the 2007 volumes; however, some recharge activity is captured such as in polygons 23-25 in 2011.

4.1.3 Pevensey Bay

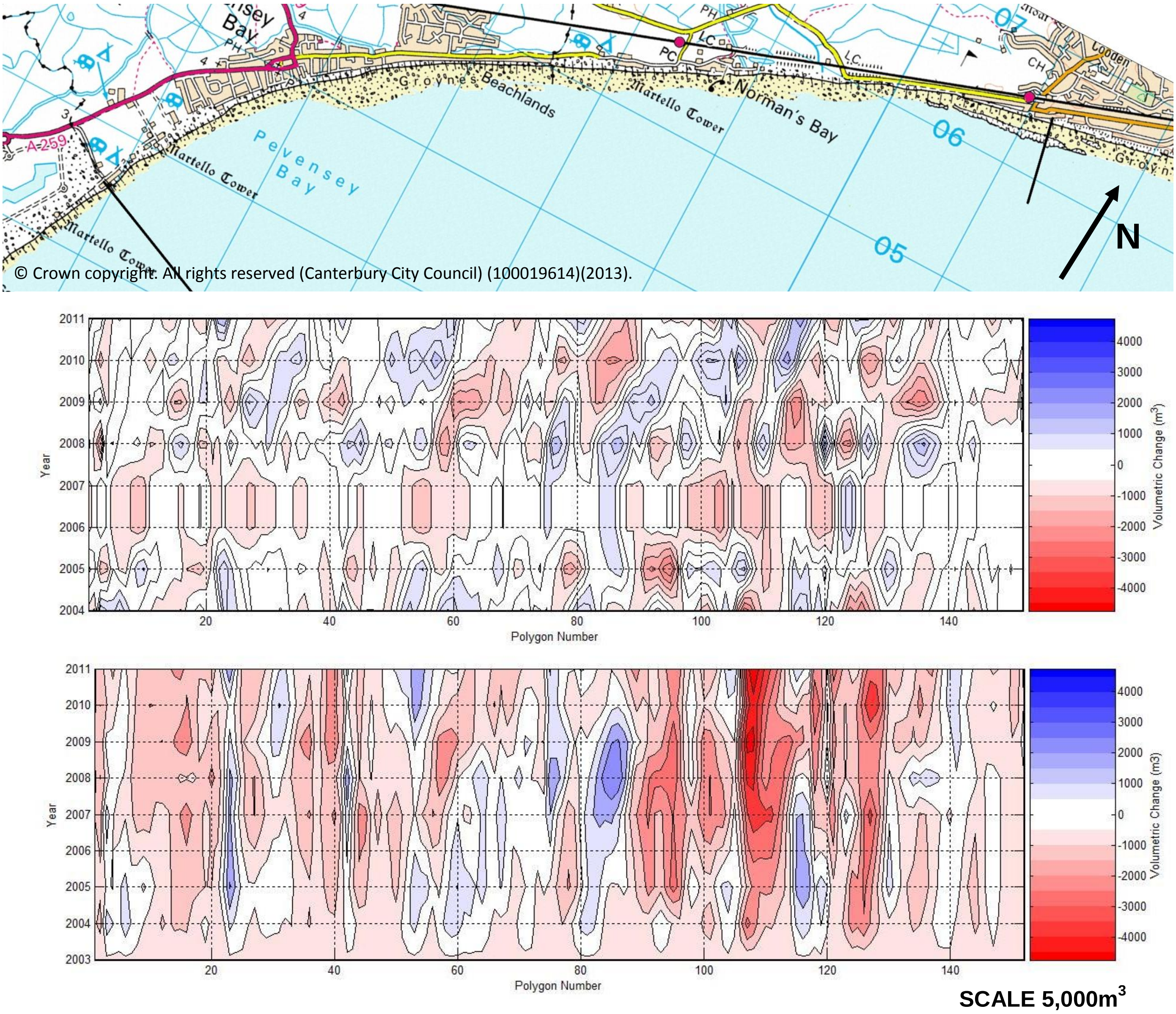
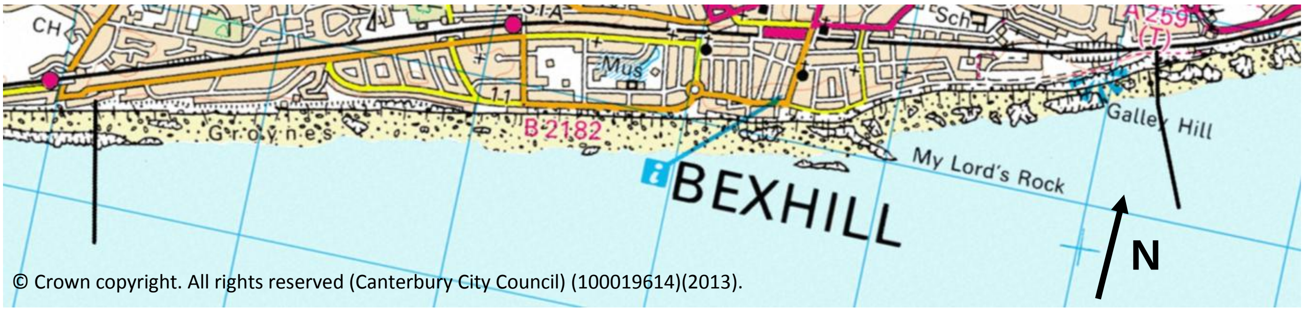
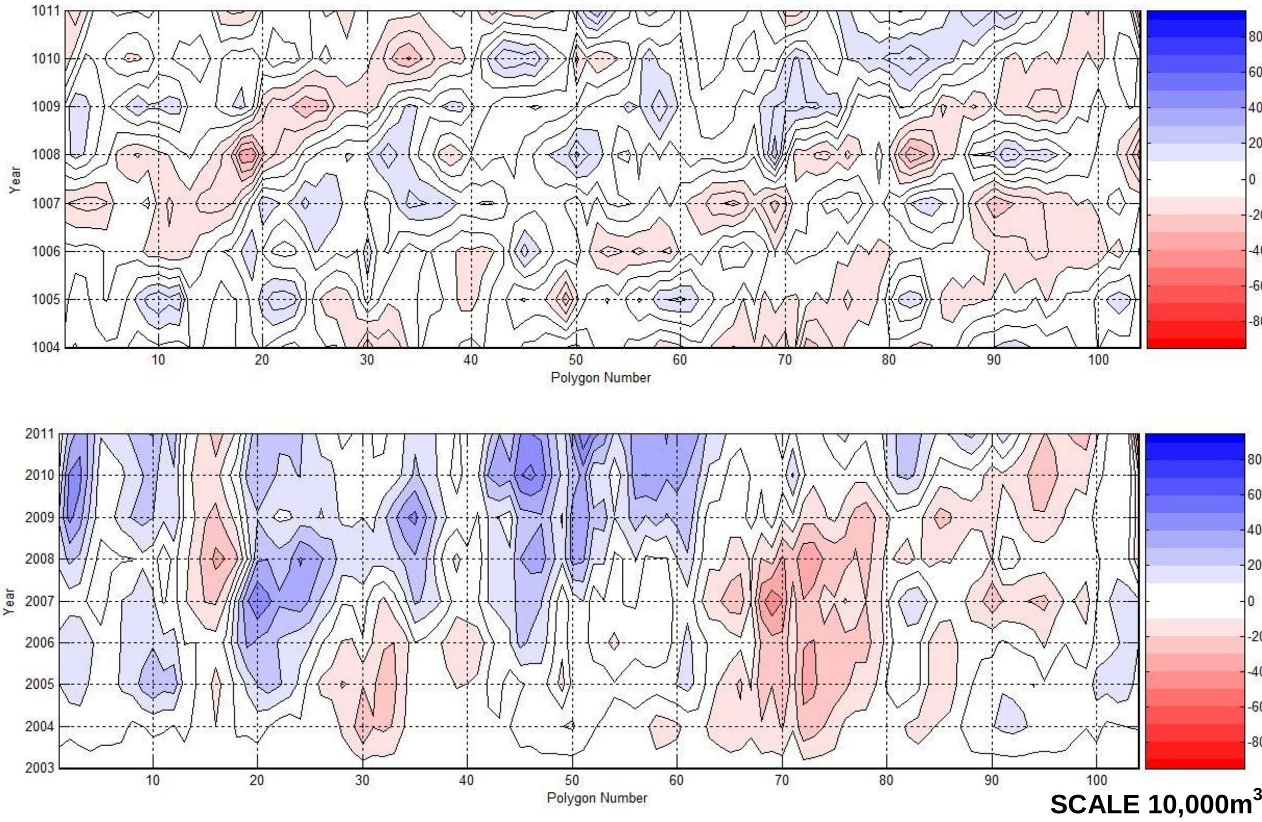


Figure 4-4 Year on year (top) and cumulative (bottom) contour plot for beach volumetric change in Pevensey Bay since 2003

The regular recycling works at Pevensey Bay can be clearly seen in this contour plot which shows mixture of relatively stable areas (e.g. up to polygon 45) and those where changes are more pronounced from year to year, reflecting the number and timing of the surveys used in this study. The lower values around polygon 108 compared to 2003 reflect the changed beach design, so while the loss appears significant, this area has been allowed to retreat to a more sustainable position. Consistent alternating trends of accretion and erosion are noted as material is transported in pulses around the coast. The Z-scale has been reduced to -5000 to 5000m^3 as volumetric change is typically low on this frontage, in part due to the success of management activities.

4.1.4 Bexhill-On-Sea



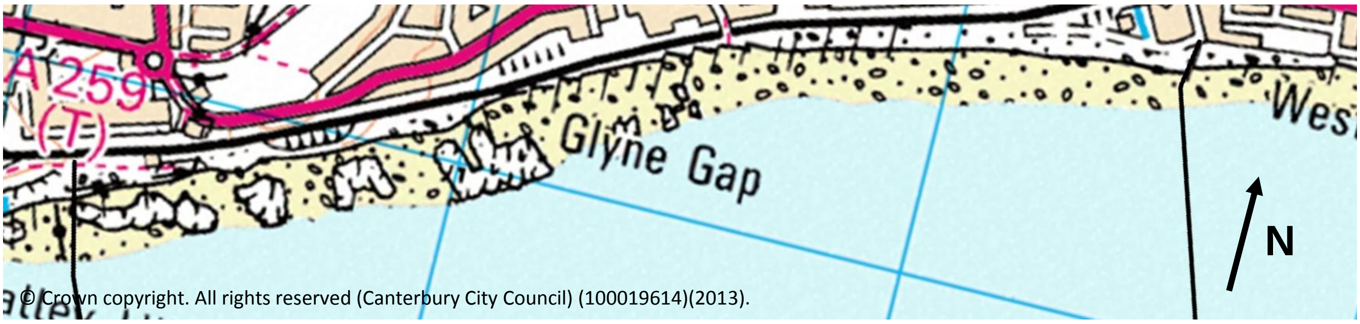


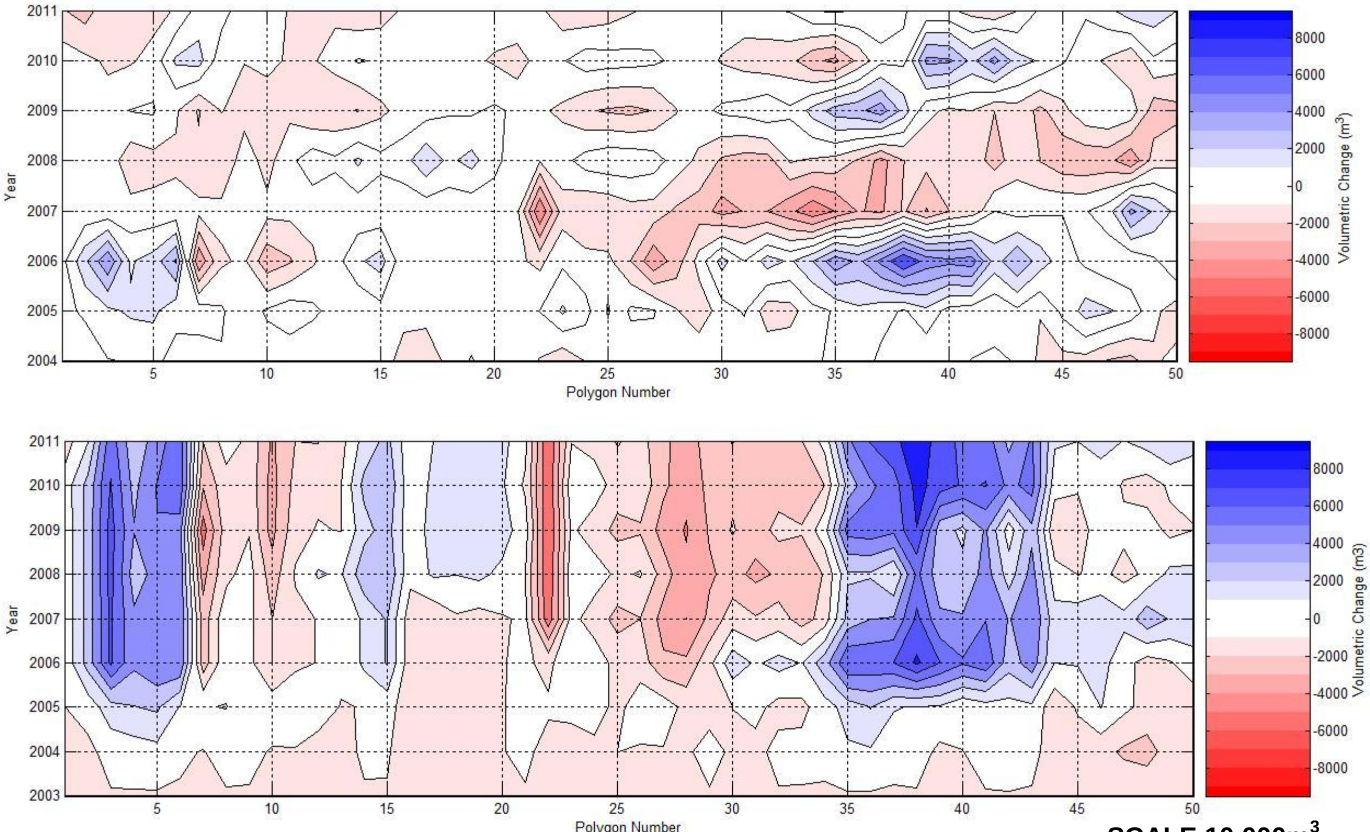
SCALE 10,000m^3

Figure 4-5 Year on year (top) and cumulative (bottom) contour plot for beach volumetric change in Bexhill-on-Sea since 2003

No beach management operations are undertaken on this frontage and the gain that proceeds through time from west to east is the consequence of ~30,000m arriving annually at the western end. On passing through the frontage, parts of this material has infilled groyne compartments to a level at which overpassing is increased. The entire frontage now contains significantly more beach material than in 2003.

4.1.5 Bulverhythe



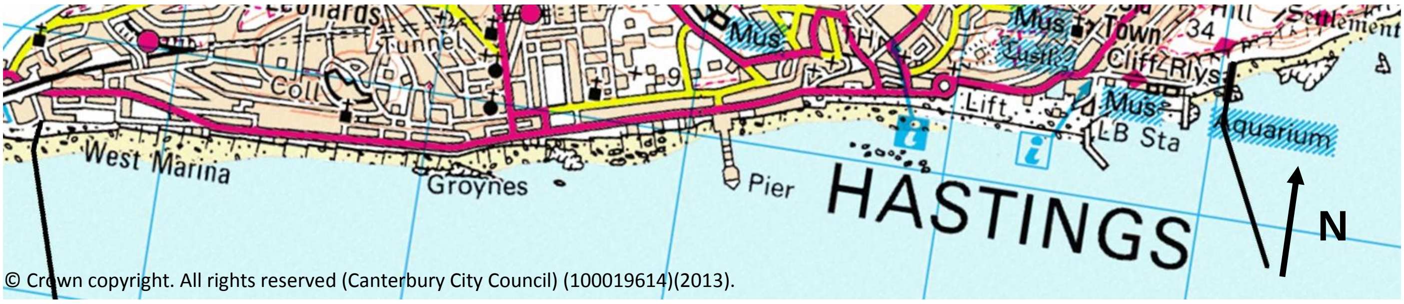


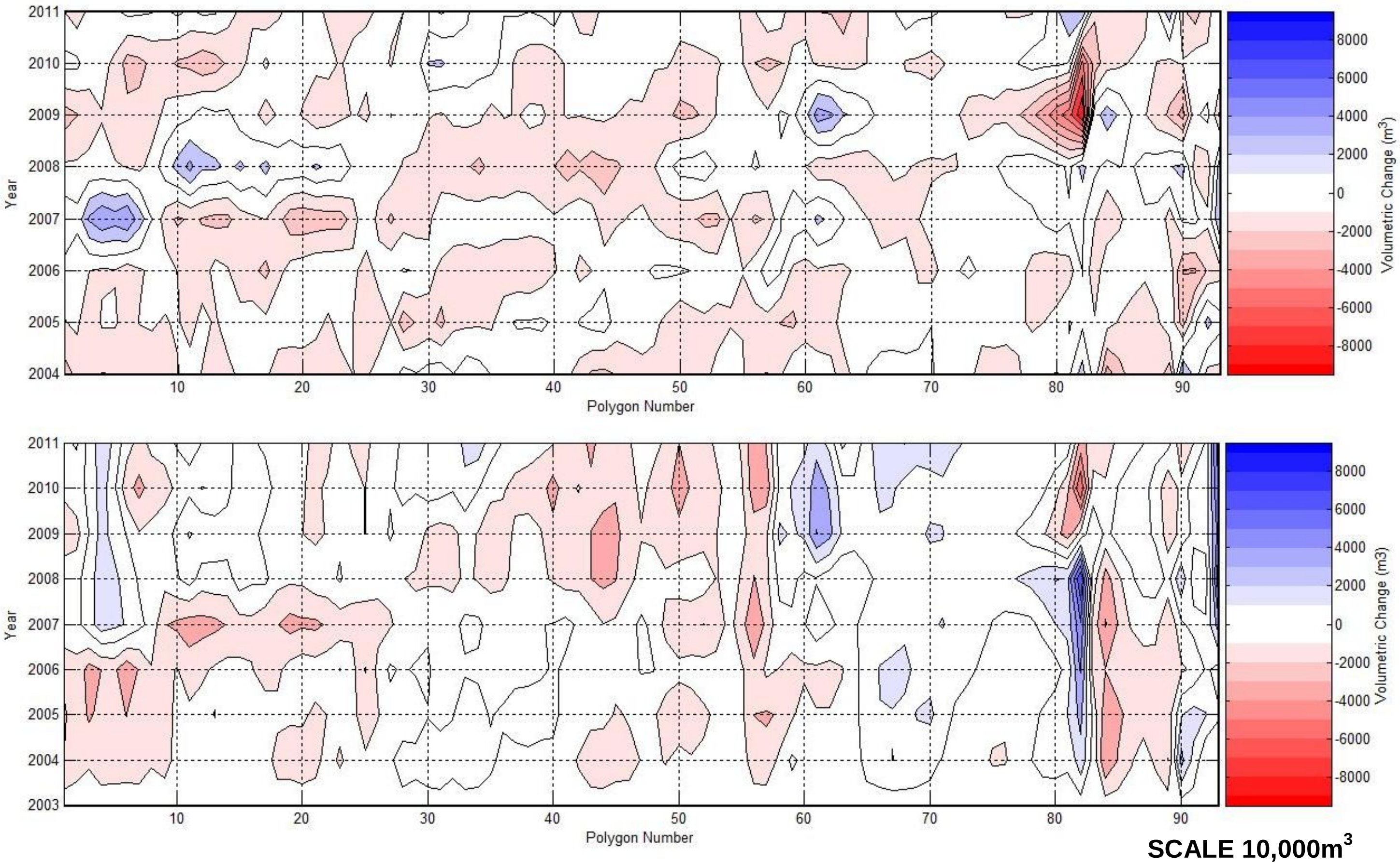
SCALE 10,000m^3

Figure 4-6 Year on year (top) and cumulative (bottom) contour plots for beach volumetric change in Bulverhythe since 2003

Beach volume change at Bulverhythe is characterised by the scheme in 2005/2006 that led to the construction of a number of rock groynes at either end and a capital replenishment of over 60,000m^3. Small scale maintenance replenishment of 5000m³ in 2008 and 2009 together with 14,000 and 13,000 in 2010 and 2011 do not show up in polygons 20 to 35 (the rock revetment) and support the assessment that this frontage, despite input from Bexhill and recharge, cannot retain any more material that there is at the moment.

4.1.6 Hastings



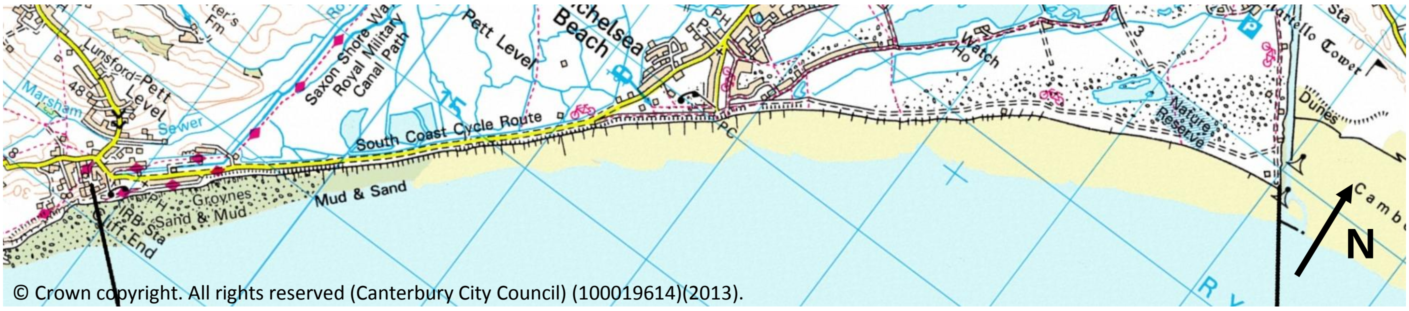


SCALE 10,000m^3

Figure 4-7 Year on year (top) and cumulative (bottom) contour plots for beach volumetric change in Hastings since 2003

Hastings shows relatively small beach volumetric changes over the past 9 years. The most pronounced change can be seen at polygons 82-84 fronting the Fisherman's Beach and polygons 60-63, just east of the Pier. While the beach west of the Harbour arm shows a strong trend of accretion from 2003-2008 the sudden reduction relates to a recycling event in 2009, when 10,000m^3 was removed from this area and deposited at the Pier. It seems that this deposited material has moved in the direction of the dominant drift, towards Polygon 67-73, shown by the area of blue just east of the deposition site and the reduction in material at 60-63.

4.1.7 Winchelsea



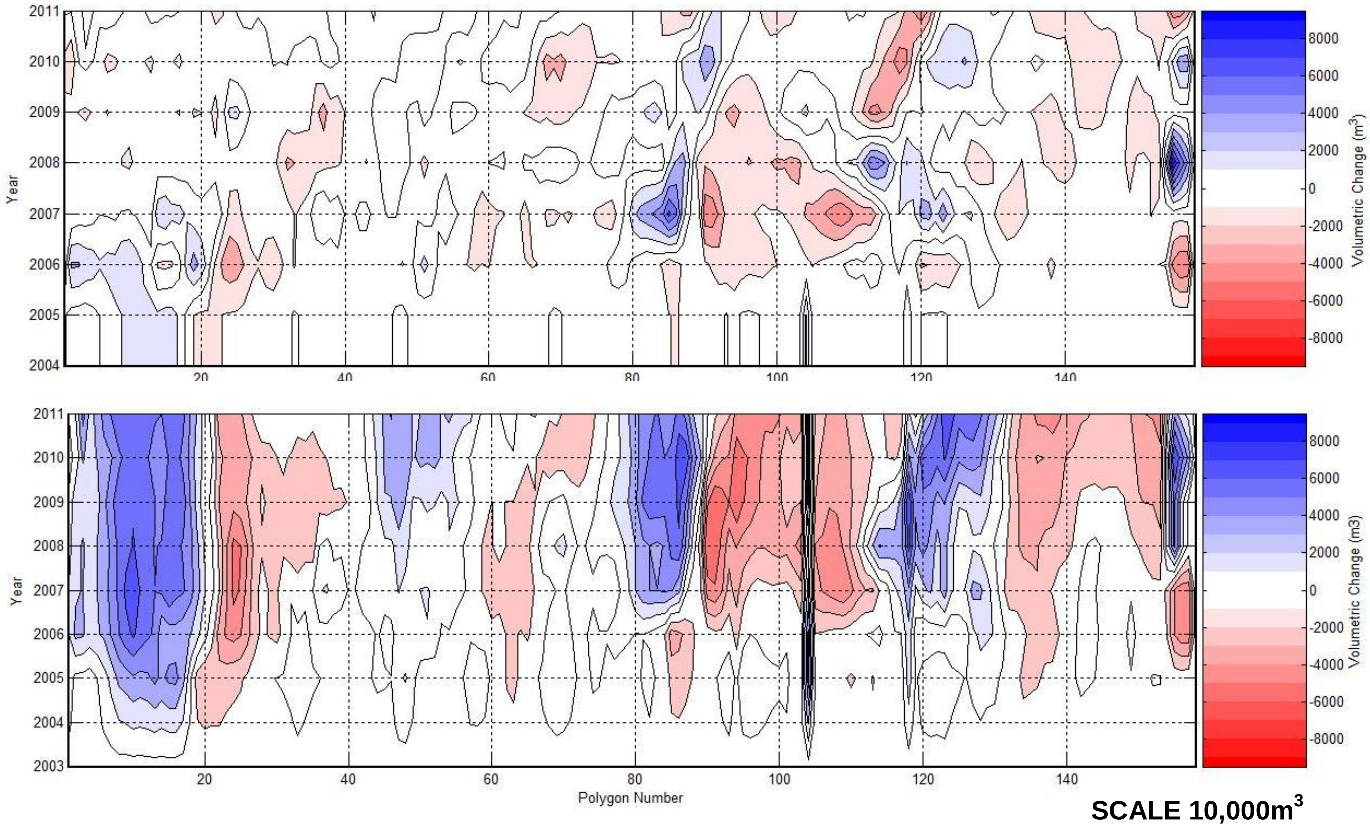


Figure 4-8 Year on year (top) and cumulative (bottom) contour plots for beach volumetric change in Winchelsea since 2003

Winchelsea shows relatively large beach volumetric changes over the last 9 years; however, this frontage is heavily managed. The large accretion from 2003 to 2006 at Polygon 1-20 can be explained by regular recycling works over this period, bringing in over 75,000m^3 into the groyne bays at Cliff End. Further west, the frontage becomes less groyned and the unit returns to an erosive trend. A similar recycling scheme can be seen at Polygon 80-87, with material being removed from Polygons 88-100. The accretion at Polygon 120 to 130 from 2007 to 2011 can be seen to be a natural build up as sediment is trapped by the improved groynes at this location. Into the ungroyned frontage after Polygon 130, the beach becomes erosive with material being transported to Rye Harbour arm. The large build up at Rye Harbour exists despite an annual extraction of around 20,000m^3/year.

Figure 4.9 summarises the findings from the Spatio-temporal plots by providing a cumulative annual loss or gain from each frontage over the reporting period. This can provide a direct comparison between each frontage, to identify their behaviour in relation to the adjacent frontages. Bexhill-on-sea shows the consistent year on year gain shown in Figure 4.5, with the preceding frontages of Eastbourne, Sovereign Harbour and Pevensey Bay showing a net export of sediment. Bulverhythe and Hastings show the overall accretive trend, despite a large amount of variability over the past 10 years. Fairlight has not been included as there are only three years of complete survey coverage. Displaying the volumetric change over the last 10 years for the whole frontage will be unrepresentative of the actual trend.

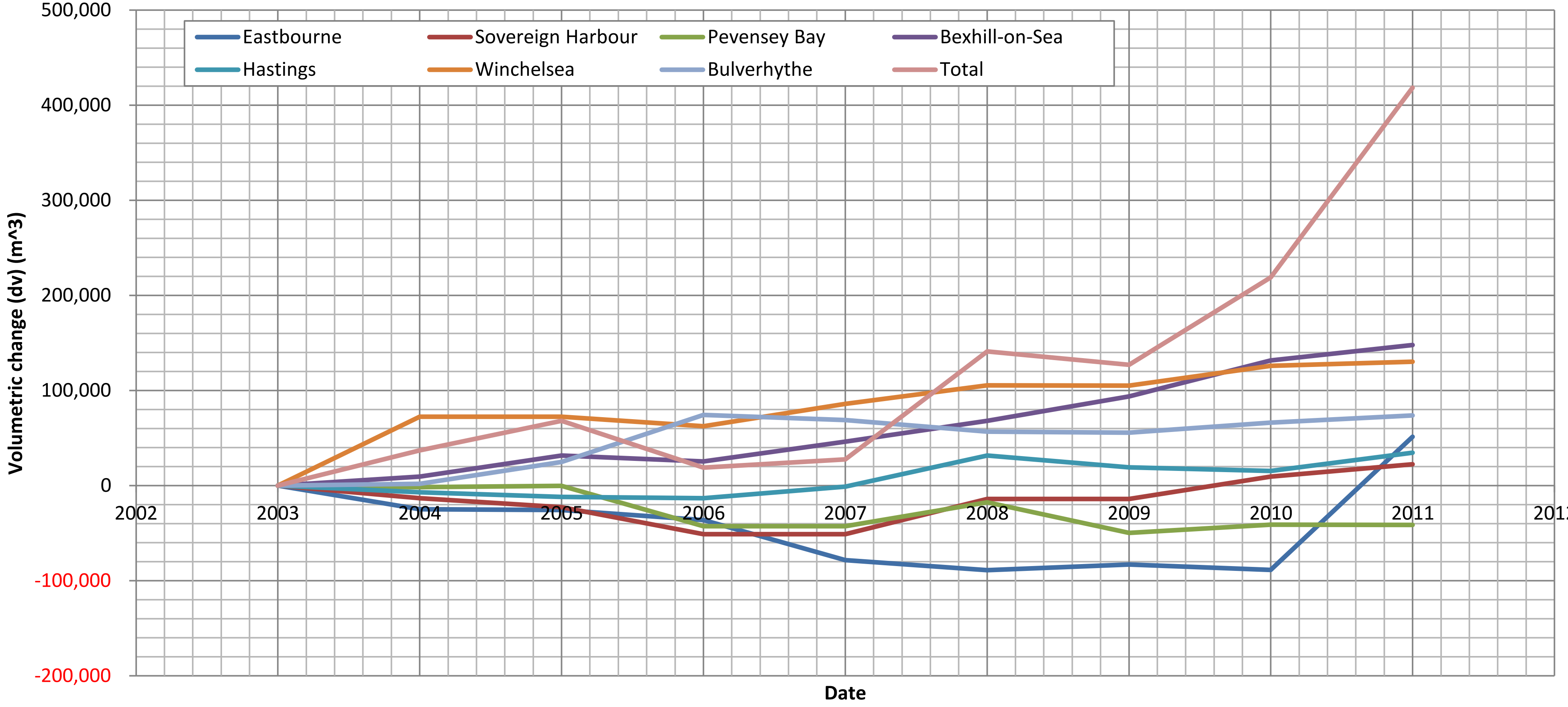


Figure 4-9 Cumulative volumetric change (dv) on all frontages since 2003 total volume

4.2 Level 3 - Coarse Sediment Budget

The level 3 sediment budget breaks down the management units into sub-cells according to similar coastal processes. The data is provided in visual and tabular format in the proceeding pages.

There is a residual volume of 7,796m^3/year at the western extent of Sovereign Harbour. Using the principles of conservation of mass, this volume should enter into Sovereign Harbour east. However after consultation with the relevant local authorities, it was decided that very little if any beach grade material leaves the west and ends up on the east of the harbour. This can be backed up by harbour dredging records, showing very low volumes of shingle in the dredged material. Therefore, this 7,796m^3/yr was considered to be a residual for the Eastbourne to Sovereign Harbour frontage. The reasons for this being so high could be explained due to the capital scheme in 1998/1999, with higher than expected losses in response to the large volume of placed material. Consequently, an attempt at quantifying this loss was made through weighting the residual to the length of the unit, providing an additional 'unaccounted' loss for the associated cells. Effectively, the residual is divided equally across the frontage so that errors are not compounded through the unit (creating artificially large transport rates). The Distance Weighted Residual was calculated as:

$$Distance\ Weighted\ Residual\ (DWR) = \ Length\ of\ cell. \left(\frac{residual\ for\ section}{length\ of\ section}\right)$$

This forced the transport rate past the terminal groyne to 0 and reduced the alongshore transport rates to those to be expected on this type of frontage. After distance weighting the residual (justified through larger than expected losses in the replenishment scheme) the section balanced well with the expected beach behaviour and magnitude of change shown. Note: DWR was added to the total loss for the individual cell for Plates 1 and 2.

A second, very low, residual volume of -505m^3/yr is shown at Rye Harbour. A negative residual indicates that the volume of sediment entering from updrift frontages is not sufficient to feed the flux at the downdrift extent of the budget.

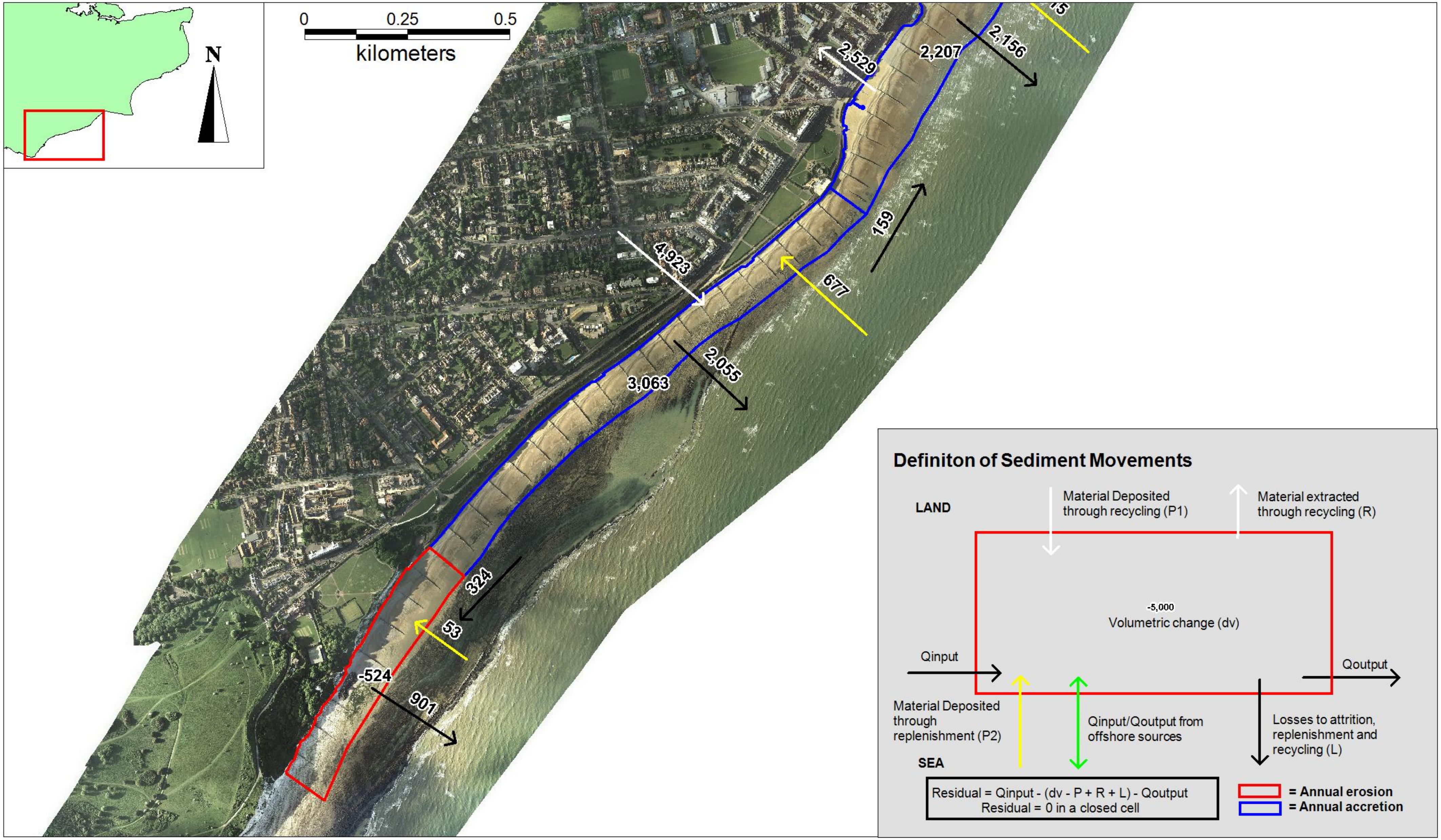
Table 4-1 Level 3 - Coarse Sediment Budget (All values in m^3/year)

Cell	Sub-cell	Average annual change (ΔV)	Recharge (P1)	Recycling		Bypassing (P3/R2)	Losses				Average annual flux (ΔV-P+R-L)	Distance Weighted Residual (DWR)	Qoutput*
				Deposition (P2)	Extraction (R1)		Attrition (L1)	Recharge (L2)	Recycling (L3)	Bypassing (L4)			
Eastbourne	1	-524	53				-127	-5	0	0	-445	-769	-324
	2	3,063	677	4,923			-192	-68	-246	0	-2,031	-1,549	159
	3	2,207	9,915		-2,529		-129	-992	0	0	-4,059	-1,036	3,181
	4	1,555	3,025	722			-145	-302	-36	0	-1,708	-1,170	3,719
	5	229	7,345	665			-219	-734	-33	0	-6,794	-1,763	8,750
	6	-1,221	853		-1,533		-124	-85	0	0	-332	-996	8,087
Sovereign Harbour	1	-2,984	0	0	-2,251	-8,243	-64	0	0	0	7,573	-514	0
	2	-3,092	16,660	22,840	-6,387	5,865	-169	-1,301	-1,666	-293	-38,800		38,800
	Stock				-2,378	2,378	0	0	0	-158			
Pevensey Bay	1	-746	0		-8,229		-89	0	0	0	7,571		31,228
	2	-529	0	1,117			-79	0	-56	0	-1,512		32,740
	3	-28	0		-1,022		-83	0	0	0	1,077		31,663
	4	255	0				-135	0	0	0	390		31,272
	5	956	3,256	6,019			-161	-326	-301	0	-7,532		38,804
	6	223	0		-1,838		-20	0	0	0	2,081		36,724
	7	275	0		-6,423		-104	0	0	0	6,802		29,922
	8	6	0	20,000			-89	0	-1,000	0	-18,905		48,826
	9	438	0		-6,899		-28	0	0	0	7,364		41,462
	10	-1,989	0		-9,235		-93	0	0	0	7,339		34,123
	11	-627	0	12,468			-36	0	-623	0	-12,435		46,558
	12	-1,991	0		-20,034		-224	0	0	0	18,267		28,291
Bexhill-on-Sea	1	5,455					-254	0	0	0	5,710		22,581
	2	9,552					-294	0	0	0	9,846		12,735
	3	3,343					-149	0	0	0	3,492		9,243
	4	-841					-81	0	0	0	-759		10,002

* Positive Qoutput values represent west to east drift, Negative Qoutput values represent east to west drift

Cell	Sub-cell	Average annual change (ΔV)	Recharge (P1)	Recycling		Bypassing (P3/R2)	Losses				Average annual flux (ΔV-P+R-L)	Qoutput
				Deposition (P2)	Extraction (R1)		Attrition (L1)	Recharge (L2)	Recycling (L3)	Bypassing (L4)		
Bulverhythe	1	7,419	3,036				-150	-304	0	0	4,836	5,166
	2	-2,366	4,312				-101	-431	0	0	-6,146	11,312
	3	7,389	3,218				-128	-322	0	0	4,621	6,691
Hastings	1	1,963					-278	0	0	0	2,241	4,450
	2	-1,404		1,215			-232	0	-61	0	-2,326	6,776
	3	3,507			-1,188		-161	0	0	0	4,856	1,920
	4	-150					-24	0	0	0	-126	2,047
Fairlight	1	-2,361					-256	0	0	0	-2,105	4,151
	2	-4,984					-407	0	0	0	-4,577	8,729
	3	-12,111					-417	0	0	0	-11,694	20,423
Winchelsea	1	11,177		9,186			-138	0	-459	0	2,589	17,834
	2	-269		11,912			-194	0	-596	0	-11,391	29,225
	3	11,662			-1,037		-337	0	0	0	13,036	16,189
	4	-5,427					-206	0	0	0	-5,221	21,410
	5	7,445					-102	0	0	0	7,547	13,863
	6	-5,812			-331		-200	0	0	0	-5,281	19,144
	7	-110			-19,729		-31	0	0	0	19,649	-505
Eastbourne to Rye Harbour		28,555	52,350	91,065	-91,041	0	-6,447	-4,870	-5,235	-412	-7,291	

Note: Sub-cell locations shown in Section 6.0

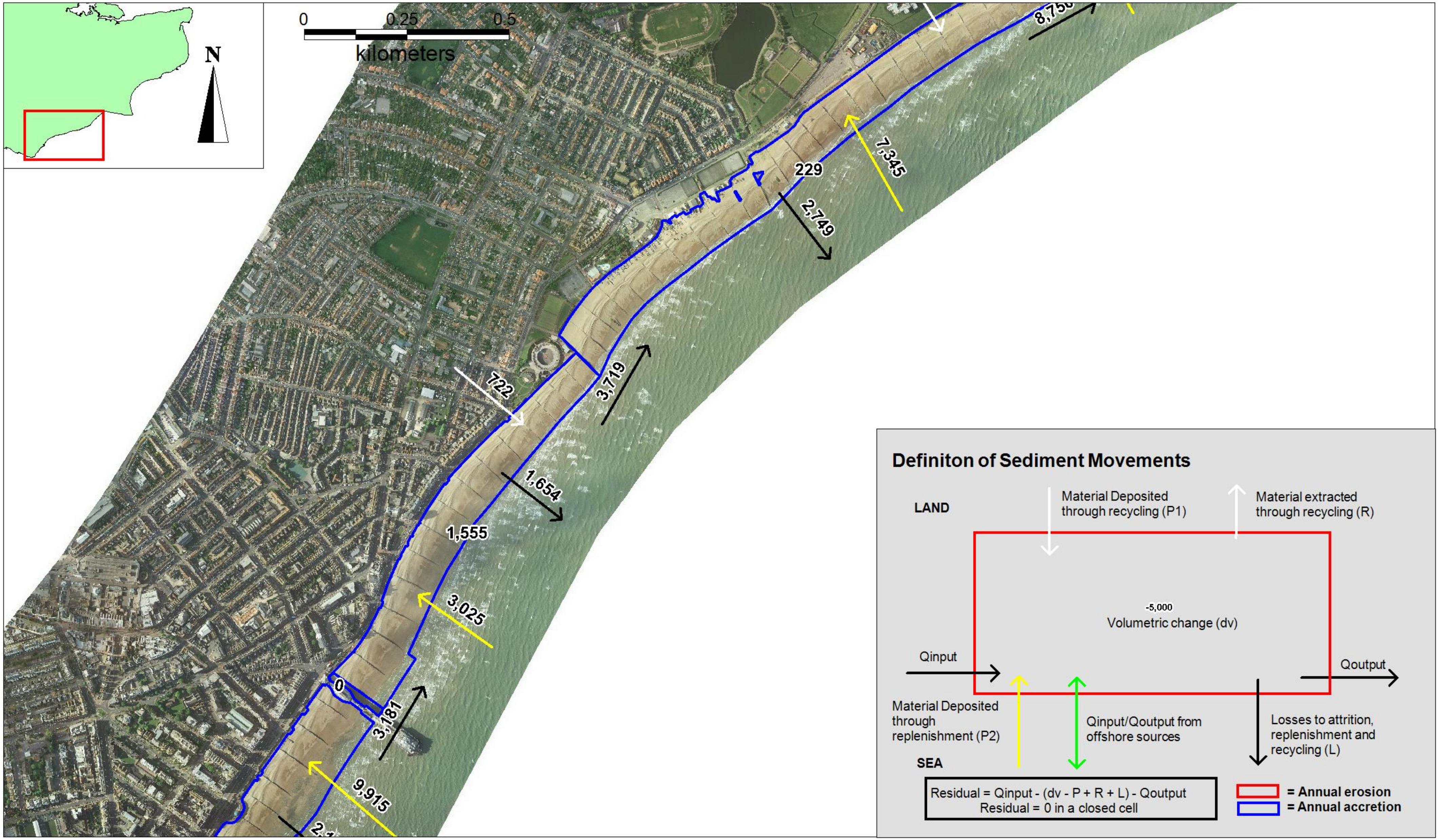


Eastbourne to Rye Harbour Sediment Budget

Eastbourne - 1

South East Regional Coastal Monitoring Programme

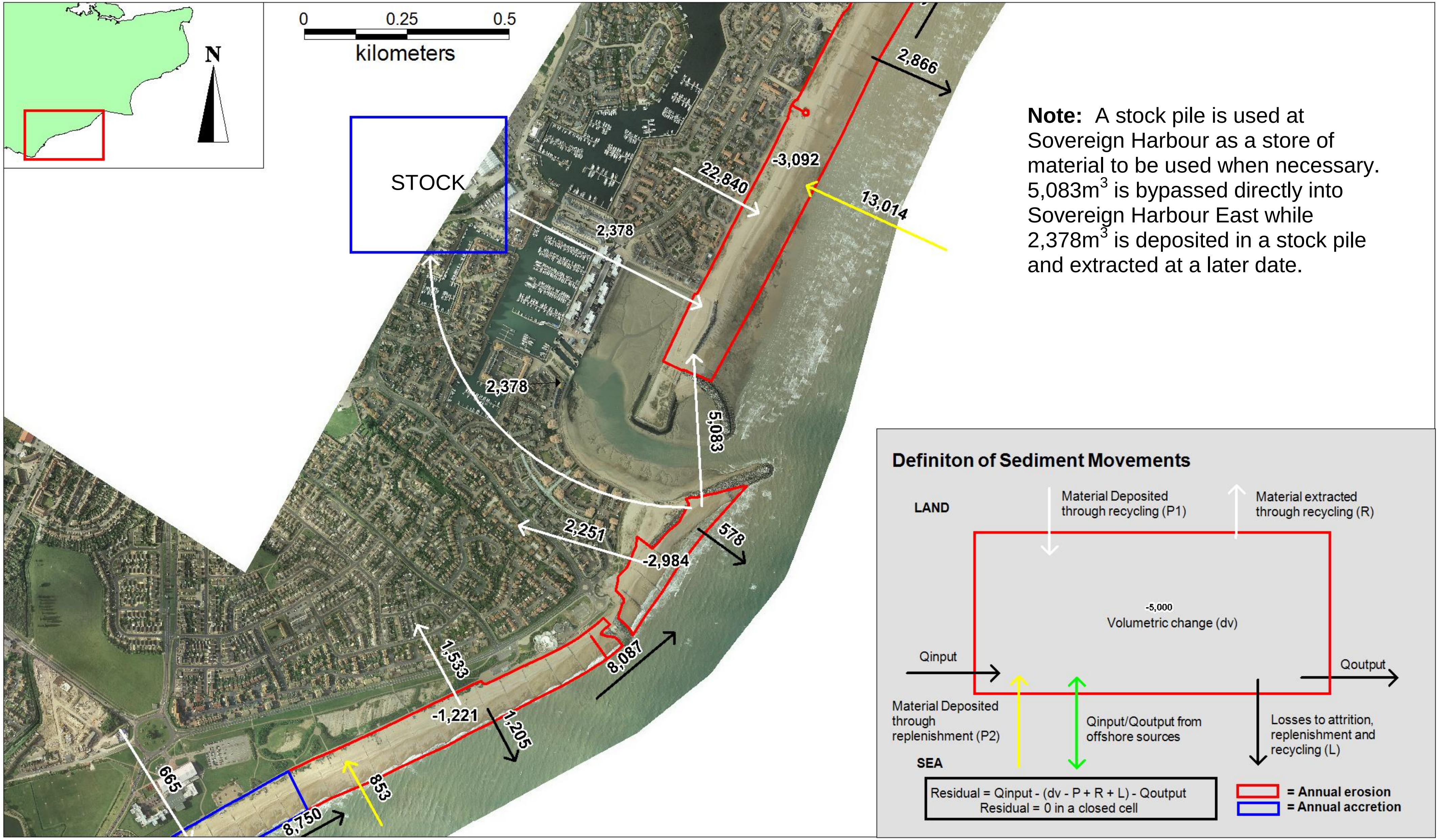
Level 3 - Sediment Budget



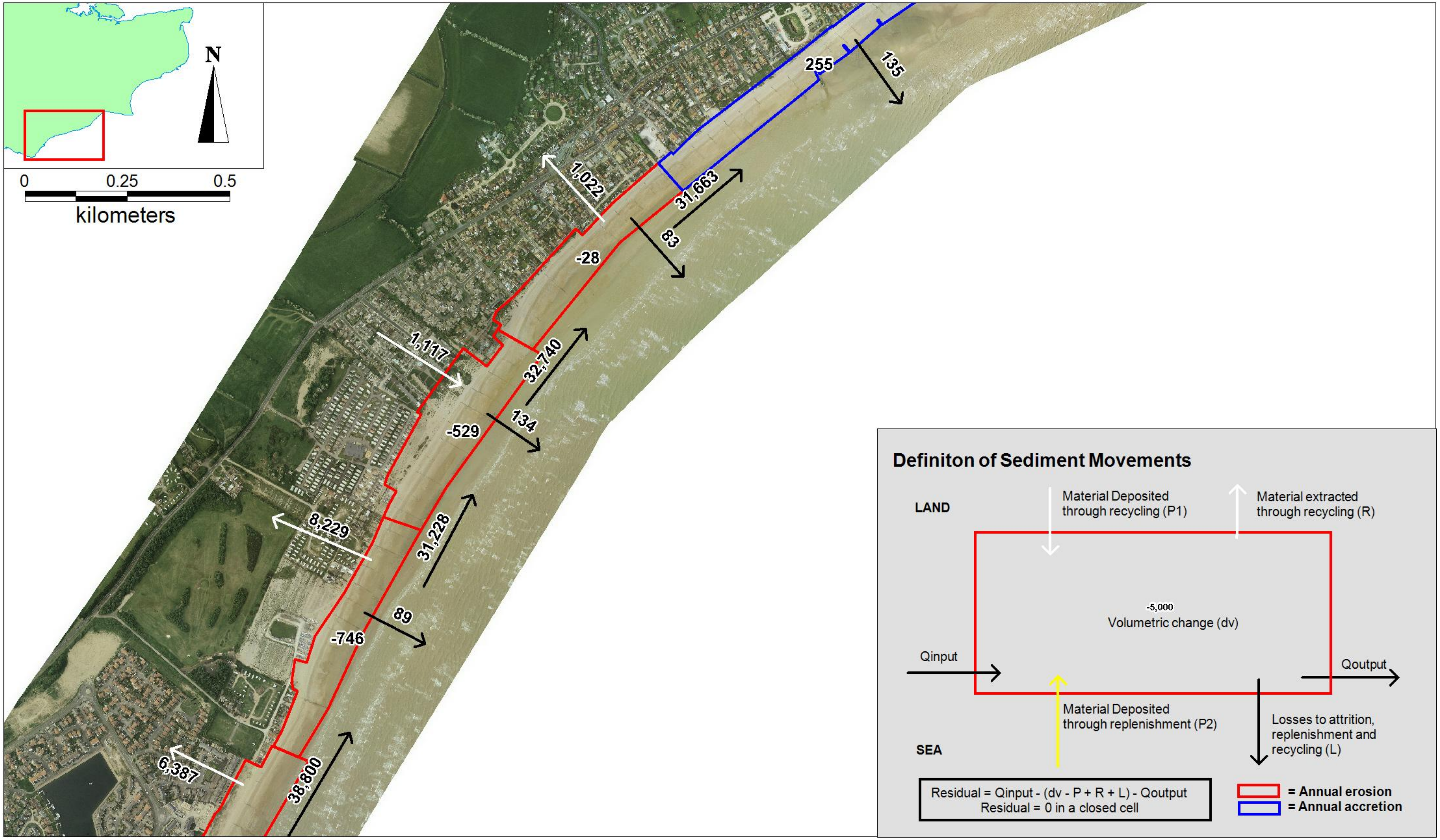
Eastbourne to Rye Harbour Sediment Budget

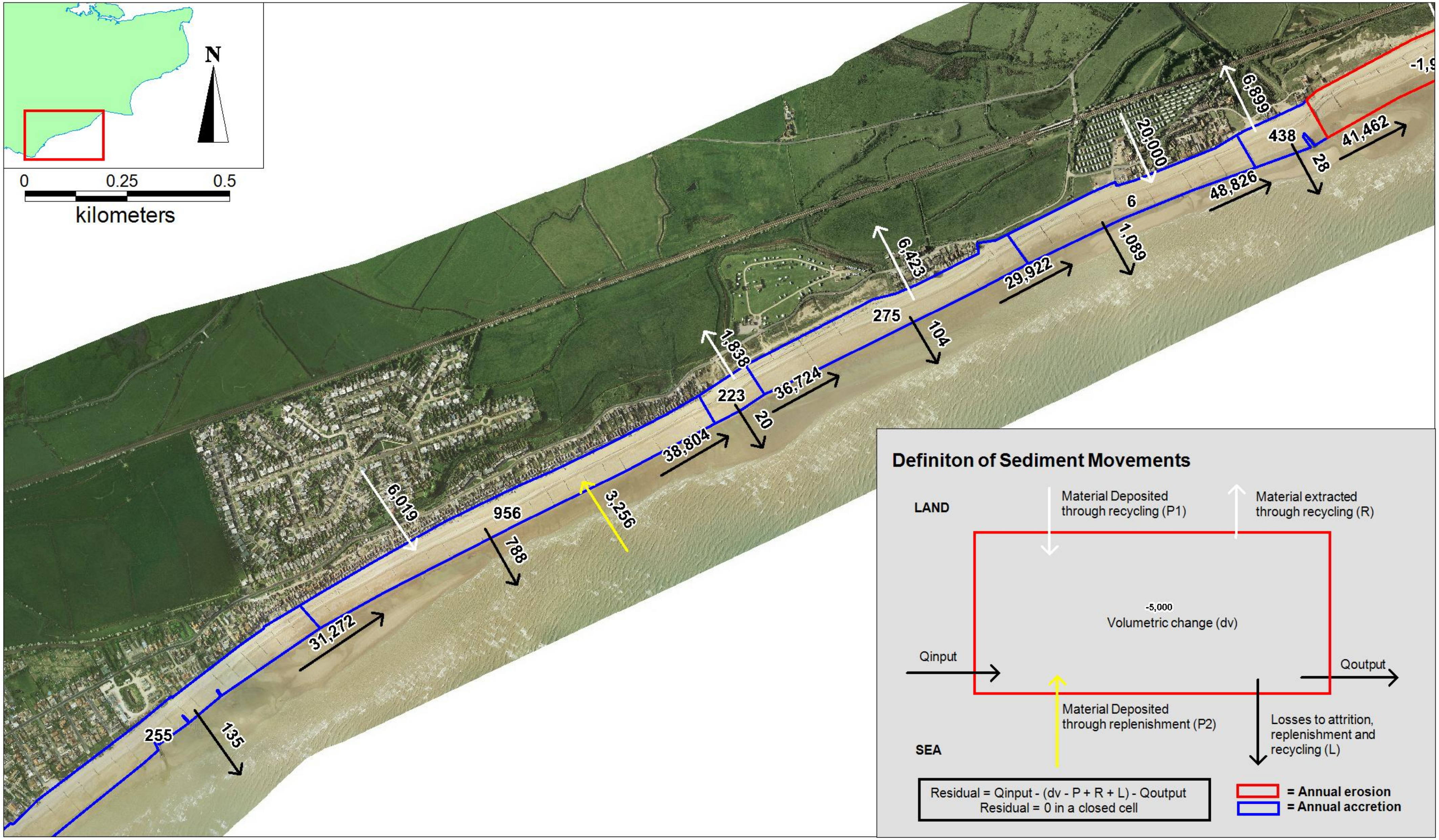
Eastbourne - 2

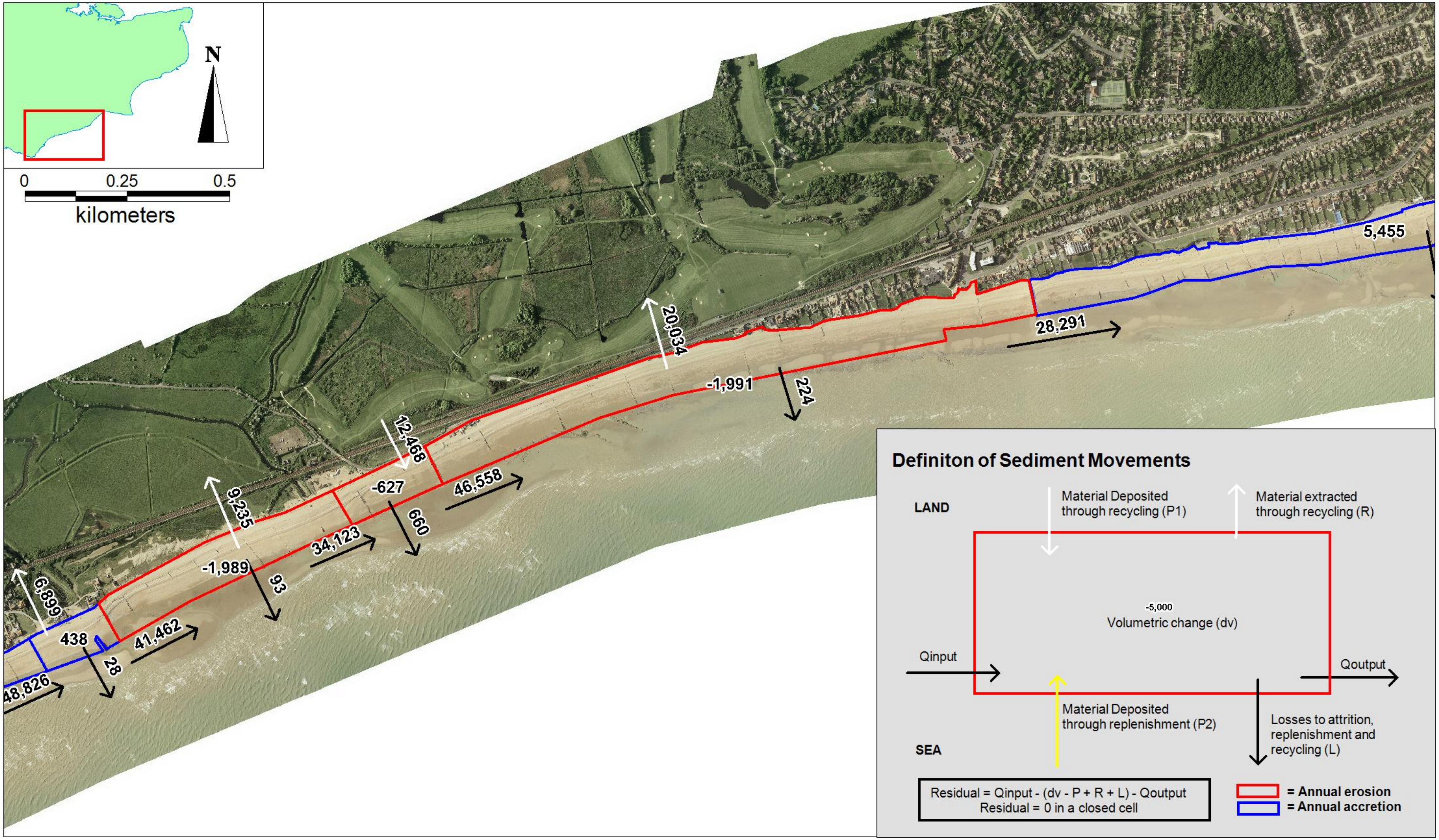
Plate 2 (2 of 16)

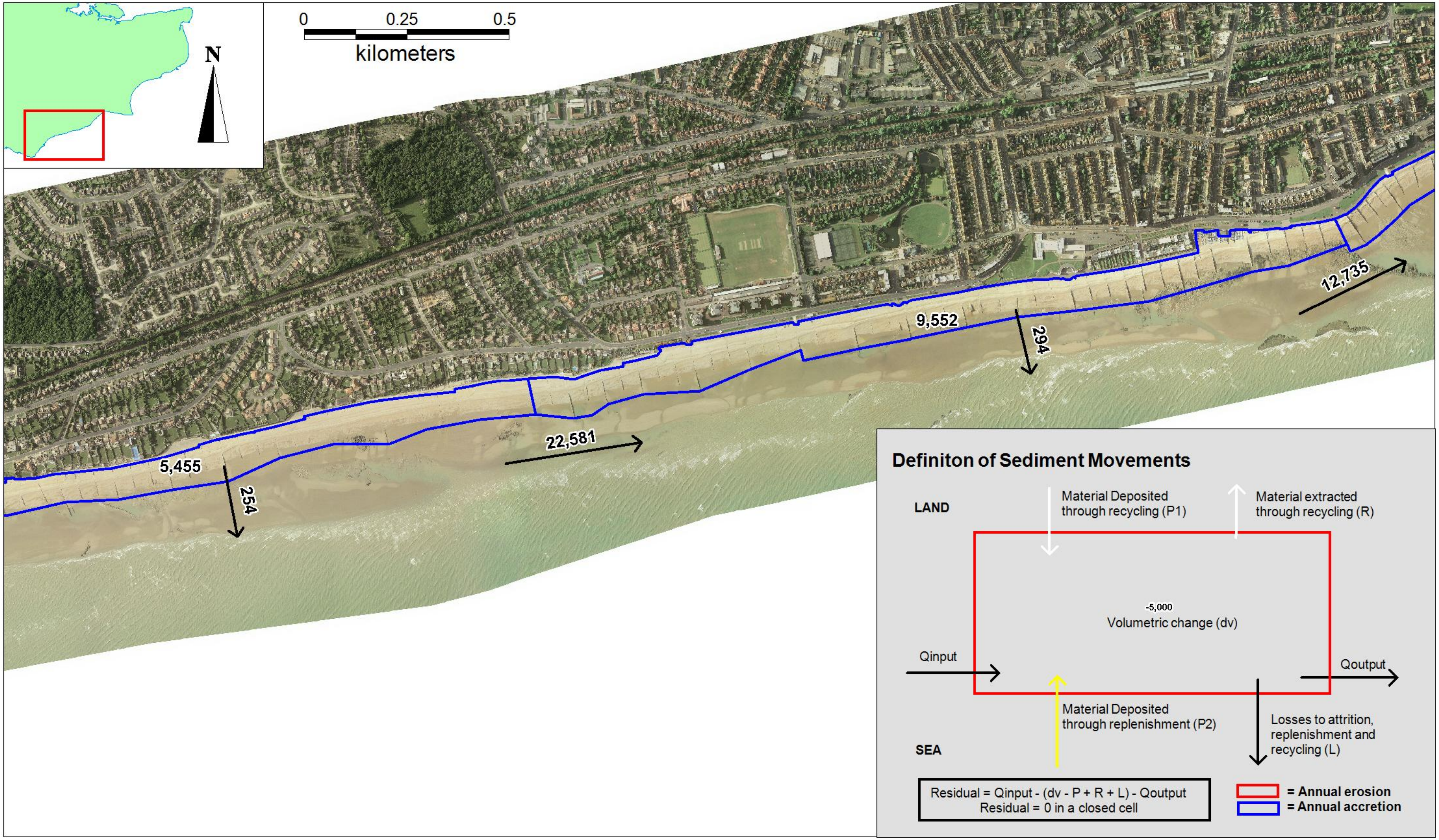


Note: A stock pile is used at Sovereign Harbour as a store of material to be used when necessary. 5,083m^3 is bypassed directly into Sovereign Harbour East while 2,378m^3 is deposited in a stock pile and extracted at a later date.

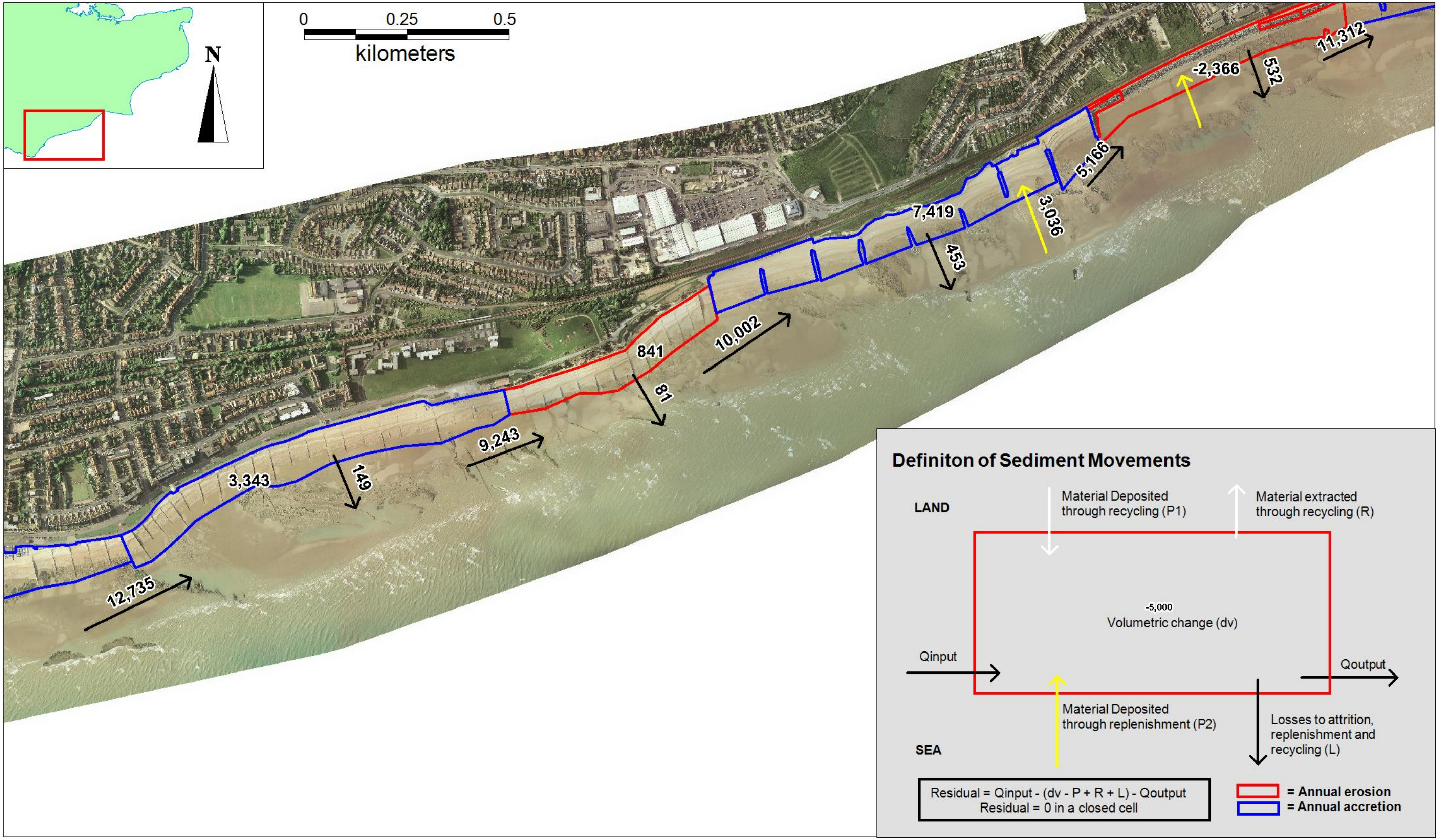

N
0
0.25
0.5
kilometers
255
135
1,022
31,663
83
-28
1,117
32,740
134
-529
8,229
31,228
89
-746
6,387
38,800
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion


N
0
0.25
0.5
kilometers
255
135
31,272
956
788
6,019
3,256
38,804
223
20
1,838
36,724
275
104
6,423
29,922
6
1,089
20,000
48,826
438
28
6,899
41,462
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion


N
0
0.25
0.5
kilometers
5,455
28,291
20,034
-1,991
224
12,468
-627
46,558
9,235
660
34,123
-1,989
93
6,899
438
41,462
28
48,826
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion



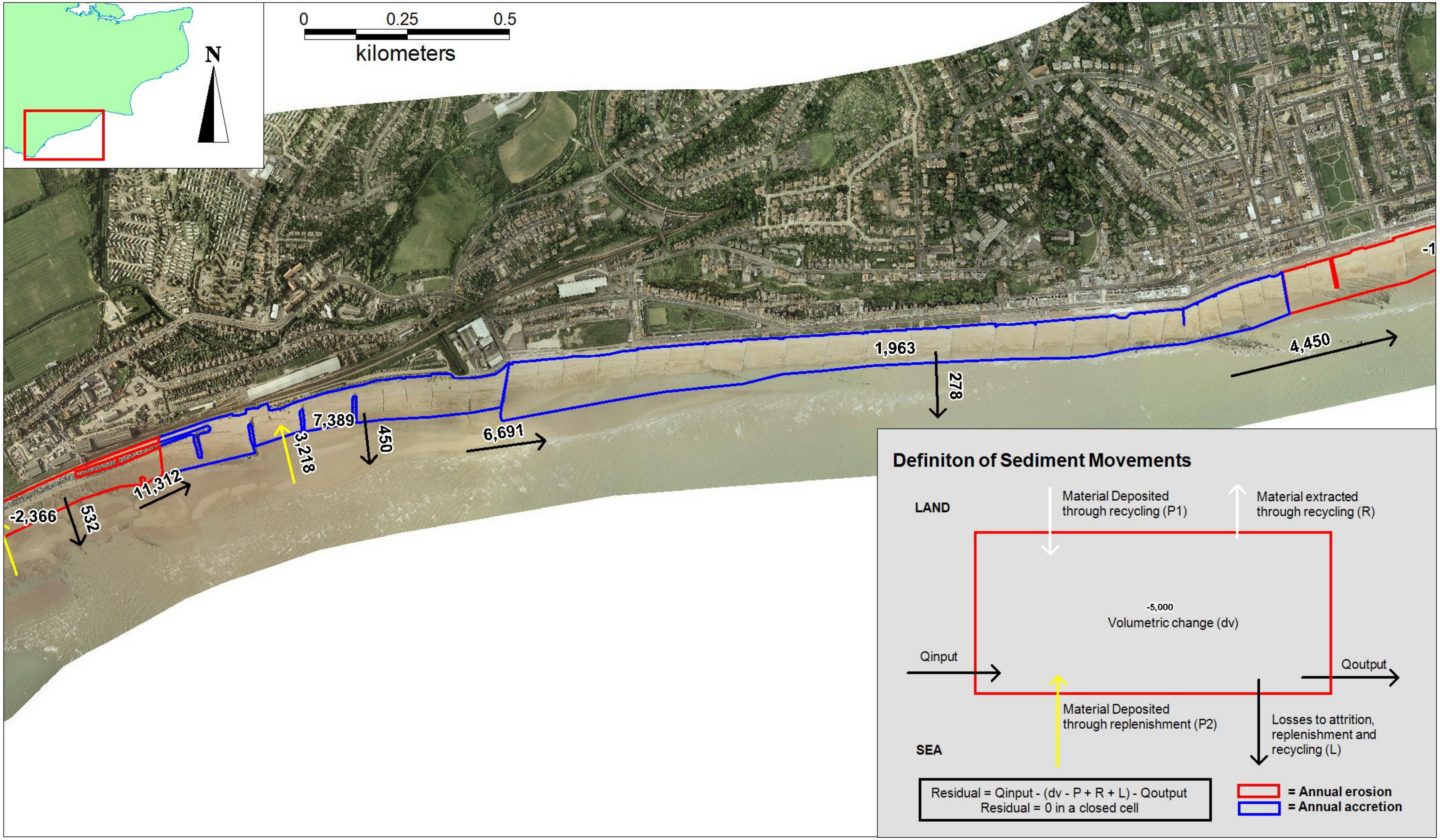
N
0
0.25
0.5
kilometers
5,455
254
22,581
9,552
294
12,735
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion



Eastbourne to Rye Harbour Sediment Budget

Bexhill-on-Sea to Bulverhythe

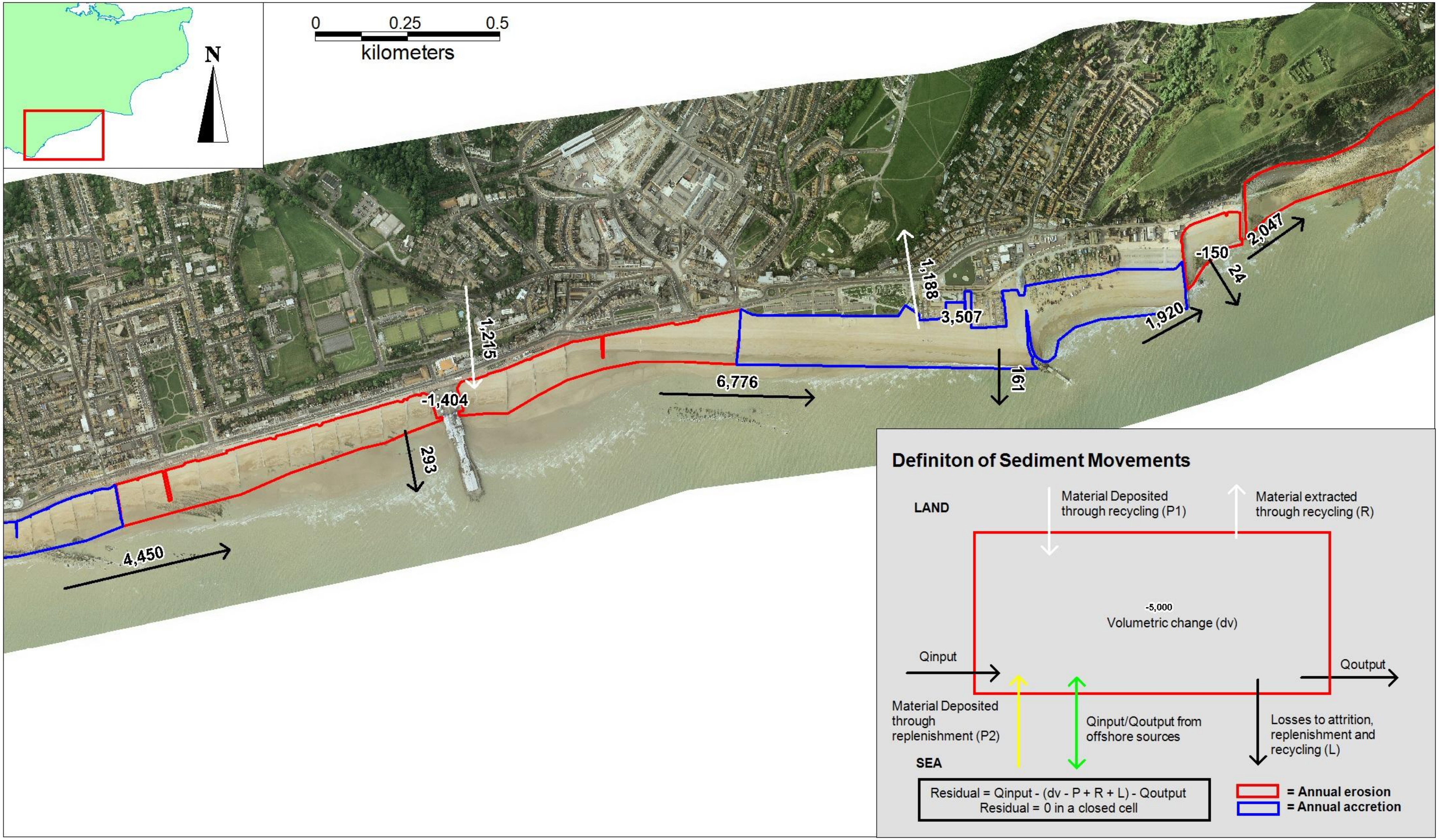
Plate 2 (8 of 16)



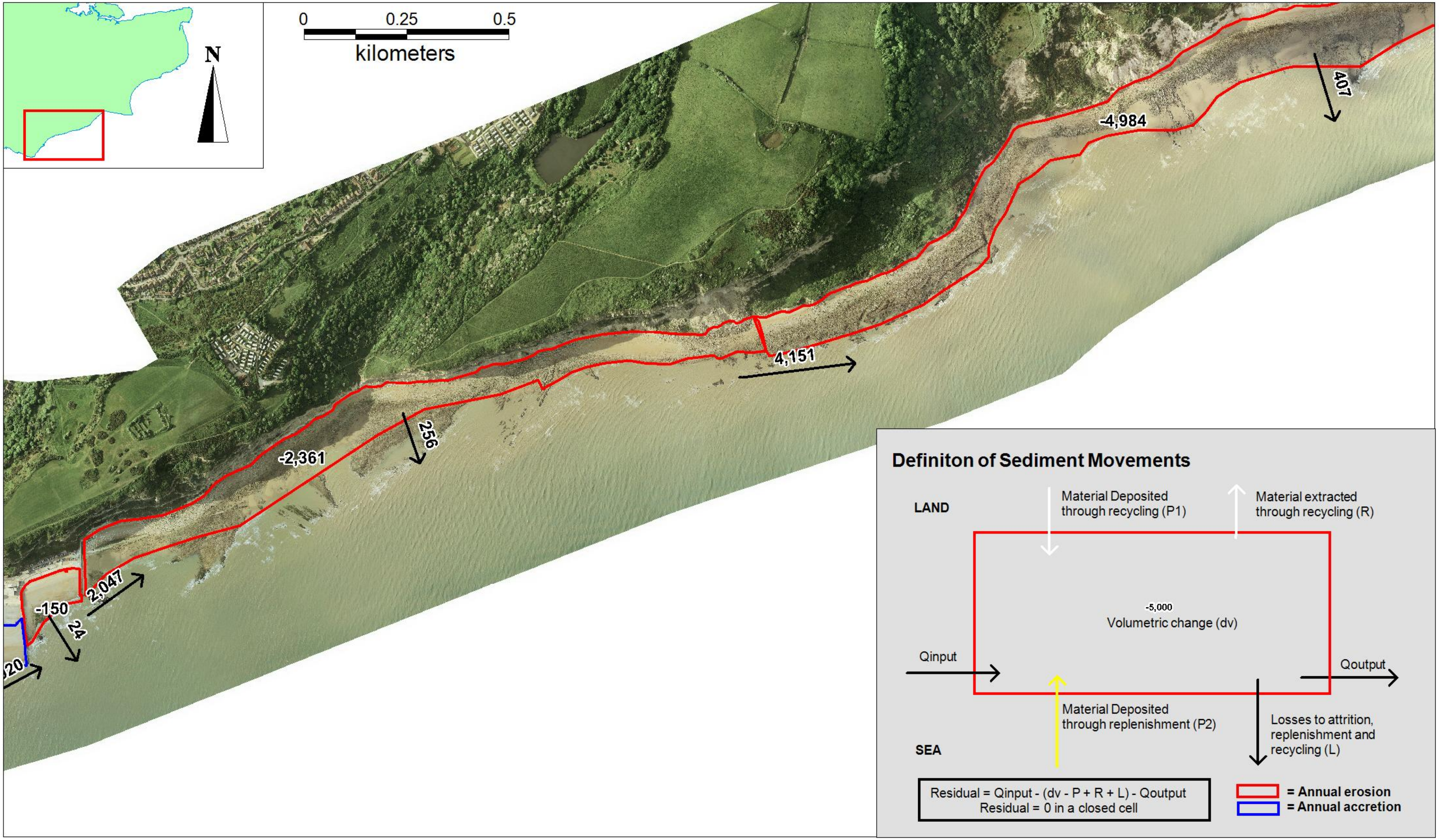
Eastbourne to Rye Harbour Sediment Budget

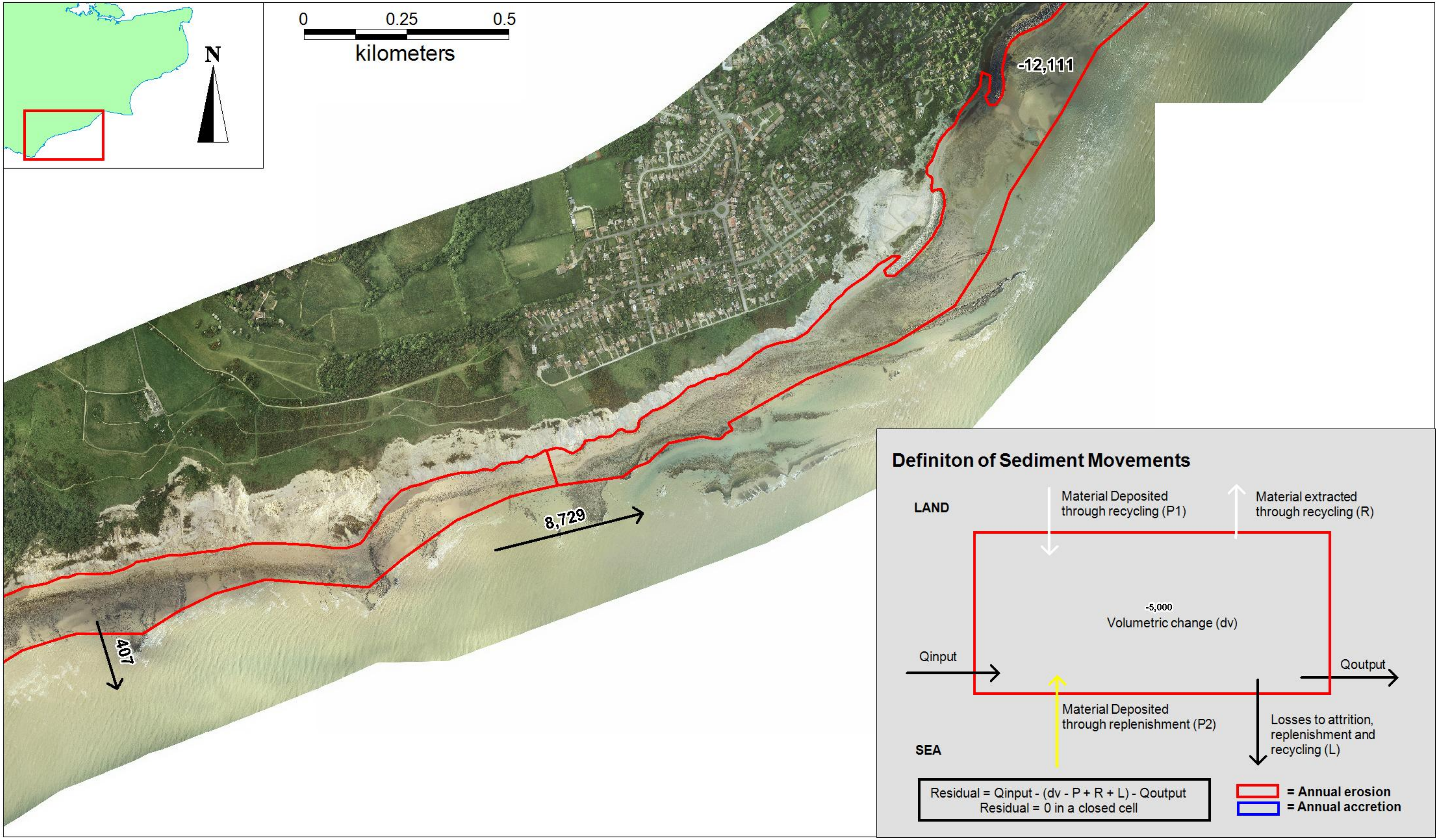
Bulverhythe to Hastings

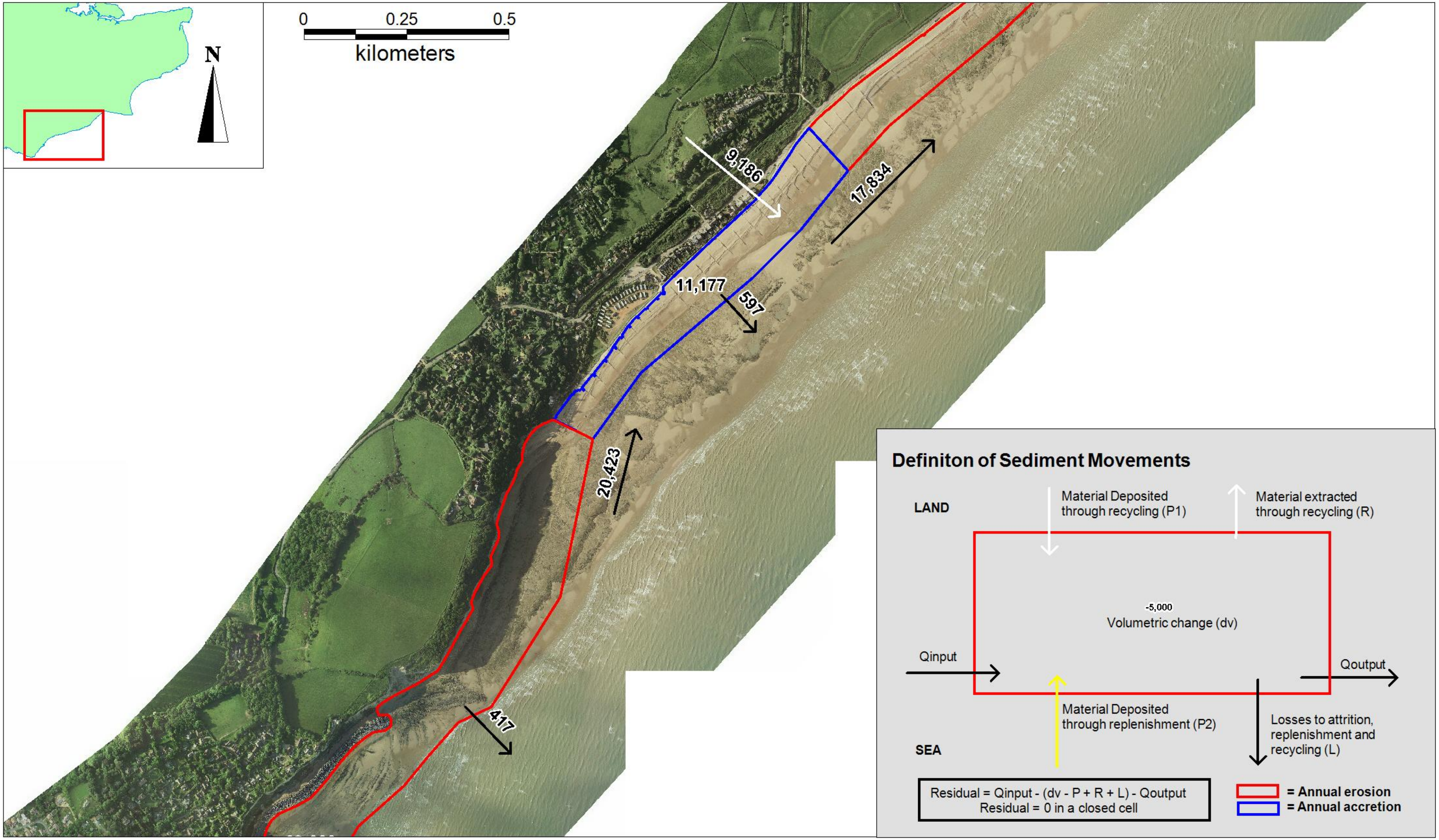
Plate 2 (9 of 16)

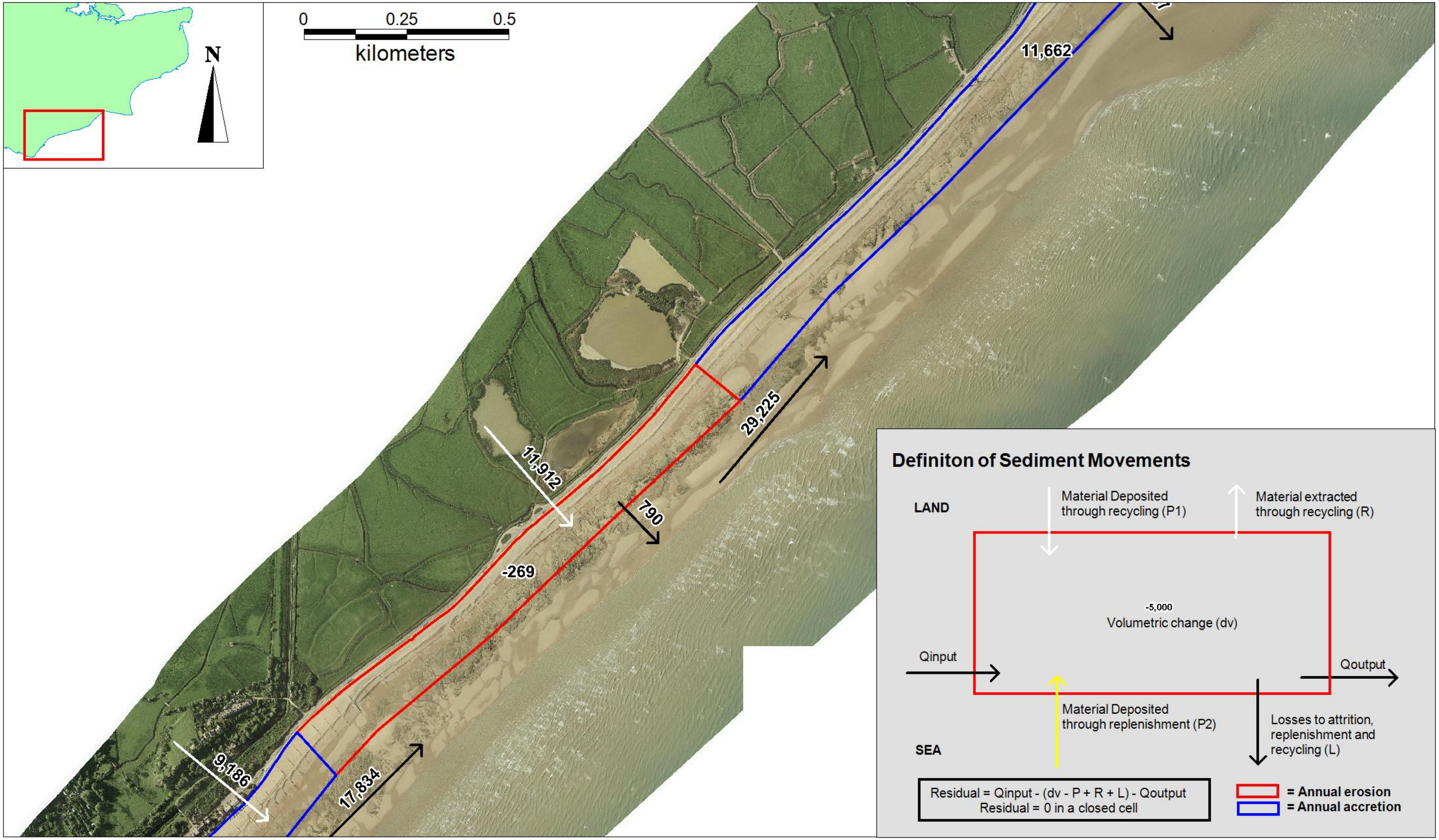


0
0.25
0.5
kilometers
N
1,215
-1,404
293
4,450
6,776
1,188
3,507
161
1,920
-150
24
2,047
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Qinput/Qoutput from offshore sources
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion


0
0.25
0.5
kilometers
N
-4,984
407
4,151
256
-2,361
2,047
-150
24
20
Definiton of Sediment Movements
LAND
Material Deposited
through recycling (P1)
Material extracted
through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited
through replenishment (P2)
Losses to attrition,
replenishment and
recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion

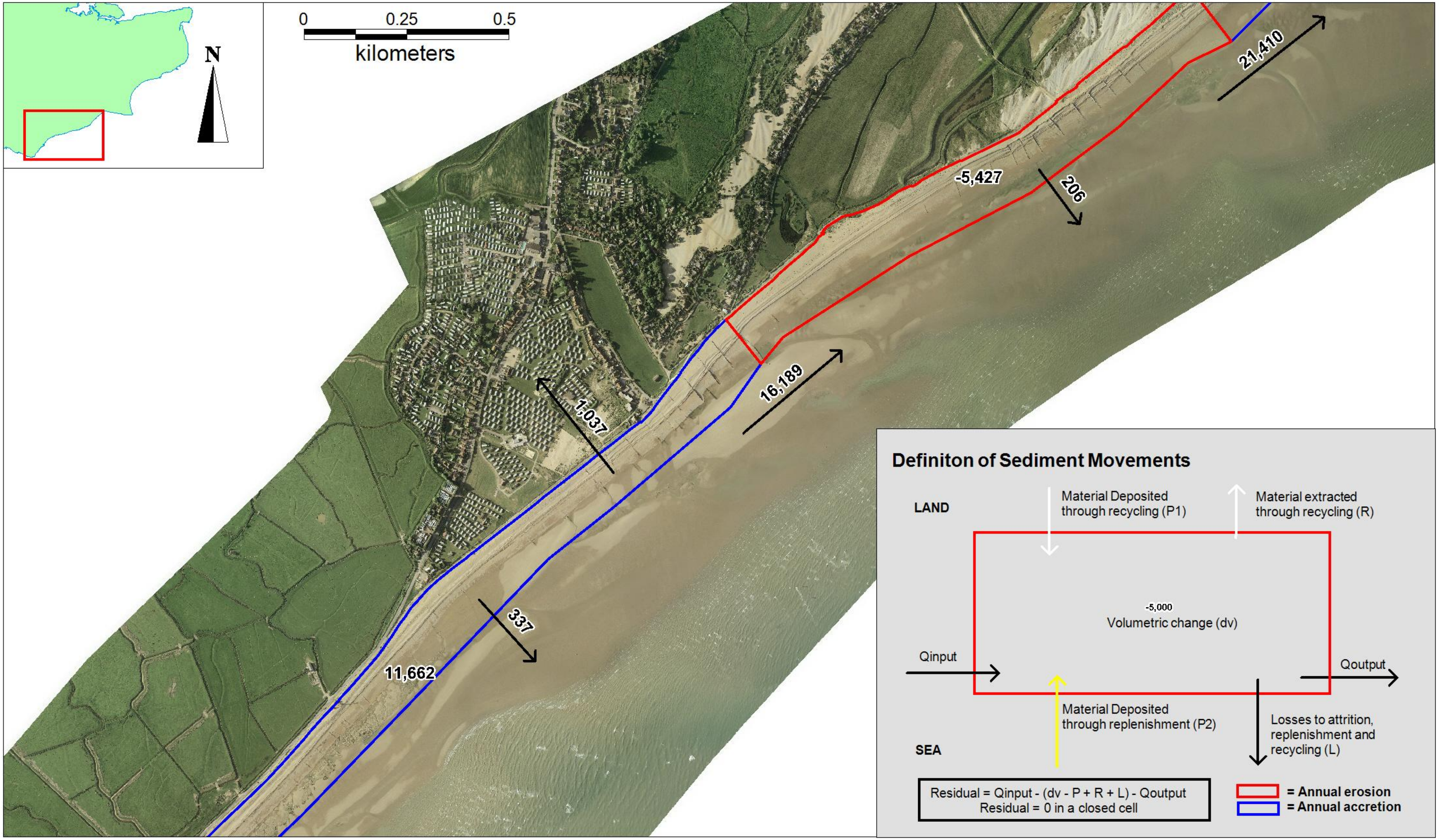

0
0.25
0.5
kilometers
N
-12,111
8,729
407
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion

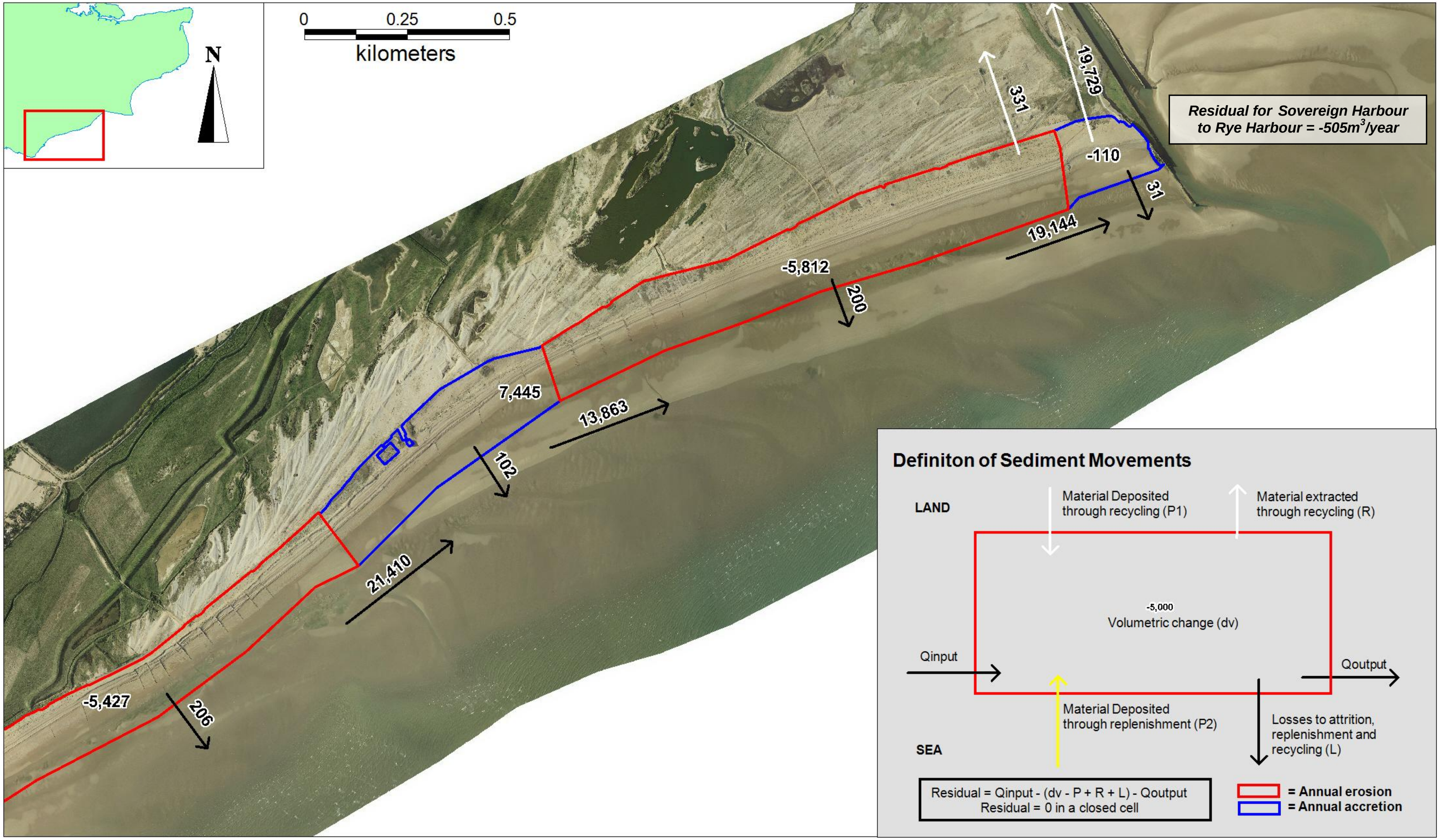

N
0
0.25
0.5
kilometers
9,186
17,834
11,177
597
20,423
417
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion



Eastbourne to Rye Harbour Sediment Budget

Winchelsea - 1


0
0.25
0.5
kilometers
N
21,410
-5,427
206
16,189
1,037
337
11,662
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion


0
0.25
0.5
kilometers
N
Residual for Sovereign Harbour to Rye Harbour = -505m3/year
19,729
331
-110
31
19,144
-5,812
200
7,445
13,863
102
21,410
-5,427
206
Definiton of Sediment Movements
LAND
Material Deposited through recycling (P1)
Material extracted through recycling (R)
-5,000
Volumetric change (dv)
Qinput
Qoutput
Material Deposited through replenishment (P2)
Losses to attrition, replenishment and recycling (L)
SEA
Residual = Qinput - (dv - P + R + L) - Qoutput
Residual = 0 in a closed cell
= Annual erosion
= Annual accretion

4.3 Level 4 - Regional Sediment Budget

The level 4 sediment budget has been analysed and displayed in both tabular and visual formats on the following pages to summarise the Level 3 coarse sediment budget. The total average annual flux for Eastbourne to Rye harbour is -7,296m^3/year. This figure can also be referred to as the residual for the whole budget, where in a closed system this residual should near 0. However, this residual is made up of two components, the residual from Eastbourne to Sovereign Harbour, 7,796m^3/yr, and the residual from Sovereign Harbour to Rye Harbour, -505m^3/yr. As previously discussed, the residual form Sovereign Harbour was not fed into the Pevensey frontage as the natural feed round the harbour has been shown to be minimal. This residual volume is likely to be lost over the whole frontage, a result of larger than expected losses from attrition, replenishment or recycling. This has been accounted for in a Distance Weighted Residual (DWR).

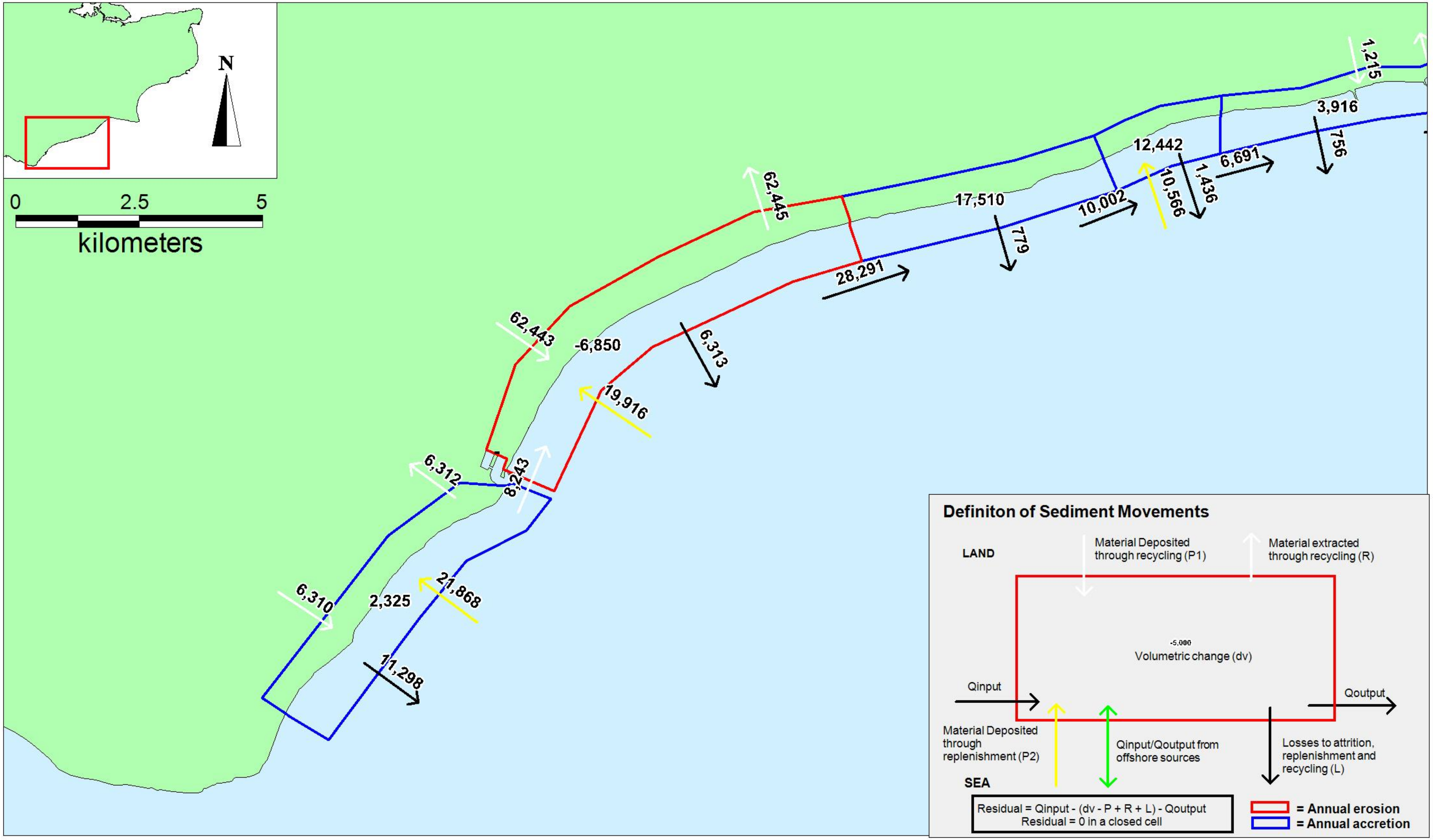
Over the 42,000m stretch of coastline, with a total beach volume in the order of 12,000,000m^3, 7,296m^3 or 0.00068% is unaccounted for. With the various assumptions in methodology in mind and the error in the data collected in SRCMP surveys, this residual suggests the budget is performing very well.

Frontages that are exporting material are clearly evident, such as Eastbourne, Sovereign Harbour and Pevensey Bay. This exported material is almost entirely taken up by the three frontages downdrift, Bexhill-on-Sea, Bulverhythe and Hastings. 2,046m^3/year is transported out of Hastings into the Fairlight frontage. The loss at Fairlight is roughly equivalent to the gain at Winchelsea yielding the low residual of -505m^3/year for Sovereign Harbour to Rye Harbour. The transport rates respond well to the presence of groyne fields, with transport rates increasing on open beaches such as Pevensey Bay and Winchelsea and reducing on groyned frontages such as Eastbourne and Bexhill-on-Sea.

Table 4-2 Level 4 - Regional Sediment Budget (m^3/year)

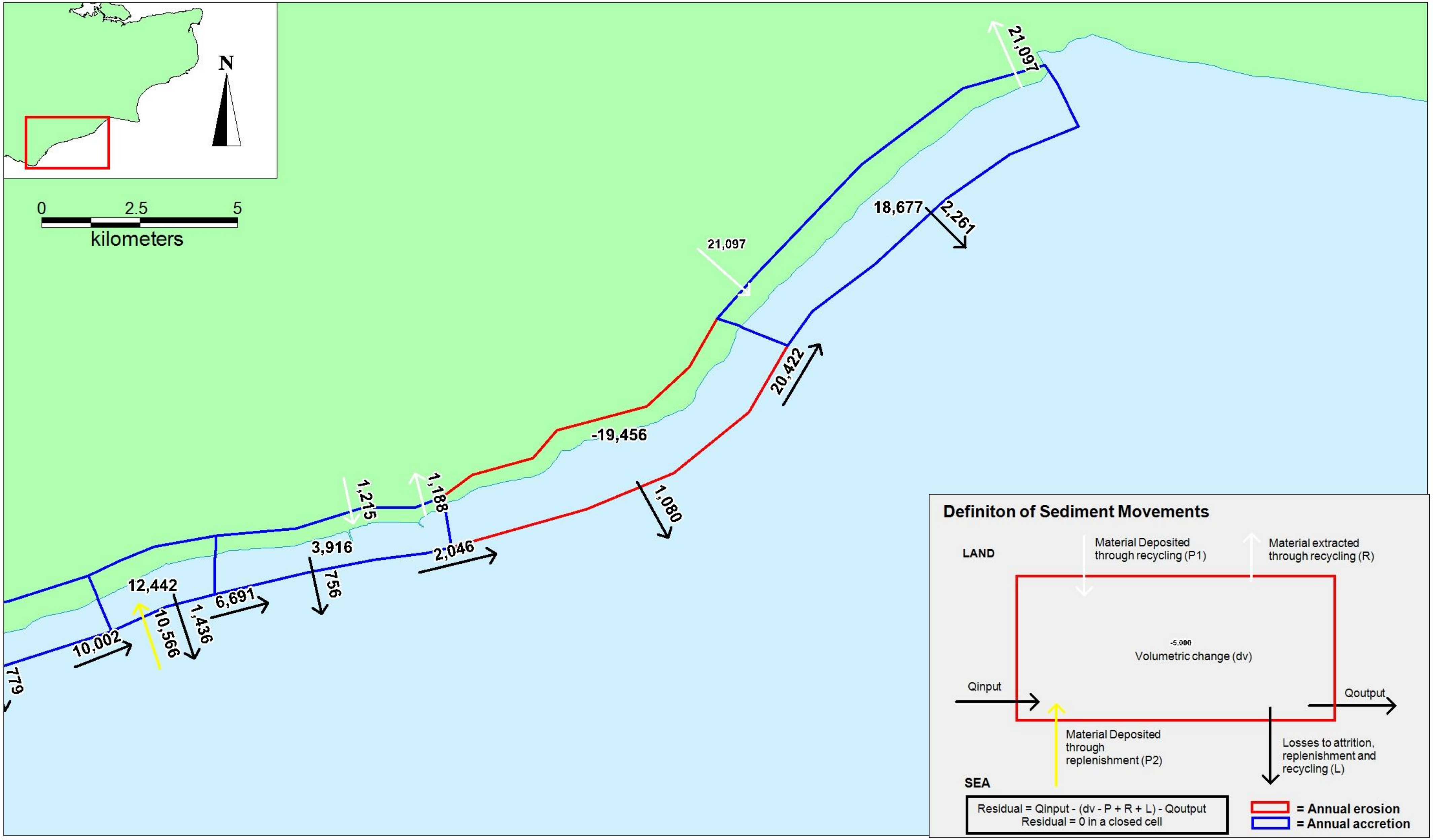
		Average Annual Change (m^3/year)							
		Eastbourne to Langney Point	Sovereign Harbour to Cooden	Bexhill-on-Sea	Bulverhythe	Hastings	Fairlight	Winchelsea	Eastbourne to Rye Harbour
Average Annual Change (ΔV)		2,325	-6,850	17,510	12,442	3,916	-19,456	18,667	28,555
Recharge (P1)		21,868	19,916	0	10,566	0	0	0	52,350
Recycling	**Deposition (P2)**	6,310	62,443	0		1,215	0	21,097	91,065
	Extraction (R1)	-6,312	-62,445	0		-1,188	0	-21,097	-91,041
Bypassing (P3/R2)		-8,243	8,243	0		0	0	0	0
Losses	**Attrition (L1)**	-999	-1,310	-779	-379	-695	-1,080	-1,207	-6,447
	Recharge (L2)	-2,187	-1,992	0	-1,057	0	0	0	-4,870
	Recycling (L3)	-315	-3,122	0	0	-61	0	-1,055	-4,553
	Bypassing (L4)	0	-254	0	0	0	0	0	-254
Average Annual Flux (ΔV-P+R-L)		-7,796	-28,291	18,289	3,311	4,645	-18,376	20,928	-7,291
Distance Weighted Residual (DWR)*		-7,796							-7,796
Qinput		0	0	28,291	10,002	6,691	2,046	20,422	
Qoutput		0	28,291	10,002	6,691	2,046	20,422	-505	

* See section 4.2.



Eastbourne to Rye Harbour Sediment Budget

Plate 1 (1 of 2)



Eastbourne to Rye Harbour Sediment Budget

4.4 Level 4 – Beach Volumes

Beach volumes over all timescales were calculated for each frontage to show the actual total volumes of sediment rather than just the volumetric change. The method for the calculation of these volumes is provided in Appendix B. The beach volumes show logical and conceivable beach volumes over the majority of frontages and time scales. This provides confidence in both the methodology for calculating the volumetric change and the methodology for calculating the beach volume. However, in 1890 and 1910, Hastings shows very small beach volumes (less than 100,000m^3). The explanation for this is explored in depth in the analysis of Historic Beach Volumetric Change (Section 4.6).

Table 4-3 Beach Volumes

	BEACH VOLUME (m^3)											
	2011	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**1930**	**1910**	**1890**
EASTBOURNE	2,023,478	1,883,582	1,889,269	1,883,378	1,893,699	1,935,895	1,946,602	1,947,418	1,972,237	1,285,175	1,657,719	1,656,387
SOVEREIGN HARBOUR	797,090	784,017	774,586	774,586	788,614	788,614	817,095	826,434	839,743	1,138,819	1,358,022	1,282,730
PEVENSEY BAY	3,158,207	3,158,637	3,150,008	3,182,011	3,157,096	3,157,096	3,199,344	3,198,025	3,199,731	2,733,075	2,409,324	2,500,661
BEXHILL ON SEA	1,323,805	1,307,594	1,269,686	1,243,953	1,222,016	1,201,381	1,207,473	1,185,412	1,175,885	1,044,921	1,009,040	973,160
BULVERHYTHE	747,760	740,386	729,759	730,784	742,946	748,501	699,005	676,058	674,102	730,210	815,321	801,477
HASTINGS	1,644,438	1,625,301	1,629,057	1,641,406	1,608,702	1,596,665	1,597,859	1,602,820	1,609,907	534,095	97,838	96,580
FAIRLIGHT	736,901	787,683	803,159									
WINCHELSEA	2,216,113	2,211,769	2,190,988	2,191,409	2,171,972	2,148,252	2,158,359	2,158,359	2,085,977	2,135,872	2,886,539	

Note: Fairlight has only 3 years of complete survey coverage and so beach volumes have only been calculated over those timescales.

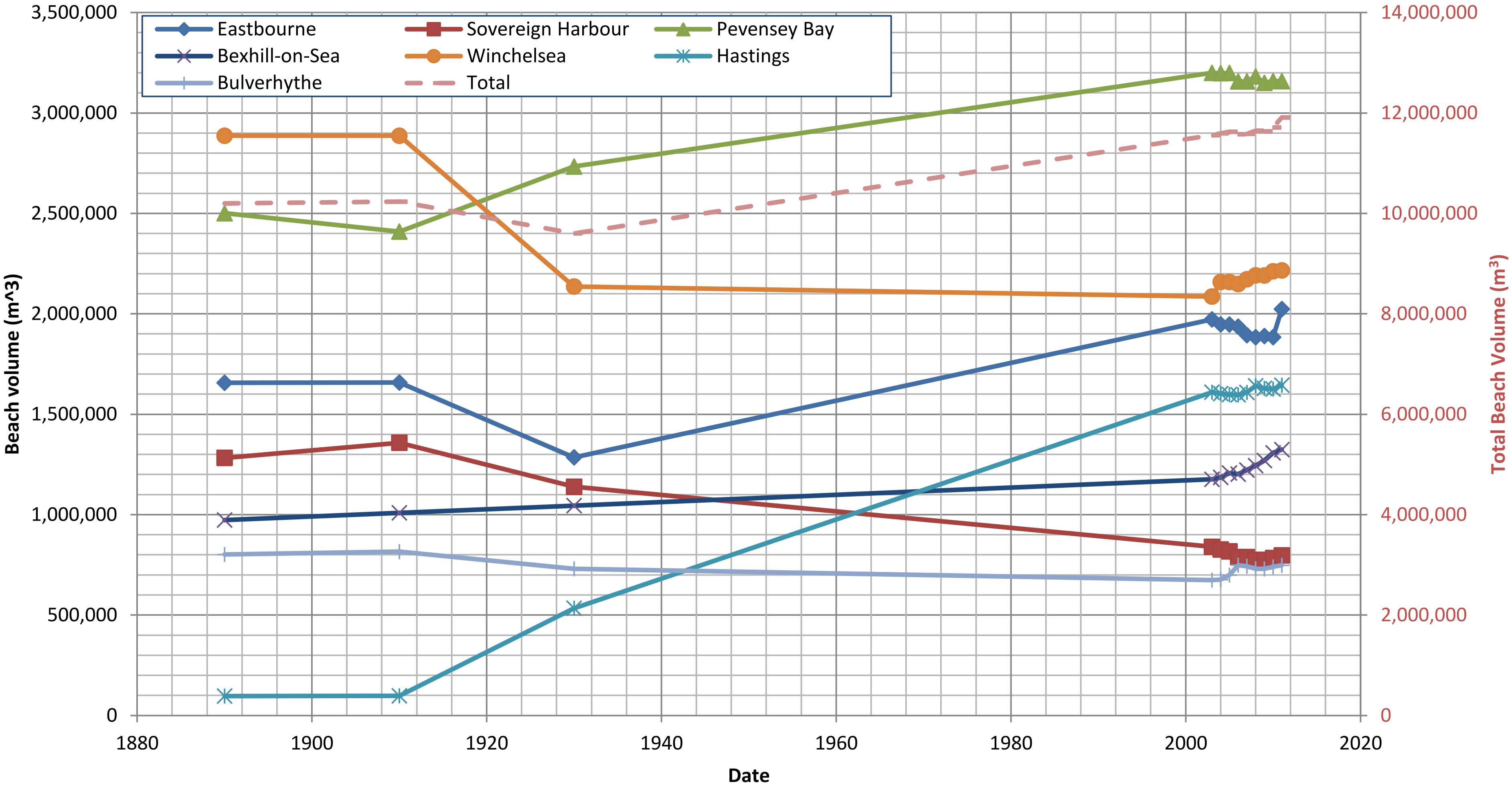


Figure 4-10 Comparison of beach volumes since 1870

Figure 4.10 shows the relative changes in total beach volume over a longer period of time. This helps to put the more recent volumetric changes explored through the contour plots and sediment budgets into perspective. Taking Sovereign Harbour as an example, it shows that the recent loss of material is fairly insignificant in relation to the long term trend over the past 100 years. Fairlight has not been included as there is only three years of complete data for the frontage as a whole.

4.5 Historic Volumetric Change (Level 4)

The historic beach volumetric change has also been provided to help place the most recent changes and sediment budget interpretations into the context of a longer time scale. Stive et al. (2002) identified that the spatial and temporal scale of an analysis are interlinked. When looking over very small timescales, a very fine spatial analysis is possible. As the analysis of historic beach change is over multiple decades, it is unfeasible to view beach volumetric changes on a small spatial scale (Stive et al., 2002). Therefore, analysis of historic beach volumetric change has been undertaken at Level 4 as the most appropriate spatial scale to the temporal period of the analysis.

Table 4-4 Historic beach volumetric change since 1890

		Volumetric Change (m^3)								Total Change (m^3)
		Eastbourne	Sovereign Harbour	Pevensey Bay	Bexhill-on-Sea	Bulverhythe	Hastings	Fairlight	Winchelsea	
1910-1890	Change	1,332	75,292	-91,337	No Data	13,844	1,258	-288,012	No Data	-287,623
	Annual Change	67	3,765	-4,567		692	63	-14,401		-14,381
1930-1910	Change	-372,544	-219,203	323,751	No Data	-85,111	436,257	-160,724	-750,667	-828,241
	Annual Change	-18,627	-10,960	16,188		-4,256	21,813	-8,036	-37,533	-41,412
2003-1930	Change	687,062	-299,076	466,656	No Data	-56,108	1,075,812	87,432	-49,895	1,911,882
	Annual Change	9,412	-4,097	6,393		-769	14,737	1,198	-683	26,190
2003-1870	Change	-	-	-	238,606	-	-	-	-	
	Annual Change	-	-	-	1,794	-	-	-	-	

The annual rate is provided to place volumetric changes into perspective. This assumes a linear rate of change between the known beach volumes which is a significant and erroneous assumption. Consequently, no analysis of annual rates of change is undertaken in the following pages. The analysis of beach volumetric changes since 1890 seeks to justify the figures provided in Table 4.4, rather than explain why those changes occur which was deemed to be outside the scope of this report.

4.5.1 Eastbourne

Eastbourne gained 700,000m^3 over the 70 years from 2003-1930. Despite uncertainty about volume changes for most of that period, much of this increase can be attributed to the 1996-1999 capital scheme that saw the groyne field rebuild and replenishment of 794,662m^3. A profile taken through the beach just east of the pier shows the beach face translating seawards by as much as 50m with the crest elevation increased from +4.2mOD to +5.7mOD. The processes that led to the loss of beach prior to 1996 are still active and are reflective in the gradual – though small scale – decline in volumes over the last decade.

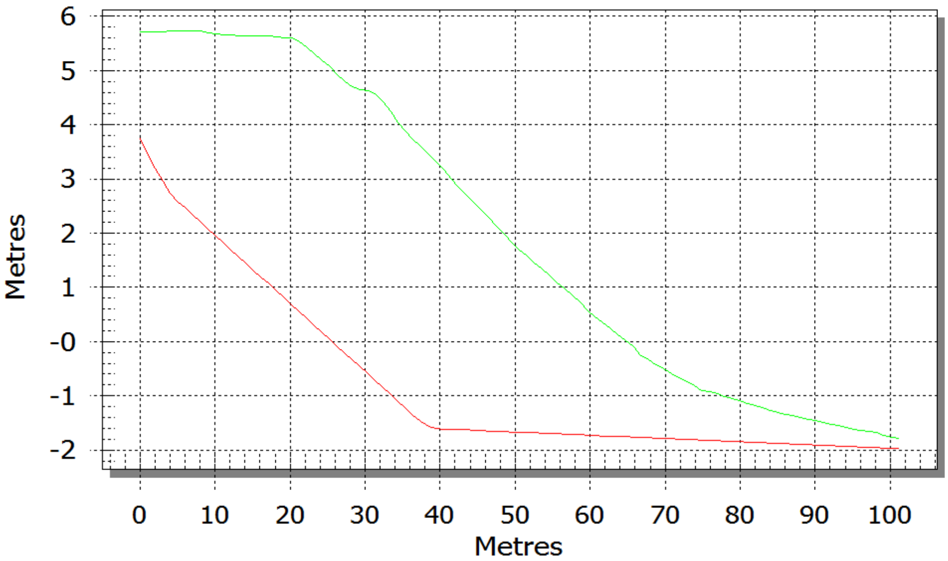


Figure 4-11 Cross section through DTM's in Eastbourne in 2003 (green) and 1930 (red)

Further evidence can be drawn from looking at historical images of the beach in Eastbourne. In the photo from 1930, the beach is very close to the sea wall, with little evidence of a berm, shown by a uniform slope angle from toe to sea wall. In the 2003 image a much wider beach is present with a berm clearly evident. This corresponds well to Figure (4.11) showing a higher and wider crest in 2003 than in 1930.

Figure 4-12 Eastbourne Pier from Wish Tower in 1930 (left) and 2003 (right) (img.auctivia.com, 2012);(Pevensey-bay.org.uk, 2003)

4.5.2 Sovereign Harbour

Sovereign Harbour was ~400,000m³ smaller in 2003 compared to the turn of the century. This is particularly evident at the eastern edge of Sovereign Harbour where the beach has cut back by as much as 100m from the position held in 1910. This is shown in Figure 4.13 in the cross section as well as in the MHW marks plotted on aerial photography. In addition to the localised cutback shown in the cross sections, the whole beach has moved landwards contributing to the loss of 500,000m^3 over the last 90 years. This implies that the significant negative flux found through the sediment budget is not a recent trend and has been occurring for the last 100 years, now exacerbated by the harbour itself and only partly addressed by the bypassing operations.

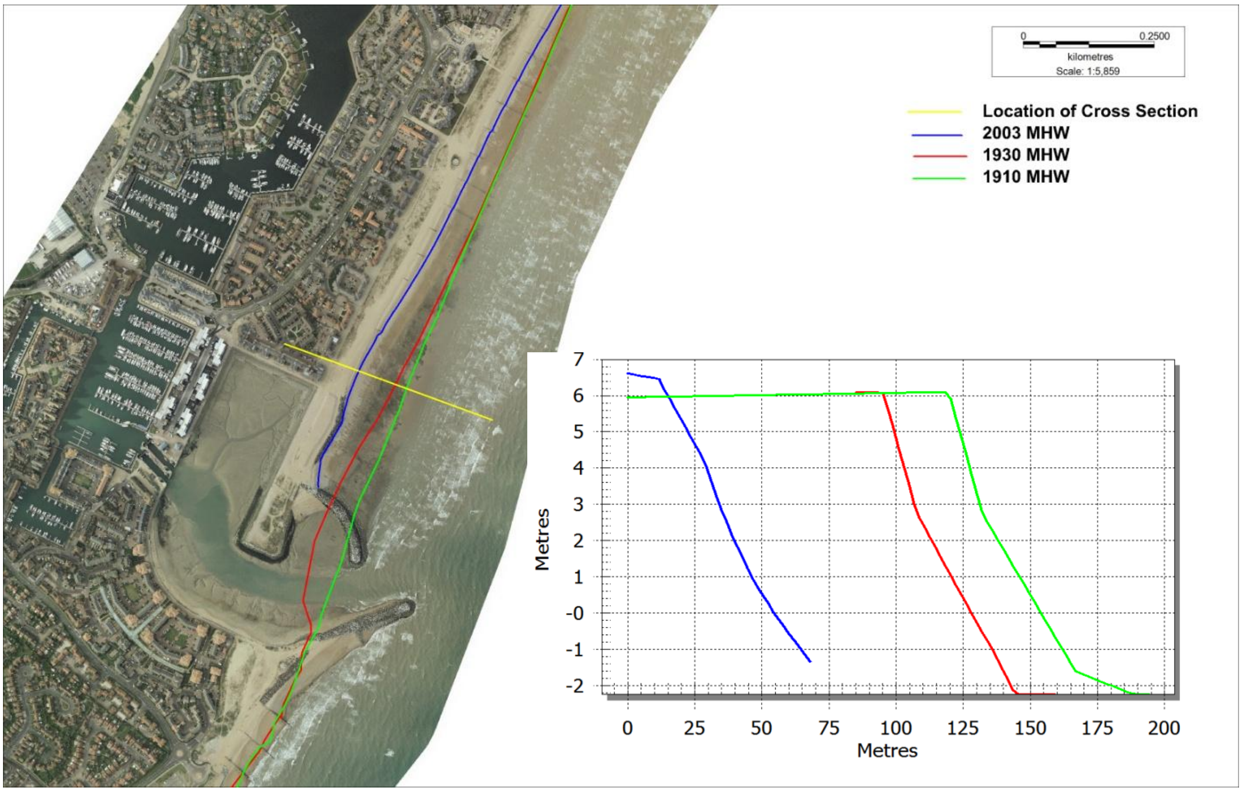


Figure 4-13 MHW marks in 2003, 1930 and 1910 at Sovereign Harbour, coupled with beach profiles at the most retreating area

4.5.3 Pevensey Bay

Pevensey Bay has gained 800,000m^3 over 90 years. This material has been accreting over the majority of the beach, but does shows bands of erosion and accretion in the difference models over each time period. For example, the area adjacent to Sovereign Harbour accreted significantly between 1890 and 1930, shown in Figure 4.14. However, the beach changed to an erosive trend after 1930, with the beach face cutting back to a pre-1910 profile. The reversal to an erosive trend by 2003 is likely to be due to a reduced sedimentary input from Eastbourne, as the development of Sovereign Harbour in 1992 reduced the alongshore transport rates (South Foreland to Beachy Head SMP, 2010). This historical evidence backs up the findings from the sediment budget analysis, with this frontage being seen to be heavily dependent on the influx from the preceding frontages.

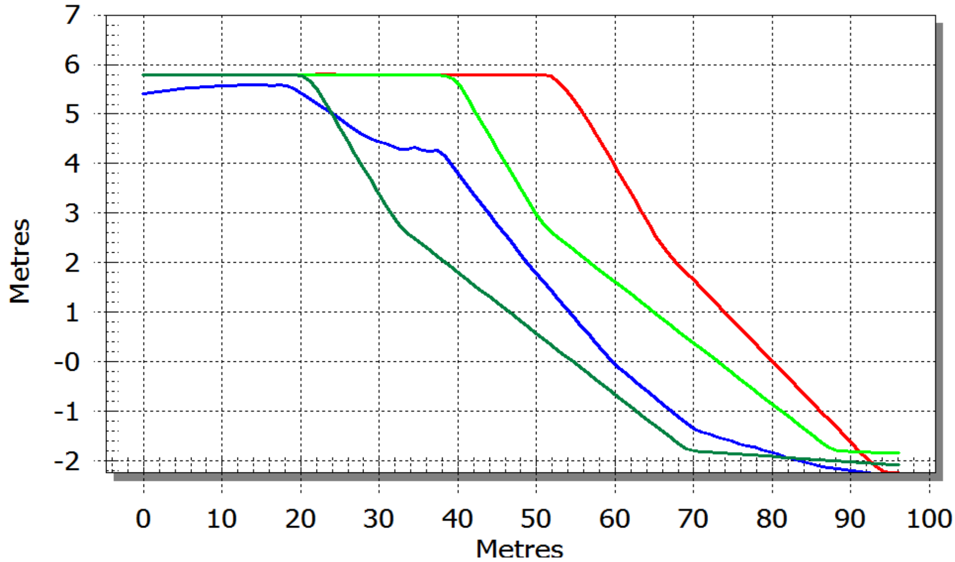


Figure 4-14 Cross sections through Pevensey DTM's in 2003 (blue); 1930 (red); 1910 (light green) and 1890 (dark green)

4.5.4 Bexhill-On-Sea

Due to a missing tile in the historical mapping, limited analysis of the historical long term trends can be undertaken. The only available data set was for the 1870's showing a gain of 200,000m^3 over the 130 year period. This contrasts with the total change from 2011- 2003 of 140,000m^3 showing that the rate of accretion has increased significantly over the last 10-20 years.

4.5.5 Bulverhythe

Due to a missing tile in the historical mapping, limited analysis of historical long term trends can be undertaken for the Bulverhythe frontage. The eastern end of the Bulverhythe frontage has been consistently accreting since 1890.

4.5.6 Hastings

Hastings has shown consistent significant accretion since 1890 with almost 1,500,000m^3 being deposited on the frontage. This gain has been shown across the whole frontage, but is particularly focussed on the Fisherman's Beach. When creating DTM's from historical mapping it was noticed that the MHW marks were found at the sea wall on the majority of the coast between 1890's and 1930's. This implies that what little beach was available, offered very minimal flood protection. This can be seen in the historical image below. In 1900's at high tide, the sea can be seen at the sea wall. This compares with the image taken in 2010 where a large beach has built up, protecting the sea wall from a high tide.

The area fronting the Fishing beach has undergone significant accretion over all timescales. Figure 4.15 shows aerial photographs of the Fishing beach in 1980 and 2008. The build up within the harbour arm is significant, as shingle overtops the breakwater into the final bay. The terminal structure at the east of the bay is sufficiently large to trap material, minimising material moving out of the unit. Although in recent years more material has been moving out due to the bay becoming full, this is particularly important in the 1930-2003 period, when beach levels were low.

Figure 4-15 Hastings Fishing Beach in 1980 (left) and 2008 (right) (Images Courtesy of EA)

The cross section in Figure 4.16 shows the extent of this gain just West of the harbour arm. The beach accreted by 25m from 1910-1890, 125m from 1910-1930 and a further 200m from 2003-1930. This significant accretion at the harbour arm helps to explain the large volumetric change since 1890 and verifies the low beach volumes shown in 1890 and 1910 (Table 4.3)
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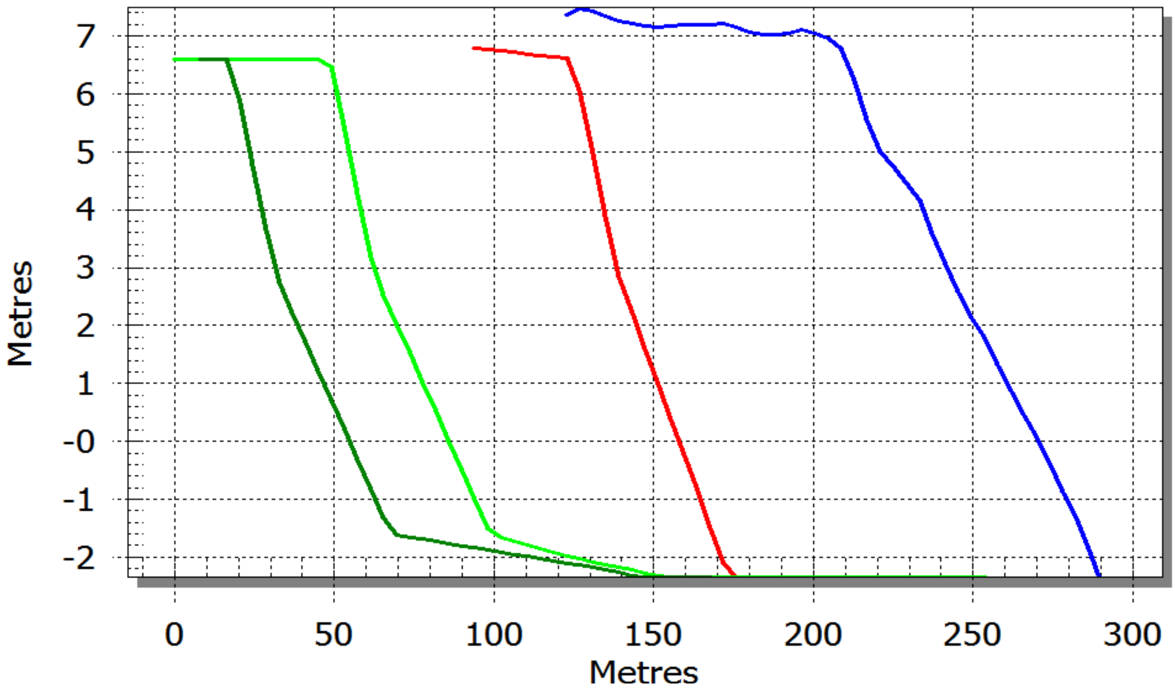


Figure 4-16 Cross section through Hastings Fishing Beach in 2003 (blue), 1930 (red), 1910 (light green) and 1890 (dark green)

4.5.7 Fairlight

Historic analysis of Fairlight was not undertaken as the frontage is predominantly cliffed. Hence, this will have limited benefit to an analysis focussing on the change in beach volumes over the last 100 years. For information on the historic behaviour of Fairlight cliffs please refer to the Beachy Head to South Foreland SMP (2010).

4.5.8 Winchelsea

Winchelsea has lost 800,000m^3 since 1910; however, this loss does not occur across the whole frontage. The west of the unit is dominated by erosion with the beach face cutting back by as much as 125m and a loss of over 2,700,000m^3 while the east of the unit has shown consistent accretion of 1,900,000m^3 at Rye Harbour arm from 2003 to 1910.

The profile in Figure 4.17 shows a cross section through the beach at Cliff End, the beach has cut back by 100m in the 20 years from 1890 to 1910. The beach stabilised to 1930 cutting back by around 20m. The beach has begun to advance again to the current position due to the improvements in the groyne field and regular recycling works.

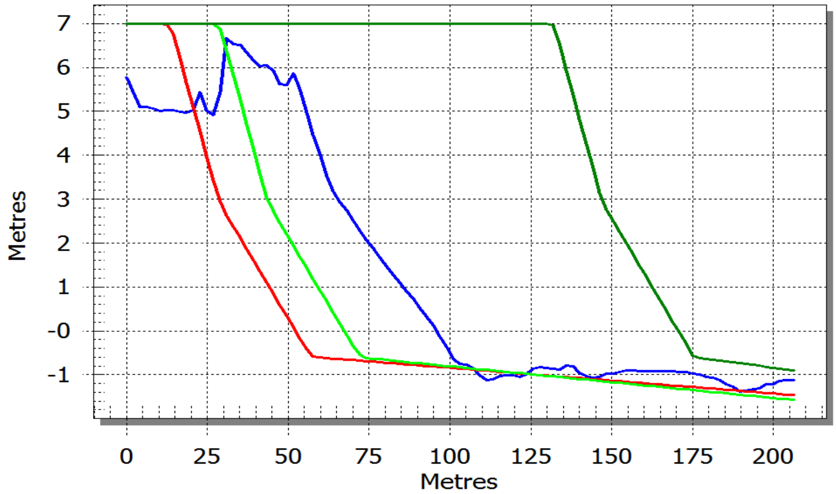


Figure 4-17 Cross section through Cliff End in 2012 (blue), 1930 (red), 1910 (light green) and 1890 (dark green)

The majority of the gain is focussed in the 500m west of Rye Harbour. 1,000,000m^3 accreted during 1910 to 1930 and a further 900,000m^3 accreted to 2003. This is shown in the profile in Figure 4.18 with the beach moving sea wards by 80m to 1930 and a further 260m to 2003. This compliments the sediment budget analysis, showing that this area is continuing to act as a sediment sink. The coast appears to have reoriented itself in response to the predominant wave direction.

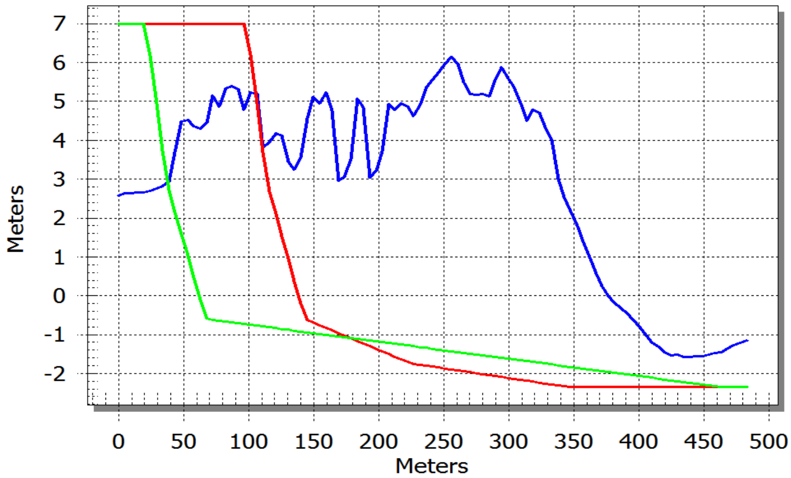


Figure 4-18 Cross section through Rye Harbour beach in 2012 (blue), 1930 (red) and 1910 (light green)

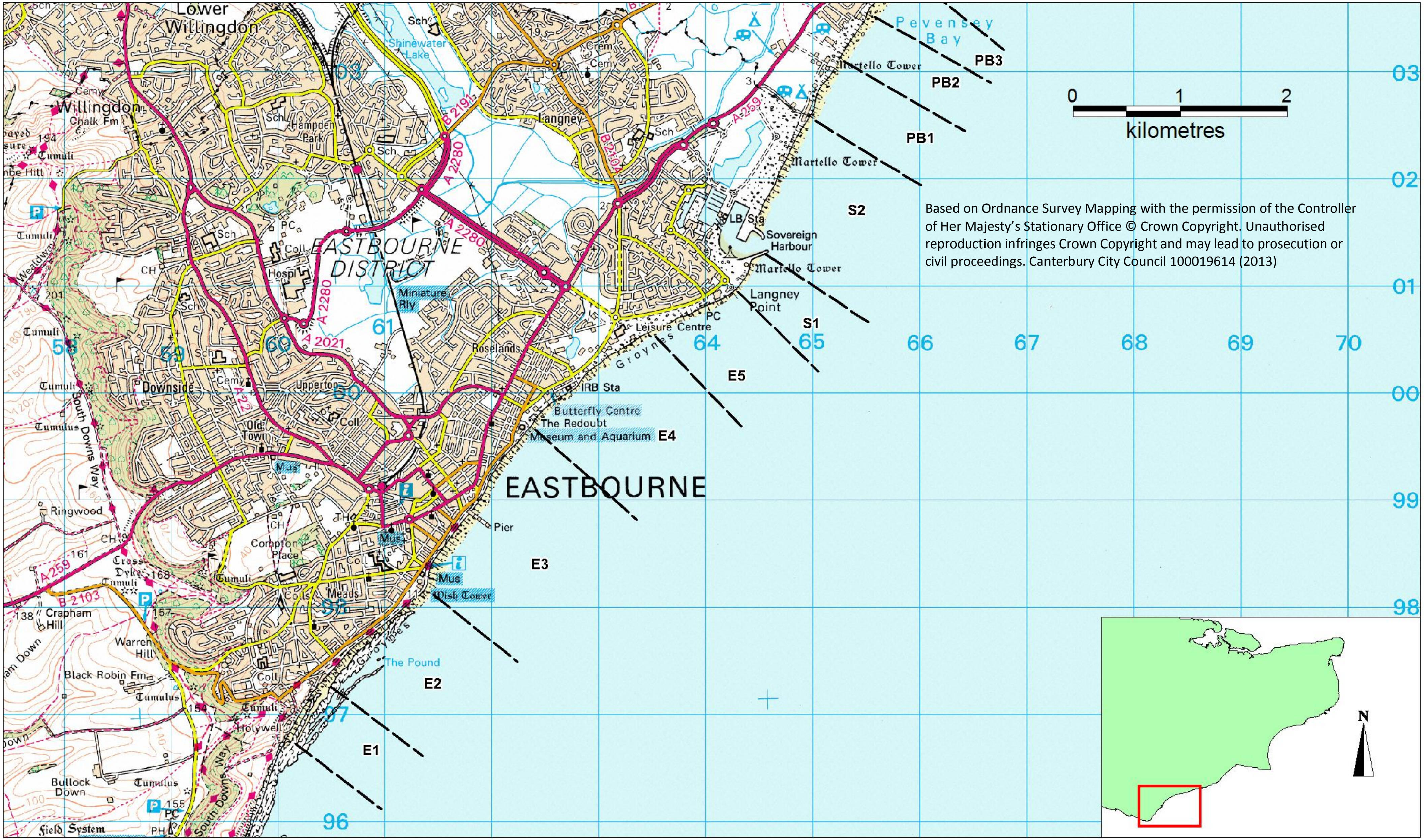
5.0 Available data

The data that can be provided with regards to the above analysis is shown in the table below. The data will be provided in CD format when the report has been finalised.

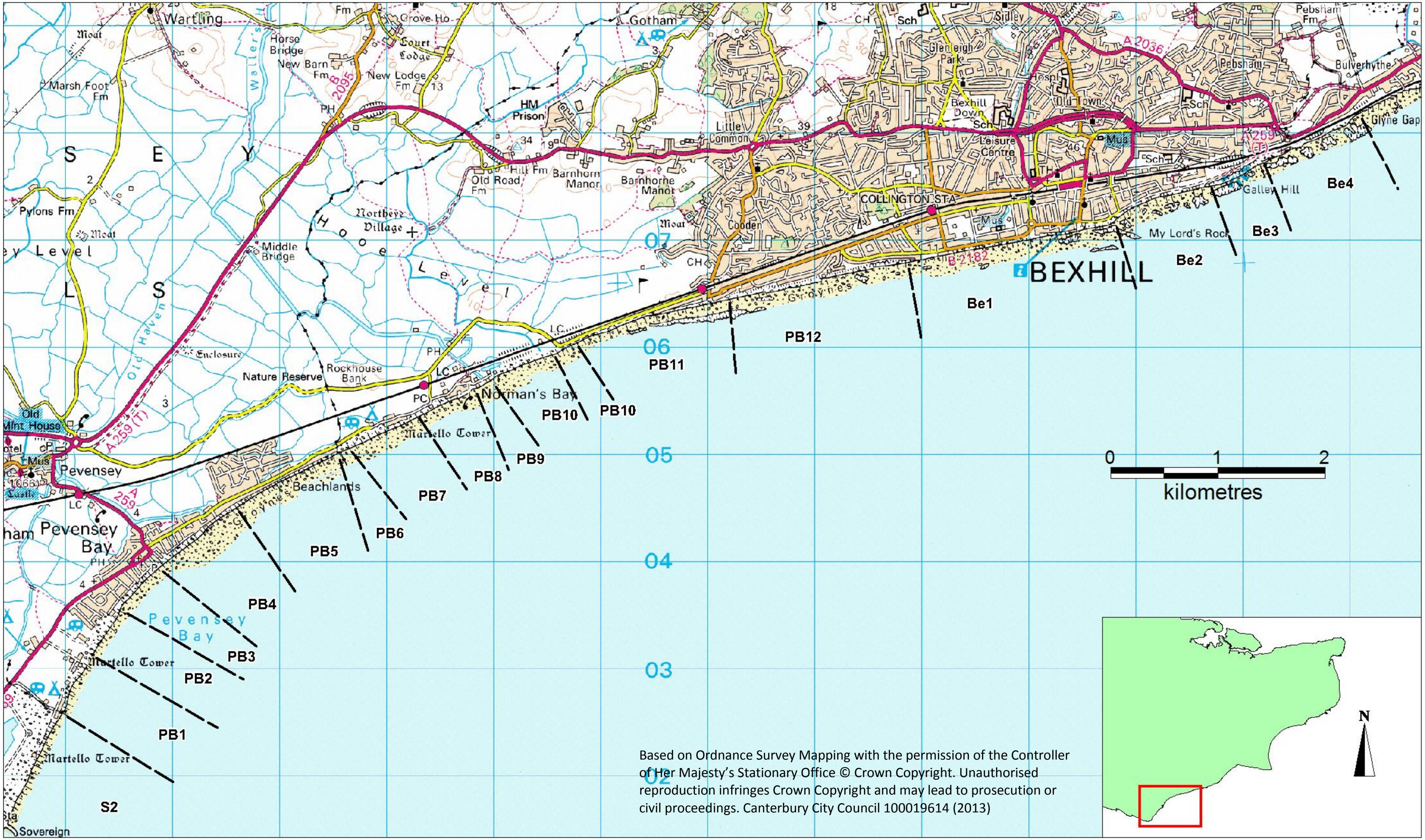
Table 5-1 Available data

Data	Type	Description
GIS (1)		**AVAILABLE FROM CANTERBURY CITY COUNCIL**
	DTMs	2012 -2003 DTMs for all frontages
	Difference Models	For all frontages
	Analysis Polygons	Level 1 - 50m length
		Level 2 - SRCMP Polygons
		Level 3 - Coarse Polygons
		Level 4 - Regional Polygons
	Historic	Historic feature lines for all frontages
		Historic DTMs for all frontages in 1890, 1910 and 1930
		Historic difference models, 1910-1890, 1930-1910, 2011-1930
	Sediment Budget	Polygons as above
		Level 3 sediment movements
		Level 4 sediment movements
GIS (2)		**AVAILABLE FROM THE ENVIRONMENT AGENCY**
	Lidar	All available Lidar data sets
SPREADSHEETS		**AVAILABLE FROM CANTERBURY CITY COUNCIL**
	Level 1	All Level 1 data in .txt format
	Level 2-4	All levels data in .xlsx format
PLATES		**AVAILABLE FROM CANTERBURY CITY COUNCIL**
	1 and 2	All plates in .jpg format
REPORT		**AVAILABLE FROM CANTERBURY CITY COUNCIL**

6.0 Sub-cell Location Diagrams



Eastbourne to Rye Harbour Sediment Budget


PB1
PB2
PB3
PB4
PB5
PB6
PB7
PB8
PB9
PB10
PB10
PB11
PB12
Be1
Be2
Be3
Be4
S2
BEXHILL
Pevensey
Pevensey Bay
Norman's Bay
Beachlands
Cooden
Little Common
Galley Hill
Glyne Gap
Bulverhythe
Pebsham
My Lord's Rock
COLLINGTON STA
0
1
2
kilometres
N


Be3
B1
B2
B3
H1
H2
H3
H4
F1
F2
F3
HASTINGS
0 1 2
kilometres
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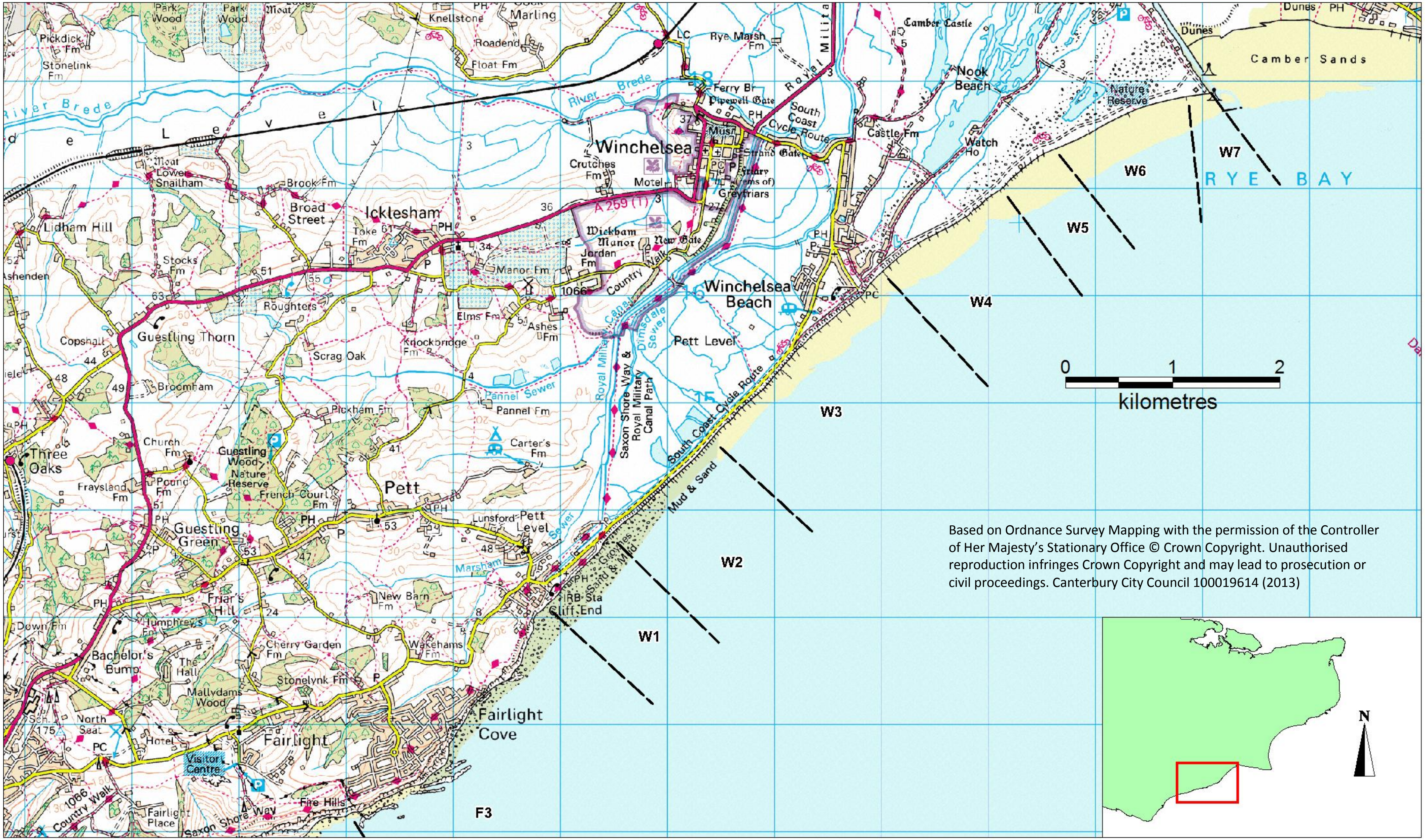
W1
W2
W3
W4
W5
W6
W7
F3
RYE BAY
Camber Sands
Camber Castle
Nook Beach
Nature Reserve
Watch Ho
Castle Fm
Winchelsea
Winchelsea Beach
Pett Level
Icklesham
Pett
Fairlight
Fairlight Cove
Cliff End
Guestling Green
Guestling Thorn
Three Oaks
River Brede
Royal Military Canal
Saxon Shore Way & Royal Military Canal Path
South Coast Cycle Route
Mud & Sand
Fire Hills
0
1
2
kilometres
N

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