Sector K: Controlled Inundation

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

FINAL REPORT
VOLUME 3: SUPPORTING REPORT

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CHAPTER K1 INUNDATION AREA

K1.1 General

After implementation of the facilities proposed in the Master Plan, the protection area will be safe from floods, but inundation areas may still remain. In this section the current inundation area is studied on the regional variation of flood depth and duration and required measures for flood disaster risk reduction are to be studied on the following.

- Current inundation area
- Regional variation of inundation depth and duration
- Required measures for flood disaster risk reduction

K1.2 Inundation Area in the 2011 Flood

A reproduction of the 2011 flood inundation area and an assumed inundation area after implementation of the Master Plan are shown in Figure K1.2.1 and Figure K1.2.2.

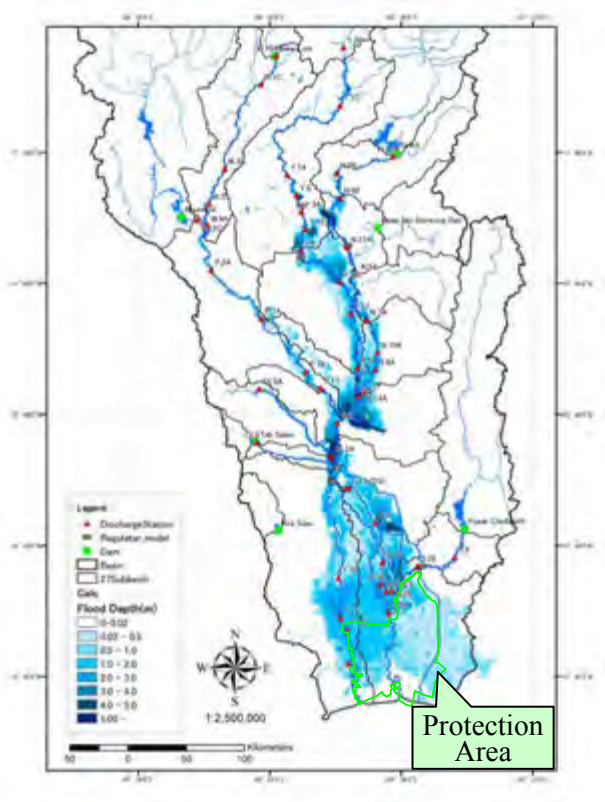


Figure K1.2.1 Reproduction of the 2011 Flood Inundation Area

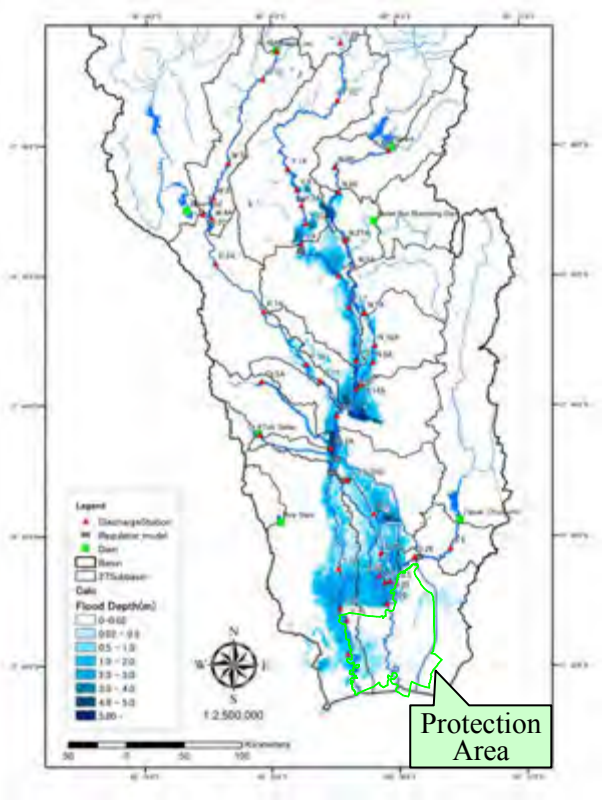


Figure K1.2.2 Assumed Inundation Area after Implementation of Structural Measures proposed in the M/P

As shown in Figure K1.2.1 and Figure K1.2.2, Bangkok and its Vicinities (Special Economic Zone), which are planned as the Protection Area is able to be protected from the design flood by implementation of the facilities proposed in the Master Plan. However, it is difficult to protect the whole low-lying areas along the Yom and Nan rivers at Upper Nakhon Sawan and the low-lying area at Lower Nakhon Sawan from floods. Besides, these low-lying areas have an important function as the natural retarding basin reducing flood peaks downstream.

From the good reason it is necessary for these low-lying areas, considering coexistence with floods, to discuss required countermeasures as "Controlled Inundation Area" like land use plans and effective agricultural methods on the assumption of habitual inundation.

The situations of low-lying areas at upper and lower Nakhon Sawan are outlined below.

K1.2.1 Upper Nakhon Sawan

The inundation area in the upper central plain in the Yom and Nan River basins has old river channels, lakes and swamps along the two rivers. The low-lying and swamp areas also function as natural retarding basins. The floods from the basins inundate the low-lying and swampy areas as well as the adjacent agricultural lands or irrigation areas depending on the scale of flood.

The central part of the inundation area at the low-lying/marsh and agricultural land has been selected by RID as the Proposed Retention Area (2012) and the Retention Area (see Figure K1.2.3), and the rest of the inundation area require measures for promotion of the controlled inundation.

K1.2.2 Lower Nakhon Sawan

The inundation areas in the lower central plain in the Chao Phraya River Basin are caused by the floods from the main stream of Chao Phraya River and branch rivers (Tha Chin, Noi River and Lopburi River). The flood waters inundated in natural levee areas, back swamp and neighboring agricultural areas along the rivers. The inundation area is mostly composed of irrigation area and the ratio of mash area is very low.

The central part of the inundation area with low-lying marsh and agricultural land has been proposed as the retantion area by RID (2012) by the Thai Government (see Figure K1.2.3). The rest of the inundation area require measures for the promotion of controlled inundation

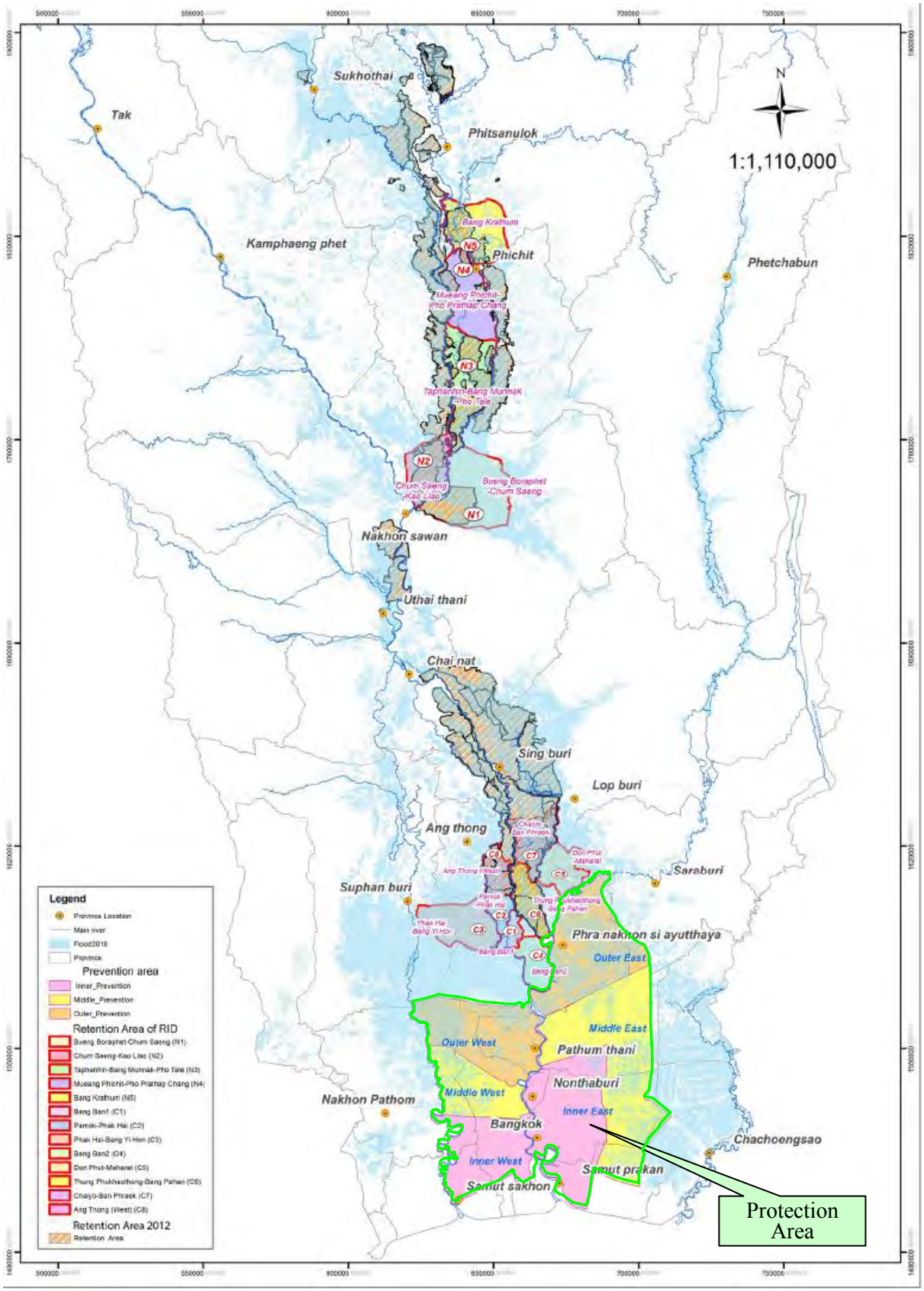


Figure K1.2.3 Location of Retention Area Planned by the Government of Thailand

K1.3 Study on Characteristics of Inundation Area

The inundation areas at upper and lower Nakhon Sawan are divided into typical subdivisions as shown in Figure K1.3.1, Figure K1.3.2 and Figure K1.3.3. The characteristics of each subdivision have been investigated.

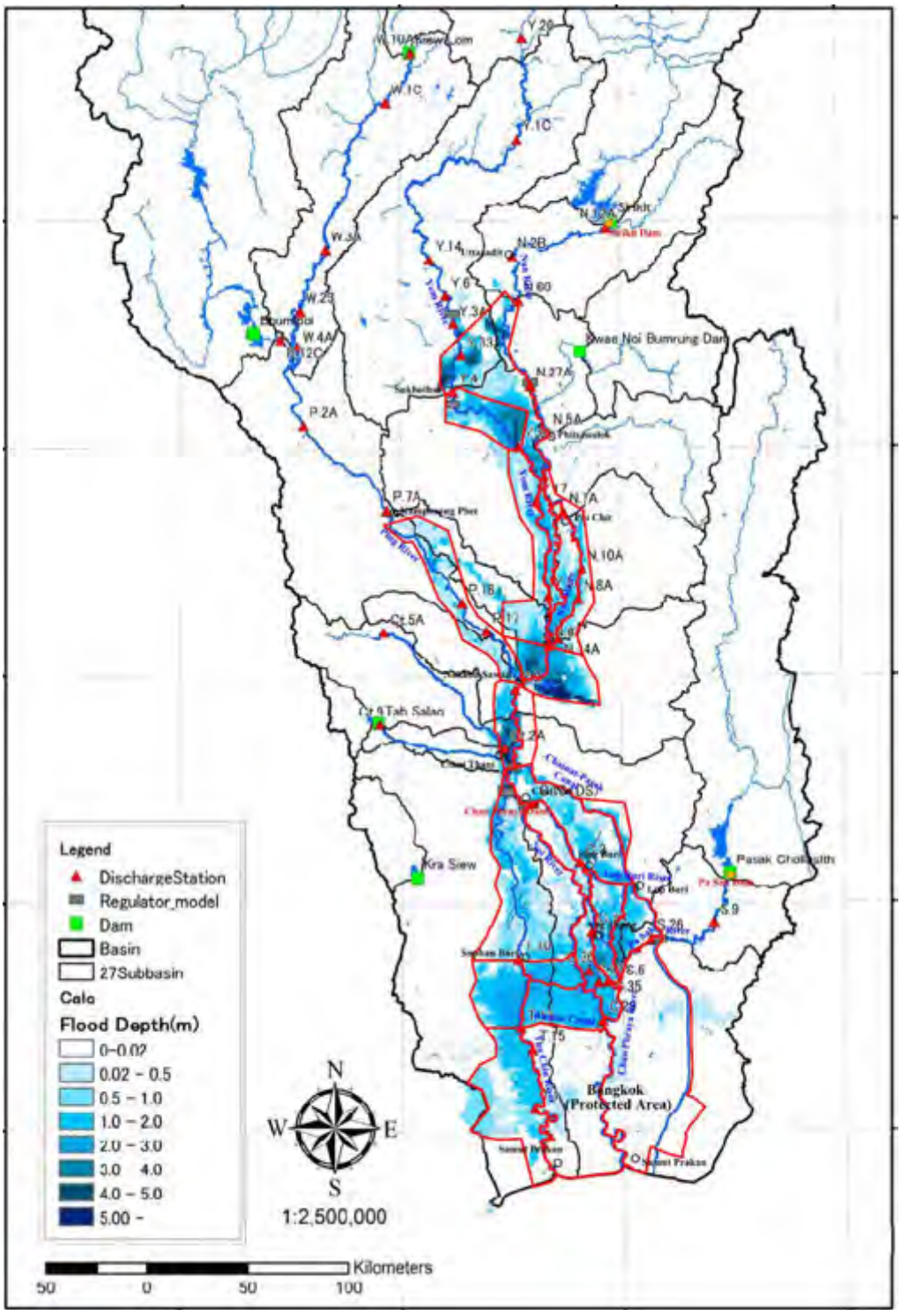


Figure K1.3.1 Subdivisions at Assumed Inundation Area after Implementation of M/P

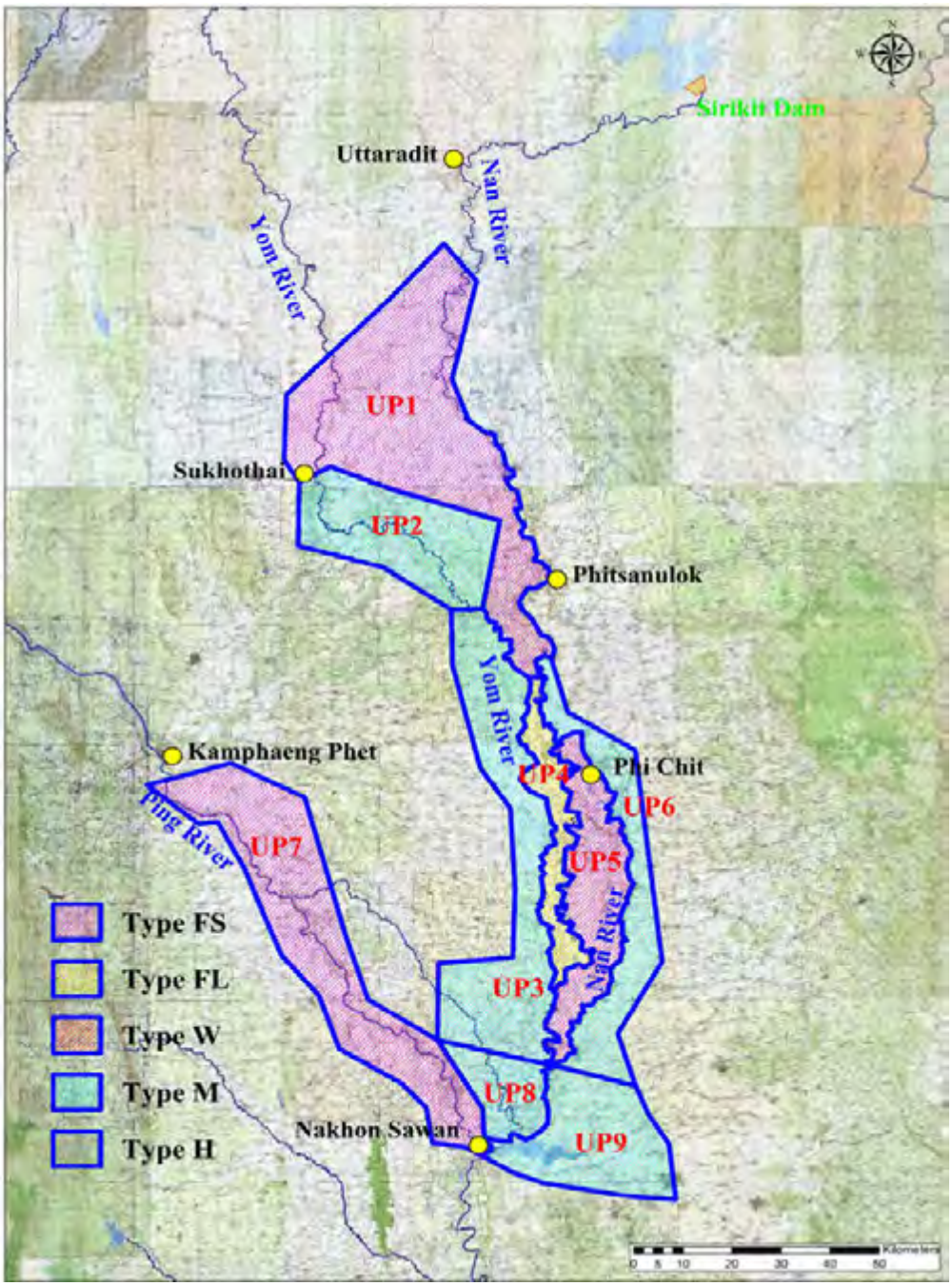


Figure K1.3.2 Subdivisions at Assumed Inundation Area in Upper Nakhon Sawan after Implementation of M/P (Based on Topographic Map in 1/50,000 Scale)

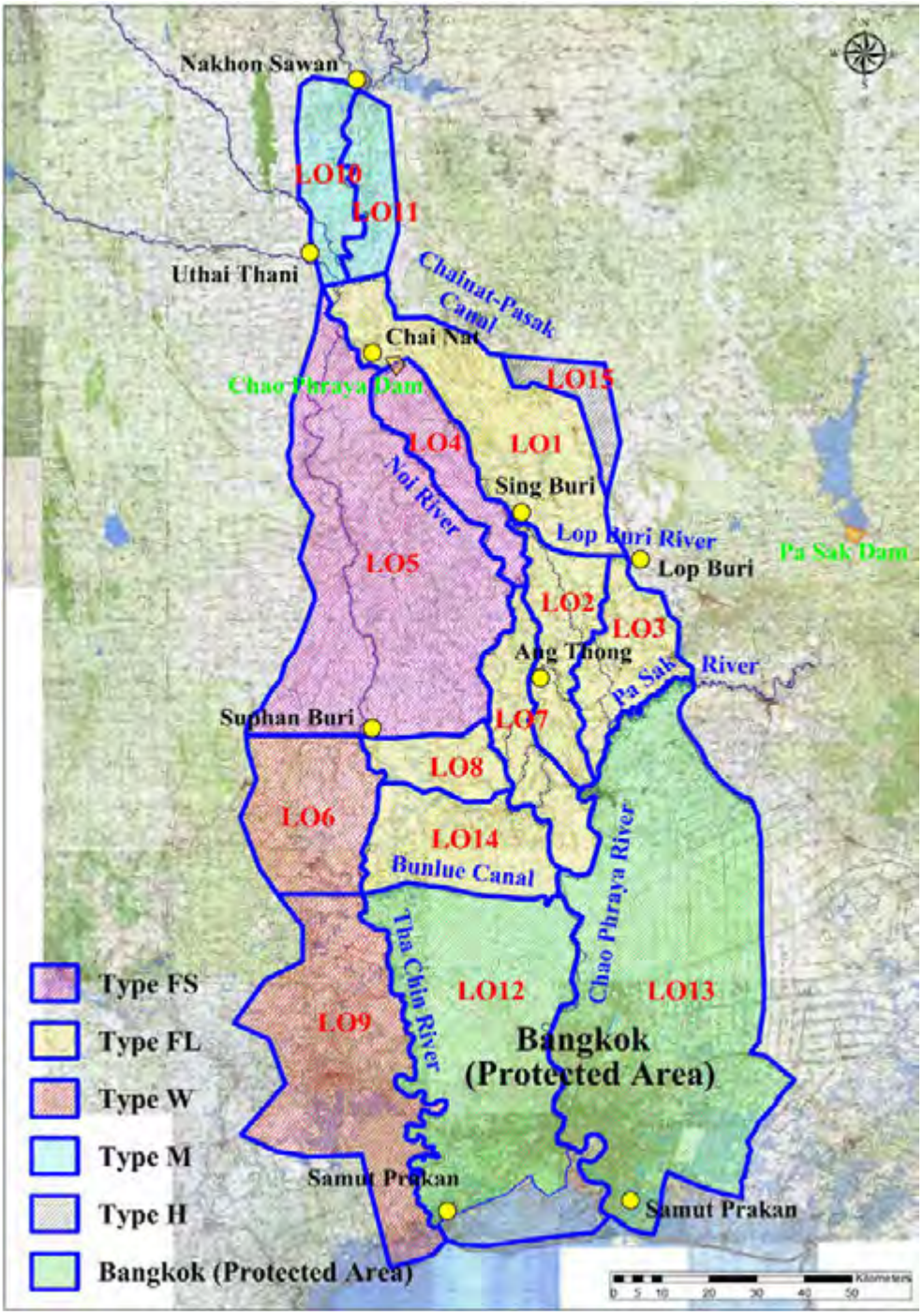


Figure K1.3.3 Subdivisions at Assumed Inundation Area in Lower Nakhon Sawan after Implementation of M/P (Based on Topographic Map in 1/50,000 Scale)

The inundation area is categorized into the following 5 types:

Type FS:

Agricultural area. Overflow water from the river spreads and flows towards downstream resulting in relatively shallow and shorter inundation. The west side is also affected by runoff from the river's own basin.

Type FL:

Agricultural area. Flood water flows over these areas and is blocked by the heightened road/embankment. Deeper inundation and longer duration than the 2011 flood would be observed near the southern border of the area.

Type W:

Agricultural area. These areas are floodways for overflow water from Type FL areas and the west hilly areas.

Type M:

These are low-lying swamp areas and floodwater stays throughout a flood season with deep inundation and long duration.

Type H:

Agricultural area. The area is affected by small scale floods from the east hill side in the basin. The inundation depth and duration are very shallow and short.

Subdivision Nos.12 and 13 belong to the protection area of Bangkok and its vicinity. The characteristics of each division of the Control Inundation Area are listed as follows:

Table K1.3.1 Land Use Types of Inundation Area at Upper Nakhon Sawan

Type	Subdivision Number	Area (km²)		Name of Irrigation Project	Land Use Type
FS	UP 1	1,800	3,710	Phai Chum Phon	Rainfed, floodplain
	UP 5	610		Tha Bua, Tum Sam, Bueng Mai	Irrigation area, rai-fed paddy land, floodplain
	UP 7	1,300		-	Rainfed area
FL	UP 4	330	330	Yom-East, Nan-West	Rainfed paddy land, floodplain
W	-	-	-		
M	UP 2	750	3,540	Phai Chum Phon	Irrigation area, floodplain
	UP 3	1,200		Yom West	Rainfed paddy land, floodplain
	UP 6	650		Tha Bua, Dong Setti	Irrigation area, floodplain
	UP 8	270		Nan-West, Chum Saeng	Rainfed paddy land, floodplain
	UP 9	670		Nan East, Bung Boraphet	Irrigation area, rainfed paddy land, floodplain
H	-	-	-		
Total		7,580			

The inundation areas in Upper Nakhon Sawan are characterized as: Area of each subdivision is narrow; Ratio of rainfed paddy field is higher and ratio of irrigation area is lower; and Land is inclined and there are vertical drops between subdivisions.

Table K1.3.2 Characteristic Features of Subdivisions in Controlled Inundation Area at Upper Nakhon Sawan under 10-Year Probable Flood

Type	Sub-division No.	Area (km^2)		Maximum Inundation Volume (MCM)					Maximum Average Depth (m)					Maximum Inundation Area (km^2)				
				Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1
FS	UP1	1,800	3,710	790	790	750	750	750	1.4	1.4	1.4	1.4	1.4	540	540	510	510	510
	UP5	610		220	220	90	100	100	0.6	0.6	0.5	0.5	0.5	350	350	180	180	180
	UP7	1,300		380	380	310	310	310	0.5	0.5	0.5	0.5	0.5	690	690	600	600	600
FL	UP4	330	330	300	290	260	260	260	1.0	1.0	1.0	1.0	1.0	280	280	270	270	270
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	UP2	750	3,540	900	900	900	900	900	1.3	1.3	1.3	1.3	1.3	690	690	690	690	690
	UP3	1,200		420	410	370	370	370	0.6	0.5	0.5	0.5	0.5	740	740	720	720	700
	UP6	650		280	280	80	90	90	0.7	0.7	0.5	0.5	0.5	420	420	160	180	180
	UP8	270		630	630	570	570	570	2.5	2.5	2.3	2.3	2.3	250	250	250	250	250
	UP9	670		2000	2000	1700	1700	1700	3.6	3.5	3.4	3.4	3.4	570	570	510	510	510
H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	7,580		5920	5900	5030	5050	5050	-	-	-	-	-	4530	4530	3890	3910	3890

Table K1.3.3 Characteristic Features of Subdivisions in Controlled Inundation Area at Upper Nakhon Sawan under 100-Year Probable Flood

Type	Sub-division No.	Area (km^2)		Maximum Inundation Volume (MCM)					Maximum Average Depth (m)					Maximum Inundation Area (km^2)				
				Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1
FS	UP1	1,800	3,710	1000	1000	910	910	910	1.5	1.5	1.5	1.5	1.5	670	680	590	590	590
	UP5	610		260	260	180	190	190	0.7	0.7	0.6	0.6	0.6	360	360	300	320	320
	UP7	1,300		610	610	480	480	480	0.7	0.7	0.6	0.6	0.6	830	830	770	780	770
FL	UP4	330	330	400	400	310	310	310	1.3	1.3	1.1	1.1	1.1	310	310	280	280	280
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	UP2	750	3,540	1100	1100	1100	1100	1100	1.5	1.5	1.5	1.5	1.5	710	710	710	710	710
	UP3	1,200		750	750	630	630	630	0.7	0.7	0.6	0.6	0.6	1100	1100	1100	1100	1100
	UP6	650		370	370	210	230	230	0.8	0.8	0.6	0.7	0.7	460	460	330	340	340
	UP8	270		780	780	690	690	690	3.0	3.0	2.7	2.7	2.7	260	260	260	260	260
	UP9	670		2400	2400	2200	2200	2200	3.8	3.8	3.7	3.7	3.7	640	640	610	610	610
H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	7,580		7670	7670	6710	6740	6740	-	-	-	-	-	5340	5350	4950	4990	4980

Table K1.3.4 Land Use Types of the Inundation Area at Lower Nakhon Sawan

Type	Subdivision Number	Area (km²)		Name of Irrigation Project	Land Use Type
FS	LO4	480	3,280	Tha Bot, Donchedee, Krasao	Irrigation area, floodplain
	LO5	2,800		Chao Chet, Bang Yi-hon	Irrigation area, floodplain
FL	LO1	1,300	4,100	Manorom	Irrigation area, floodplain
	LO2	580		Maharaj, Tu Ban Kum, Tung Chang	Irrigation area, floodplain
	LO3	550		Kok Kra Tiam, Loeng Rang	Irrigation area, floodplain
	LO7	560		Pho-Phraya, Song Phi-Nong	Irrigation area, floodplain
	LO8	330		Yang Mane, Bang Ban	Irrigation area, floodplain
	LO14	780		Phakhai	Irrigation area, floodplain
W	LO6	810	2,510	Borom That, Channasut	Irrigation area, floodplain
	LO9	1,700		Bang Lane, KPS, Nak-Pat, DNSD etc	Irrigation area
M	LO10	420	760	Grot Pra Payuha	Irrigation area, rainfed paddy land, floodplain
	LO11	340		-	Rainfed paddy land
H	LO15	230	230	Chong-kae	Irrigation area, floodplain
Total			10,880		

The characteristic features of the inundation area in Lower Nakhon Sawan are summarized as follows:

- Area of each subdivision is large; mostly irrigation area.
- Land is flat with only small vertical drops between subdivisions.
- The south side of downstream agricultural area changes gradually to industrial area.
- The low-lying area has a large function as natural retarding basin.
- Agricultural crop is only paddy, and flood damage to rice crops is small because the Government has been giving guidance not to plant in flood season.

Table K1.3.5 Characteristic Features of Subdivisions in Controlled Inundation Area at Lower Nakhon Sawan under 10-Year Probable Flood

Type	Sub-division No.	Area (km^2)		Maximum Inundation Volume (MCM)					Maximum Average Depth (m)					Maximum Inundation Area (km^2)				
				Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1
FS	LO4	480	3,280	10	10	0	0	0	0.1	0.1	0.0	0.0	0.0	50	50	0	0	0
	LO5	2,800		1100	1100	450	890	890	0.6	0.6	0.3	0.5	0.5	1800	1800	1300	1600	1600
FL	LO1	1,300	4,100	600	600	420	430	430	0.7	0.7	0.6	0.6	0.6	770	760	650	660	660
	LO2	580		550	560	160	370	360	1.3	1.3	0.9	1.2	1.2	400	410	170	300	300
	LO3	550		580	590	290	430	420	1.5	1.5	0.9	1.2	1.2	390	390	320	360	350
	LO7	560		360	520	180	320	260	0.9	1.2	0.7	0.9	0.8	380	410	260	340	310
	LO8	330		270	410	220	310	310	0.9	1.3	0.7	1.0	1.0	310	310	300	310	310
	LO14	780		610	1200	690	930	910	0.8	1.6	0.9	1.2	1.2	760	760	760	760	760
W	LO6	810	2,510	620	980	560	730	720	1.0	1.4	0.9	1.1	1.1	640	710	590	650	650
	LO9	1,700		550	1300	470	640	620	0.6	0.9	0.7	0.7	0.7	810	1300	670	830	800
M	LO10	420	760	640	640	420	550	550	1.8	1.8	1.3	1.6	1.6	350	350	320	340	340
	LO11	340		210	210	40	150	150	2.0	2.0	0.7	1.9	1.9	110	110	30	80	80
H	LO15	230	230	190	190	190	190	190	1.6	1.6	1.6	1.6	1.6	120	120	120	120	120
Total	-	10,880		6290	8310	4090	5940	5810	-	-	-	-	-	6890	7480	5490	6350	6280

Table K1.3.6 Characteristic Features of Subdivisions in Controlled Inundation Area at Lower Nakhon Sawan under 100-Year Probable Flood

Type	Sub-division No.	Area (km^2)		Maximum Inundation Volume (MCM)					Maximum Average Depth (m)					Maximum Inundation Area (km^2)				
				Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1	Case 0	Case 0-1	Case 1-1	Case 11	Case 11-1
FS	LO4	480	3,280	70	70	0	30	30	0.3	0.3	0.0	0.3	0.3	250	250	0	110	110
	LO5	2,800		1800	1800	1000	1400	1400	0.9	0.9	0.6	0.7	0.7	2100	2100	1800	2000	2000
FL	LO1	1,300	4,100	1100	1100	860	860	860	1.0	1.1	0.9	0.9	0.9	1000	1000	940	940	940
	LO2	580		860	900	700	700	690	1.6	1.6	1.4	1.4	1.4	540	550	440	480	480
	LO3	550		900	930	760	760	750	1.9	2.0	1.7	1.7	1.7	460	470	440	440	440
	LO7	560		580	990	520	640	590	1.2	1.9	1.3	1.3	1.2	490	520	380	480	480
	LO8	330		380	620	420	500	480	1.2	1.9	1.3	1.6	1.5	320	330	310	320	320
	LO14	780		880	1700	1200	1400	1400	1.1	2.3	1.6	1.9	1.8	760	760	760	760	760
W	LO6	810	2,510	880	1500	1000	1200	1200	1.2	1.9	1.4	1.5	1.5	730	800	730	770	760
	LO9	1,700		1400	2700	1400	1600	1500	0.9	1.6	0.9	1.0	1.0	1500	1600	1500	1500	1500
M	LO10	420	760	840	840	720	730	730	2.3	2.3	1.9	2.0	2.0	370	370	370	360	360
	LO11	340		270	270	190	230	230	2.3	2.3	2.4	2.0	2.0	120	120	80	120	120
H	LO15	230	230	230	230	230	230	230	1.8	1.8	1.8	1.8	1.8	130	130	130	130	130
Total	-	10,880		10190	13650	9000	10280	10090	-	-	-	-	-	8770	9000	7880	8410	8400

CHAPTER K2 REQUIRED MEASURES FOR FLOOD DISASTER MANAGEMENT

After implementation of the facilities proposed in the Master Plan (Case 10), structural and nonstructural measures are required for the inundation area in order to reduce flood disaster risks and enhance people's living conditions. The following measures are required.

K2.1 Type FS Inundation Area

Regional Characteristics

Mainly agricultural land use. Floodwater flows downward. Inundation depth and duration are comparatively shallow and short. In case of the 100-year probable flood, the inundation depth becomes deeper in the middle of September, the maximum average depth is about 0.7 m and the duration, about one month in case of average depth over 0.5m. Also, the west side is affected by the runoff from its own basin.

Structural Measures

- Strengthening measures for retention areas by the government.
- Dredging of drainage channels and lakes/marshes.
- Improvement of small scale irrigation facilities (gates, weirsm etc.).
- Construction of community-based small scale retention pond (controlled intake and discharge facilities, irrigation water supply in dry season).
- Strengthening of existing levees.
- Installation of drainage pumps.
- Optimum management of irrigation canals.
- Water conservation works at the west hilly area.

Nonstructural Measures

- Compensation for farmland damaged by inundation.
- Preparation of community-based hazard map and land use control.
- Preparation of floodplain management
- Agricultural guidance like changing forms of farming schedule.
- Measures to secure feed for livestock.
- Improvement of flood information communication and education system.

K2.2 Type FL Inundation Area

Regional Characteristics

Mainly agricultural areas. Floodwater flows downward, but retained at the area, which is classified as the lower area in the central plain. Even in the future, the inundation depth and duration in the area are deep and long. In case of the 100-year probable flood, the inundation depth becomes deep in the middle of September, the maximum average depth is from 1.3 m to 2.2 m, and the duration is 1.7 to 3.5 months in case of average depth over 1.0m.

Structural Measures

- Strengthening measures for retention areas by the Government.
- Construction of community-based small scale retention ponds (Controlled intake and discharge facilities, irrigation water supply in dry season).
- Dredging of drainage channels and lakes/marshes.
- Improvement of small-scale irrigation facilities (gates, weirs, etc.).
- Strengthening of existing levees.
- Installation of drainage pumps (reduction of inundation depth and duration).

Nonstructural Measures

- Compensation for farmland damaged by inundation.
- Agricultural guidance like changing forms of farming schedule.
- Measure to assure income during inundation period (combined agriculture and fishery or aquaculture, etc.).
- Measures to secure domestic water supply for inundation period.
- Preparation of community-based hazard map and land use control.
- Preparation of flood plain management
- Improvement of flood information, communication and education system.

K2.3 Type W Inundation Area

Regional Characteristics

Mainly agricultural. The area is located at the west side of the protection area and the passage of floodwater flowing down southward. Also this area is affected by floods from the west hill side in its own basin.

In case of the 100-year probable flood the inundation depth becomes deep early in October, the maximum average depth is from 1.3 m to 1.9 m, and the duration is 2.0 to 2.5 months in case of the average depth over 1.0m.

Structural measures

- Construction of community-based small-scale retention ponds (controlled intake and discharge facilities, irrigation water supply in dry season).
- Dredging of drainage channels and lakes/marshes.
- Improvement of small-scale irrigation facilities (gates, weirs etc.).
- Strengthening and raising the existing levees.
- Improvement of main canal (increase of discharge capacity to Gulf of Thailand).
- Maintenance of canals (increase of drainage capacity to main canal).
- Installation of drainage pumps (reduction of inundation depth and duration).
- Water conservation works at the west hilly area.

Nonstructural Measures

- Compensation for farmland damaged by inundation.
- Agricultural guidance like changing forms of farming schedule, introduction of floating vegetable etc.
- Measure to secure income during inundation period (combined agriculture and fishery or aquaculture, etc.).
- Measures to secure domestic water supply in inundation period.
- Measures to secure feed for livestock.
- Preparation of community-based hazard map and land use control.
- Improvement of flood information, communication and education system.

K2.4 Type M Inundation Area

Regional Characteristics

Low-lying mashes and habitually inundation area. The flood depth and duration are deep and long. The area is located at just downstream of Nakhon Sawan and inundation starts early. In case of the 100-year probable flood the inundation depth becomes deep in August and the maximum average depth is from 2.3 m to 3.0 m, and the duration is 3.8 to 5.0 months in case of the average depth over 1.0 m.

Structural Measures

- Strengthening of the existing levee surrounding the low-lying marsh area.

Nonstructural Measures

- Measures to maintain the current retarding function like land use control etc.
- Improvement of flood information and communication system.

K2.5 Type H Inundation Area

Regional Characteristics

Agricultural area. Small-scale inundation occurs brought by floods from the hillside in its own basin. The inundation depth and duration are very shallow and short.

Structural Measures

- Construction of community-based small-scale retention ponds (controlled intake and discharge facilities, irrigation water supply in dry season).
- Strengthening of the existing levees.
- Water conservation works at the east hilly area.

Nonstructural Measures

- Improvement of flood information, communication and education system.

K2.6 Inundation Volume, Average Depth and Area (by Case)

K2.6.1 Inundation Volume

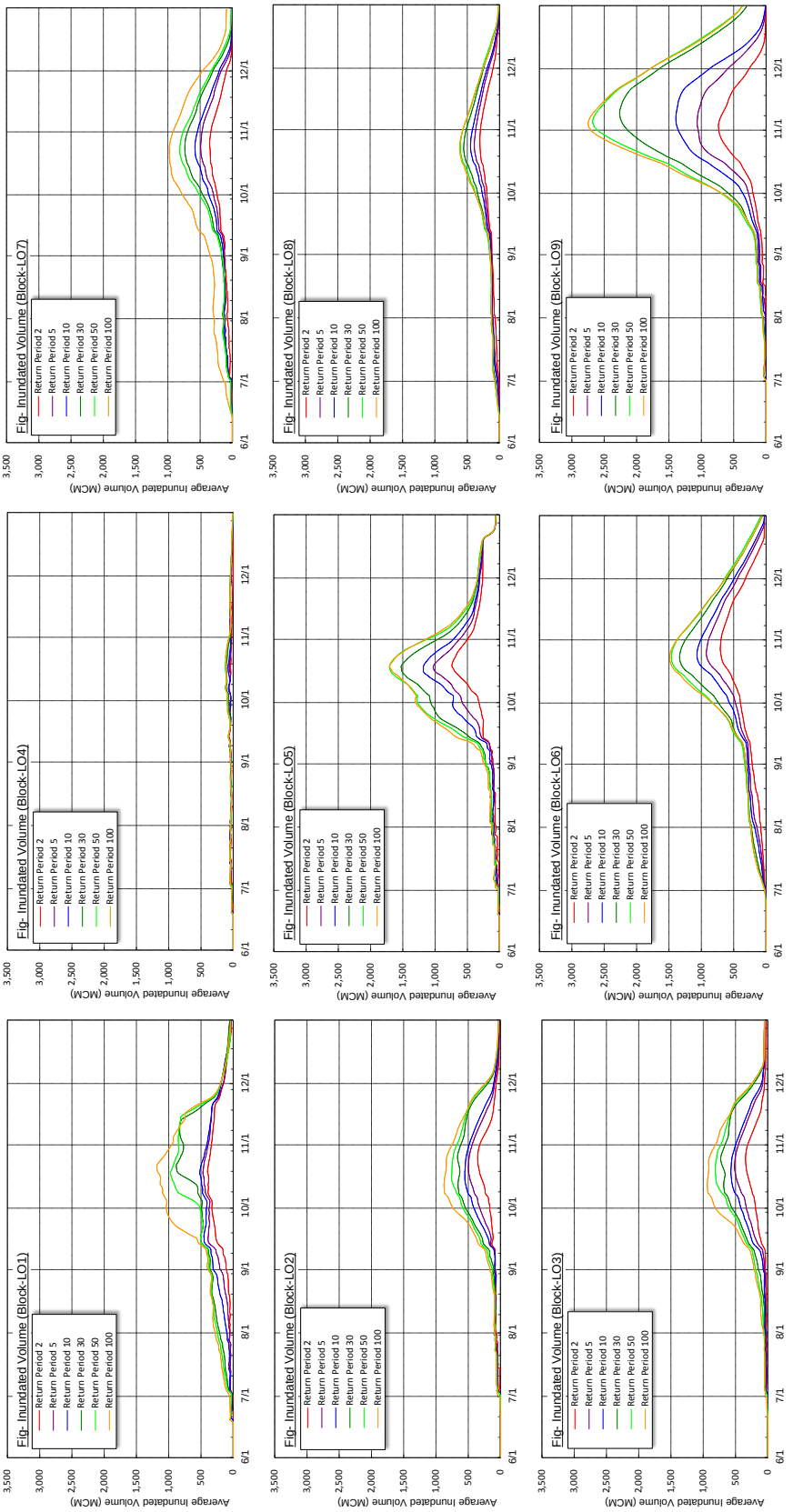


Figure K2.6.1 Inundation Volume (Case 0-1) (1/3)

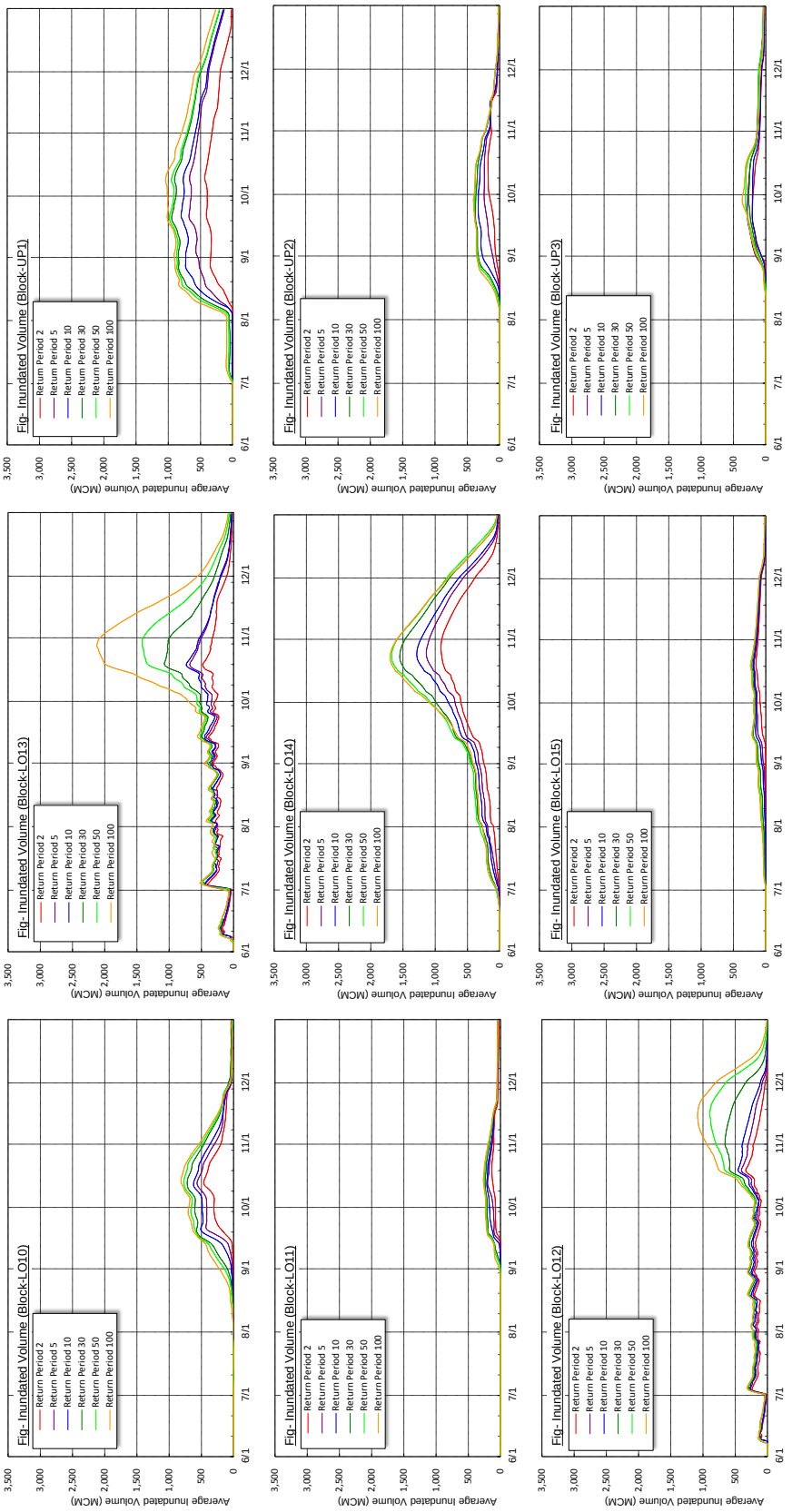


Figure K2.6.2 Inundation Volume (Case 0-1) (2/3)

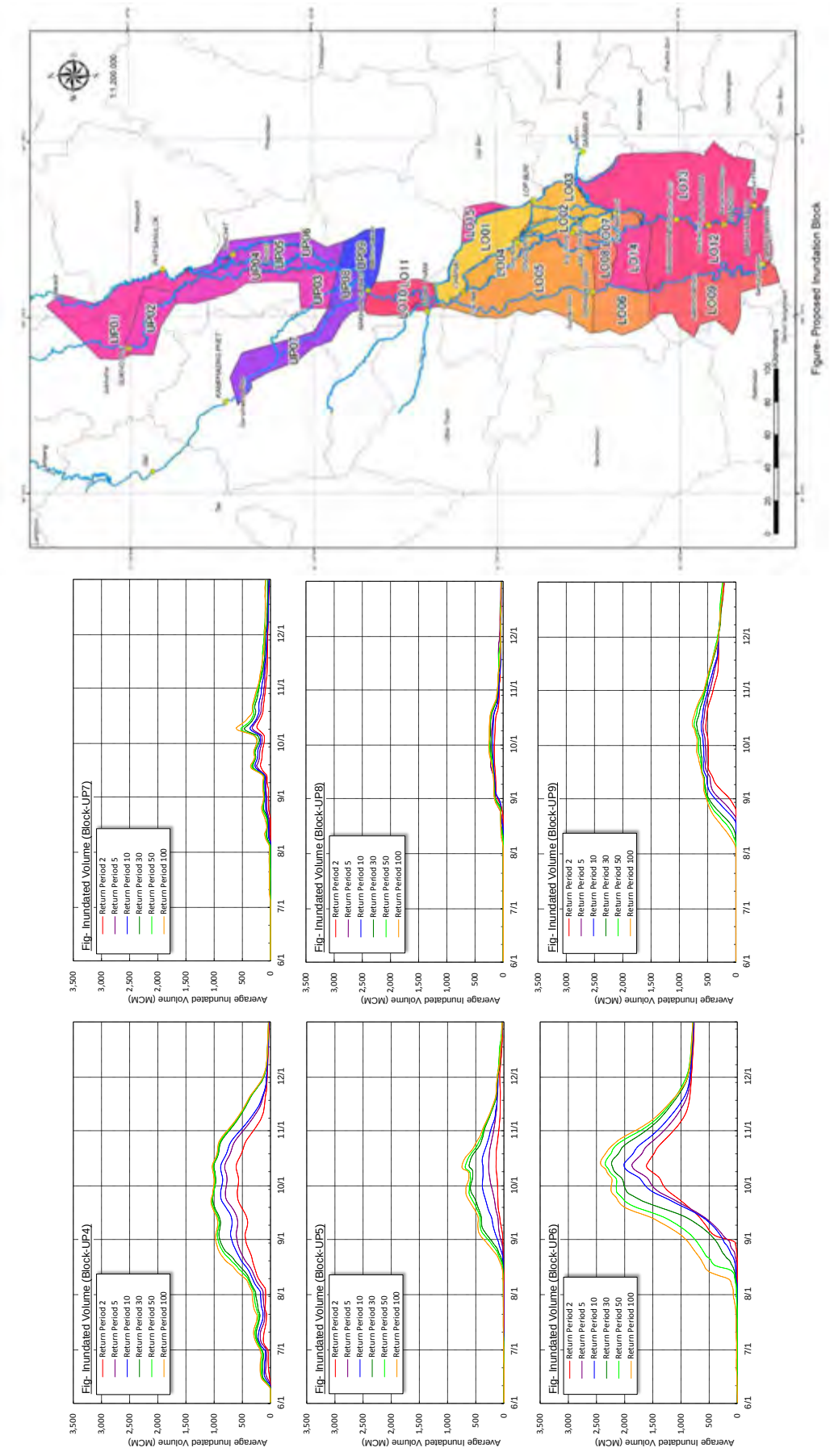


Figure K2.6.3 Inundation Volume (Case 0-1) (3/3)

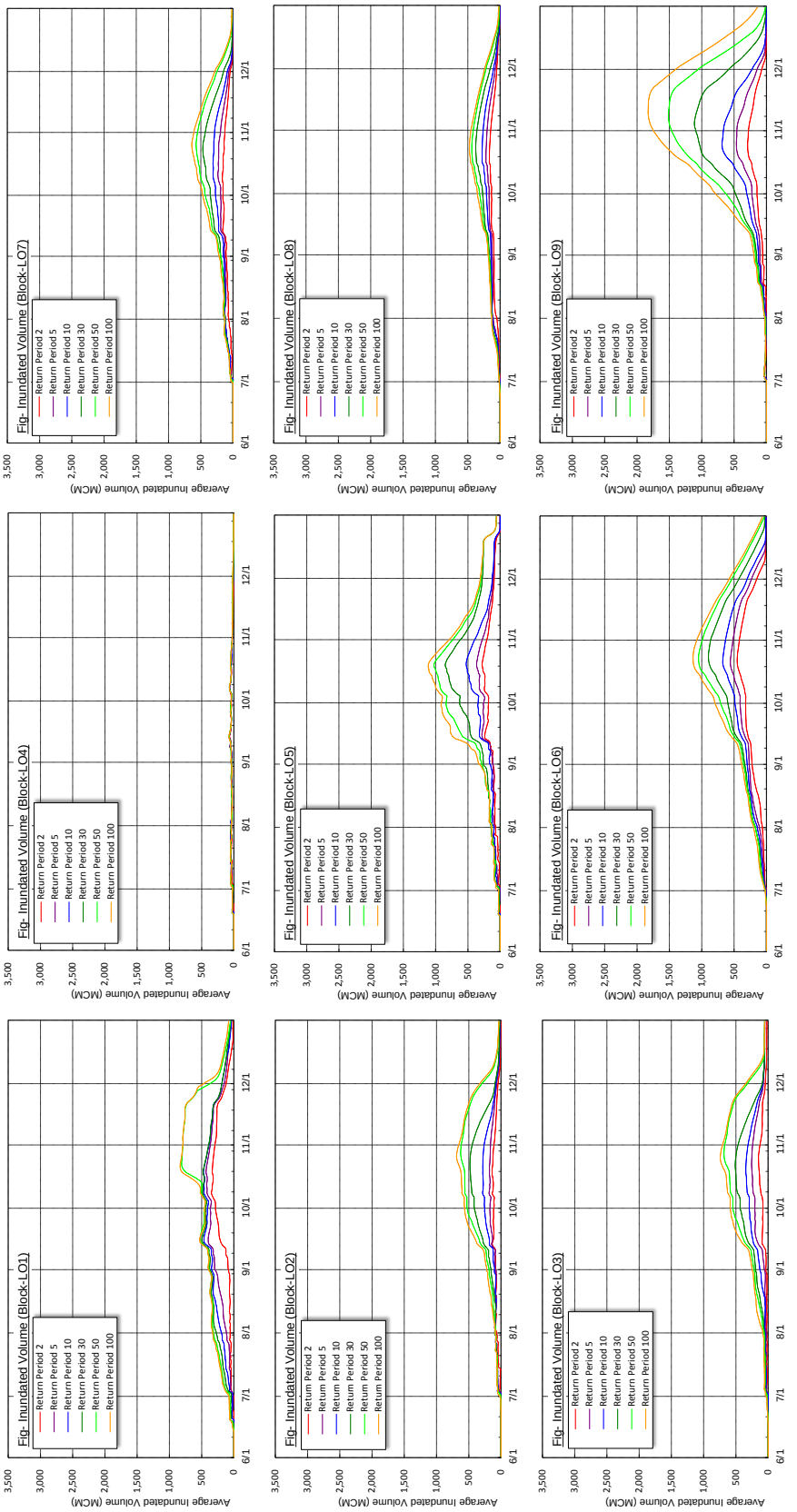


Figure K2.6.4 Inundation Volume (Case 1-0) (1/3)

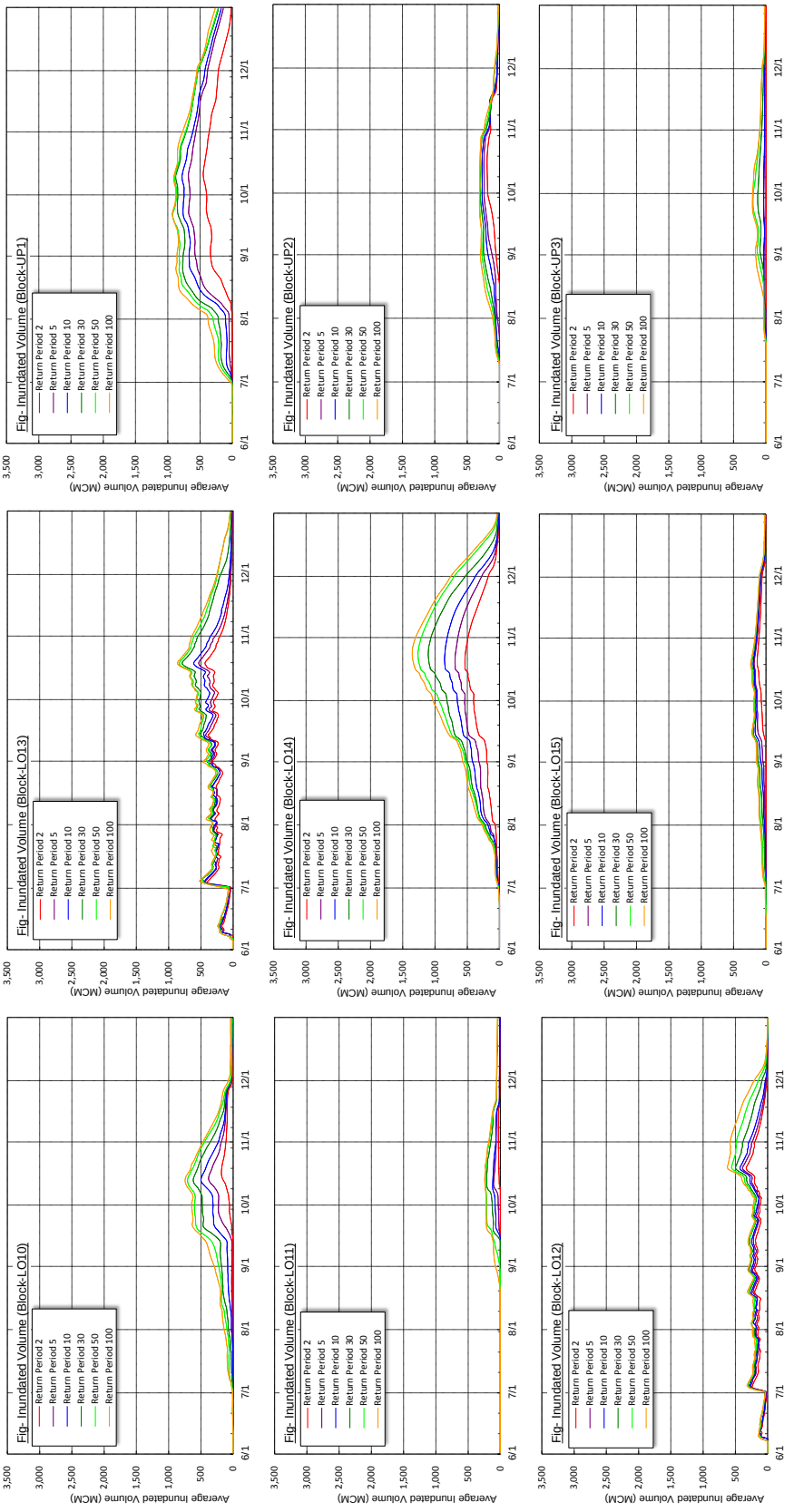


Figure K2.6.5 Inundation Volume (Case 1-0) (2/3)

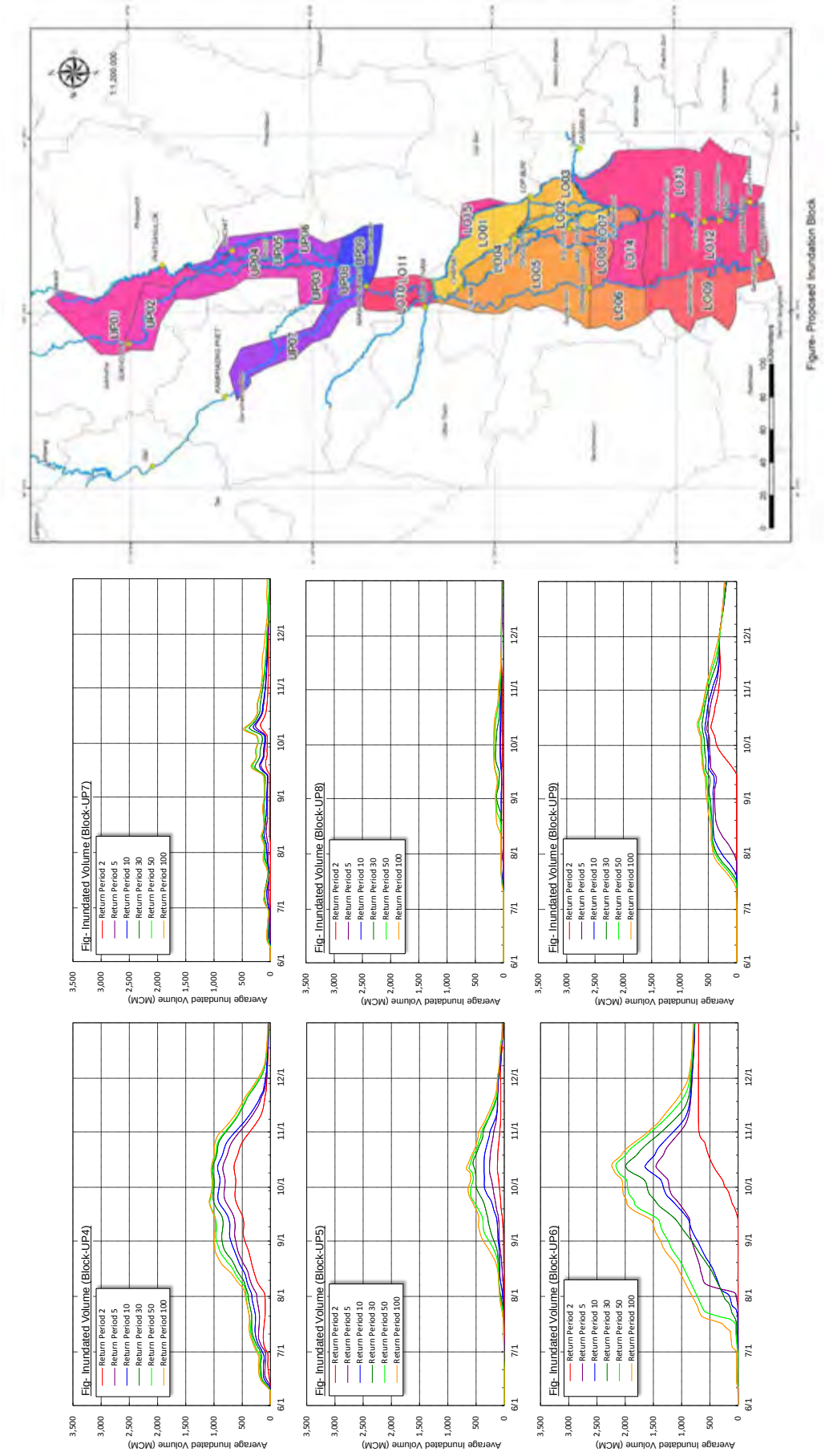


Figure K2.6.6 Inundation Volume (Case 1-0) (3/3)

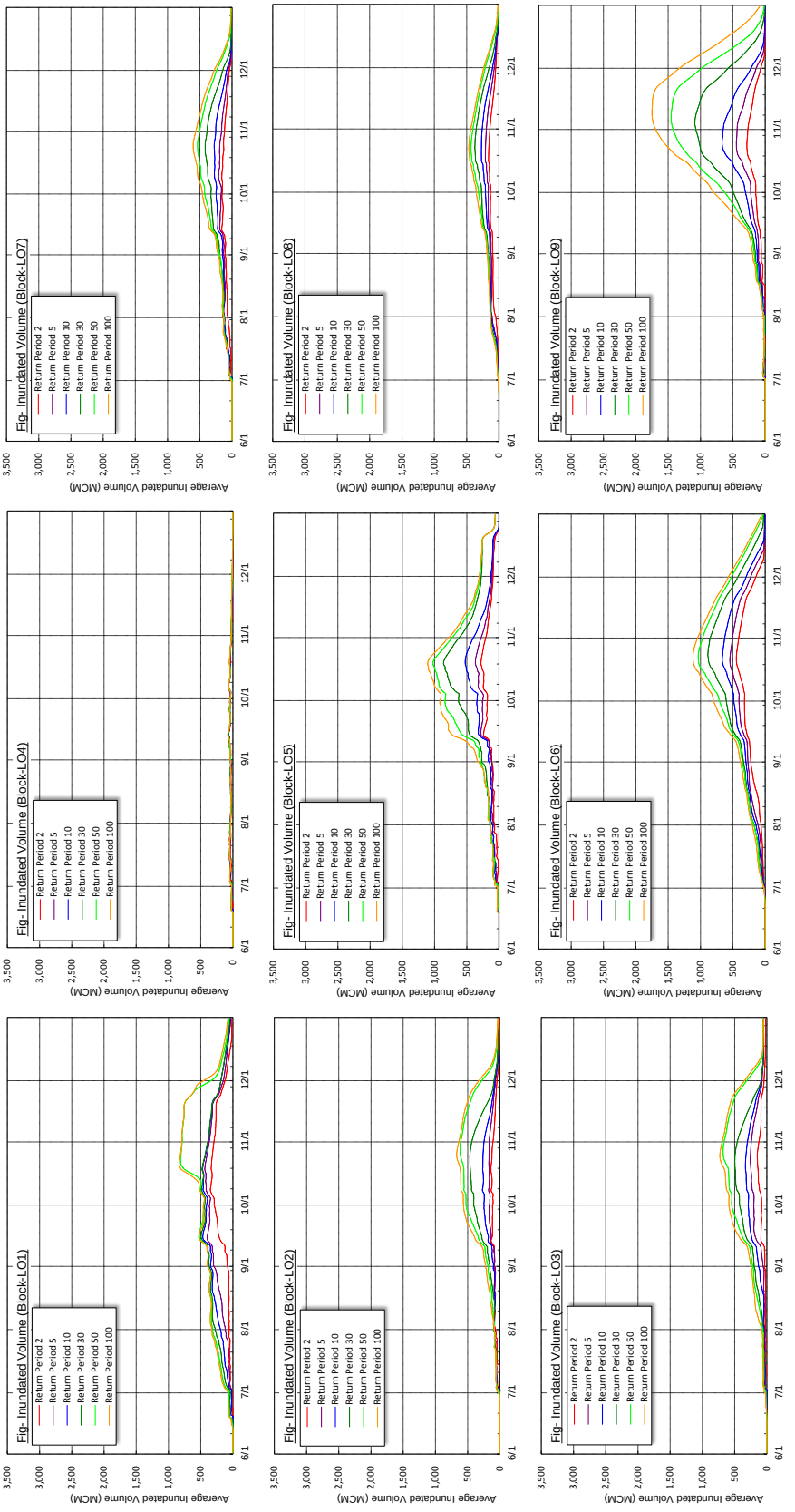


Figure K2.6.7 Inundation Volume (Case 1-1) (1/3)

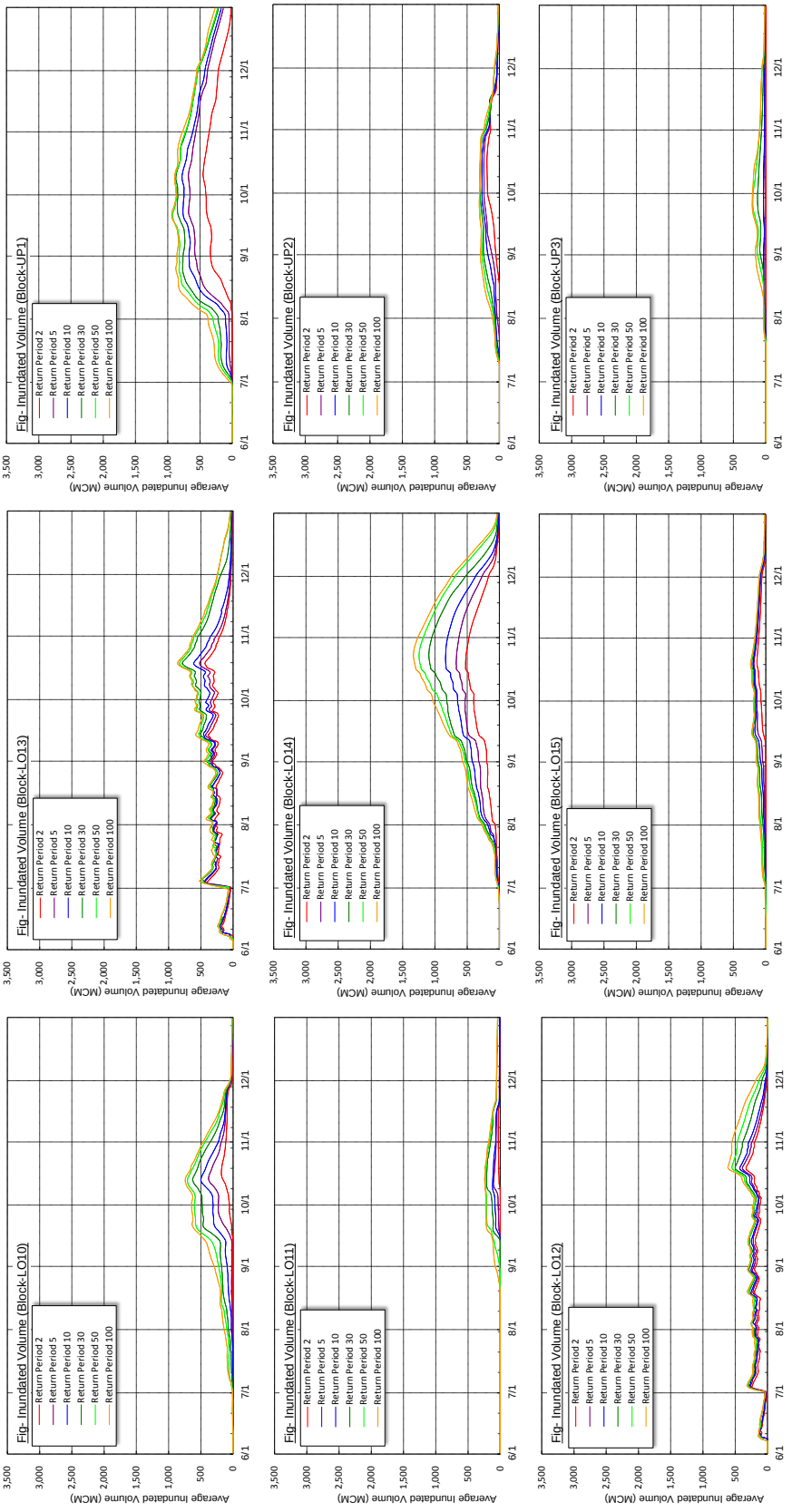


Figure K2.6.8 Inundation Volume (Case 1-1) (2/3)

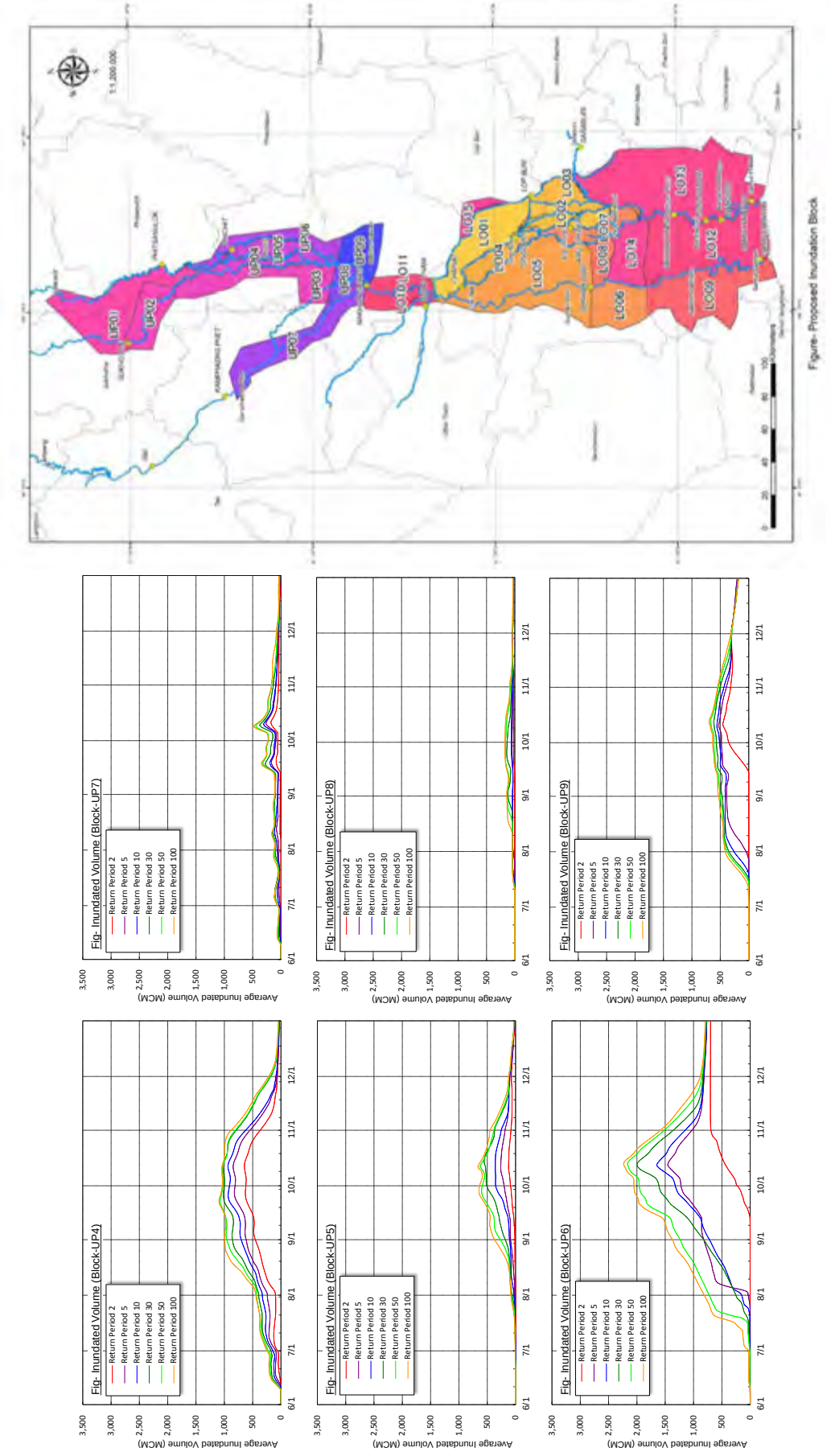


Figure K2.6.9 Inundation Volume (Case 1-1) (3/3)

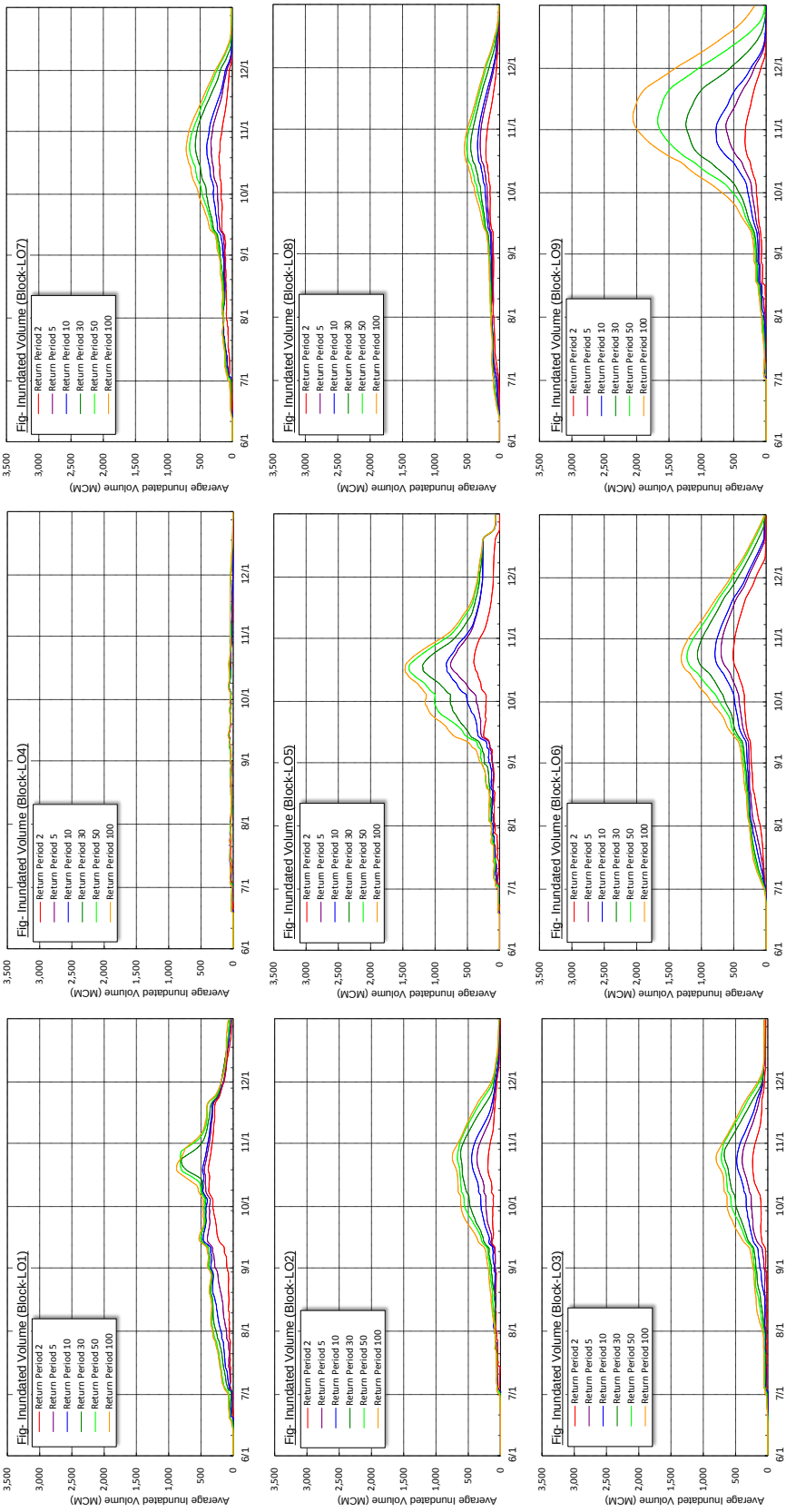


Figure K2.6.10 Inundation Volume (Case 11-0) (1/3)

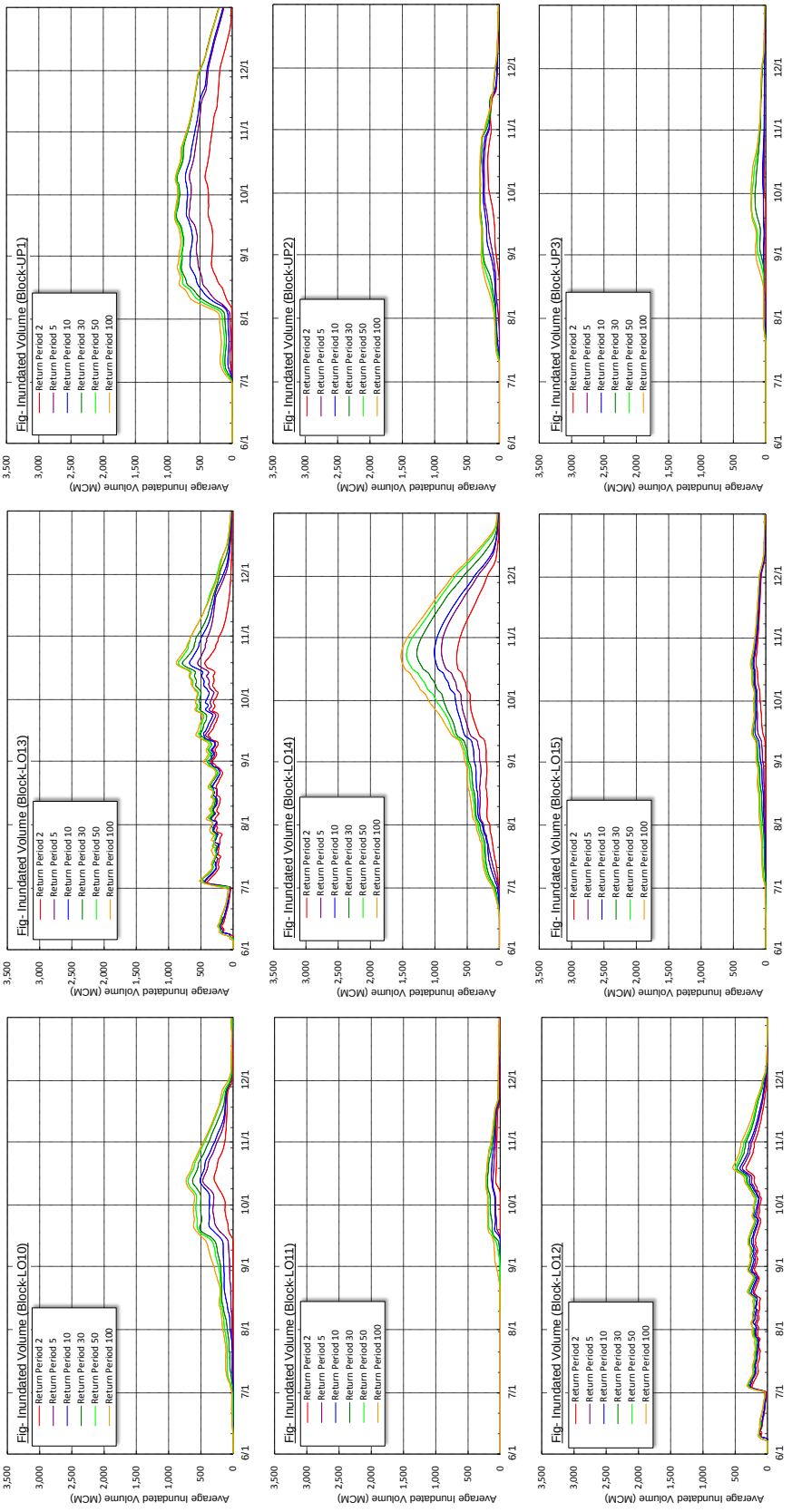


Figure K2.6.11 Inundation Volume (Case 11-0) (2/3)

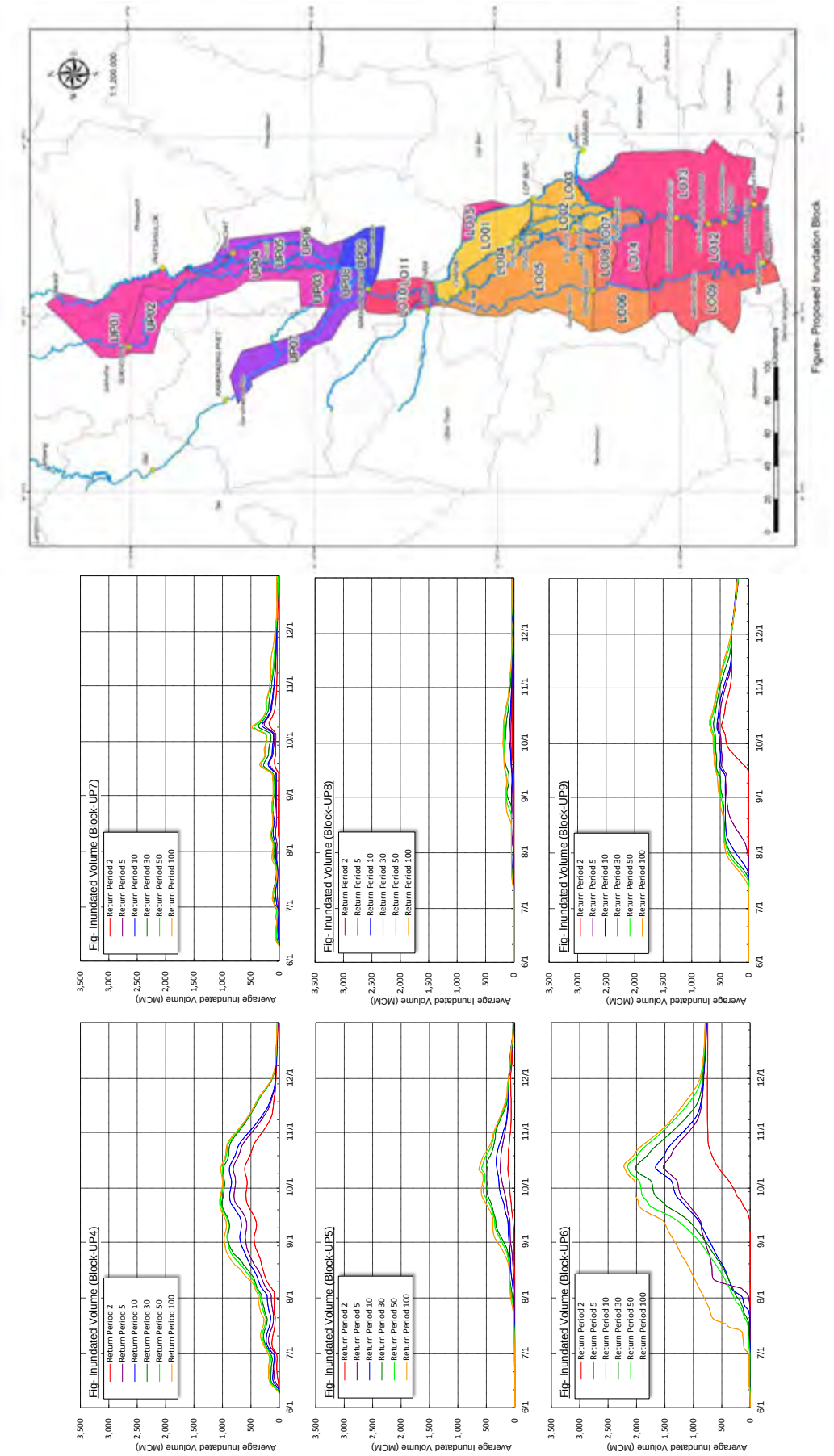


Figure K2.6.12 Inundation Volume (Case 11-0) (3/3)

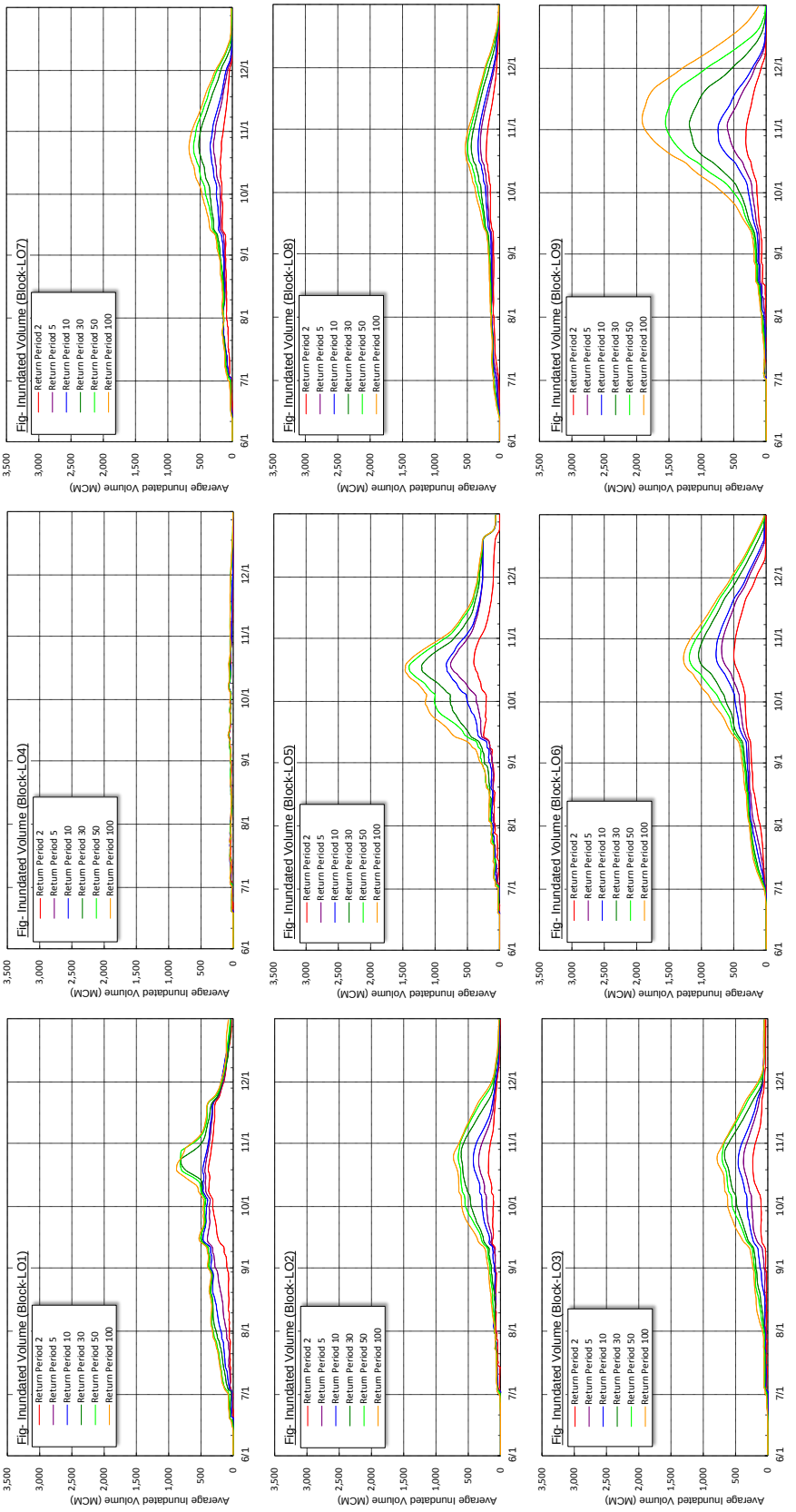


Figure K2.6.13 Inundation Volume (Case 11-1) (1/3)

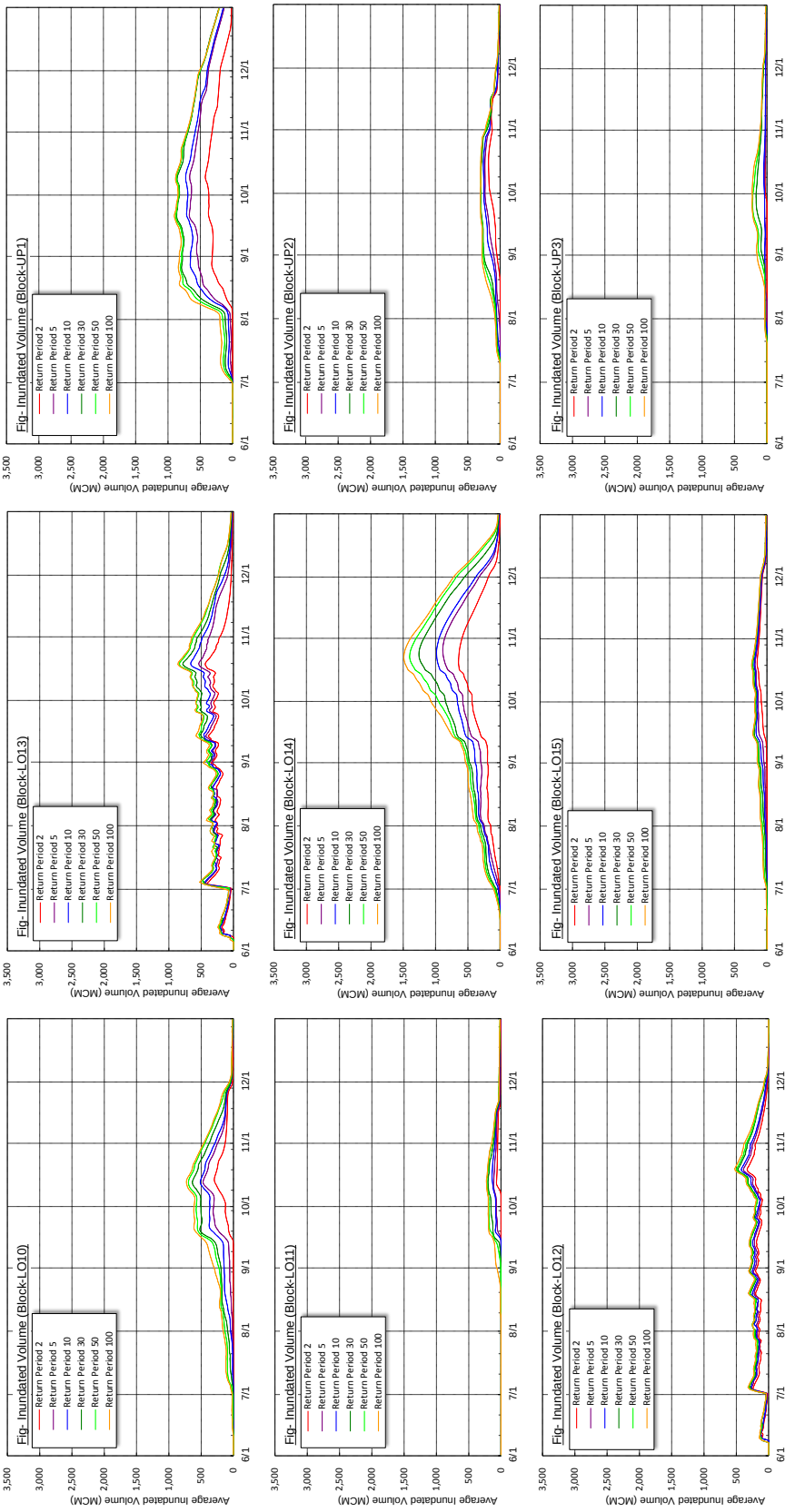


Figure K2.6.14 Inundation Volume (Case 11-1) (2/3)

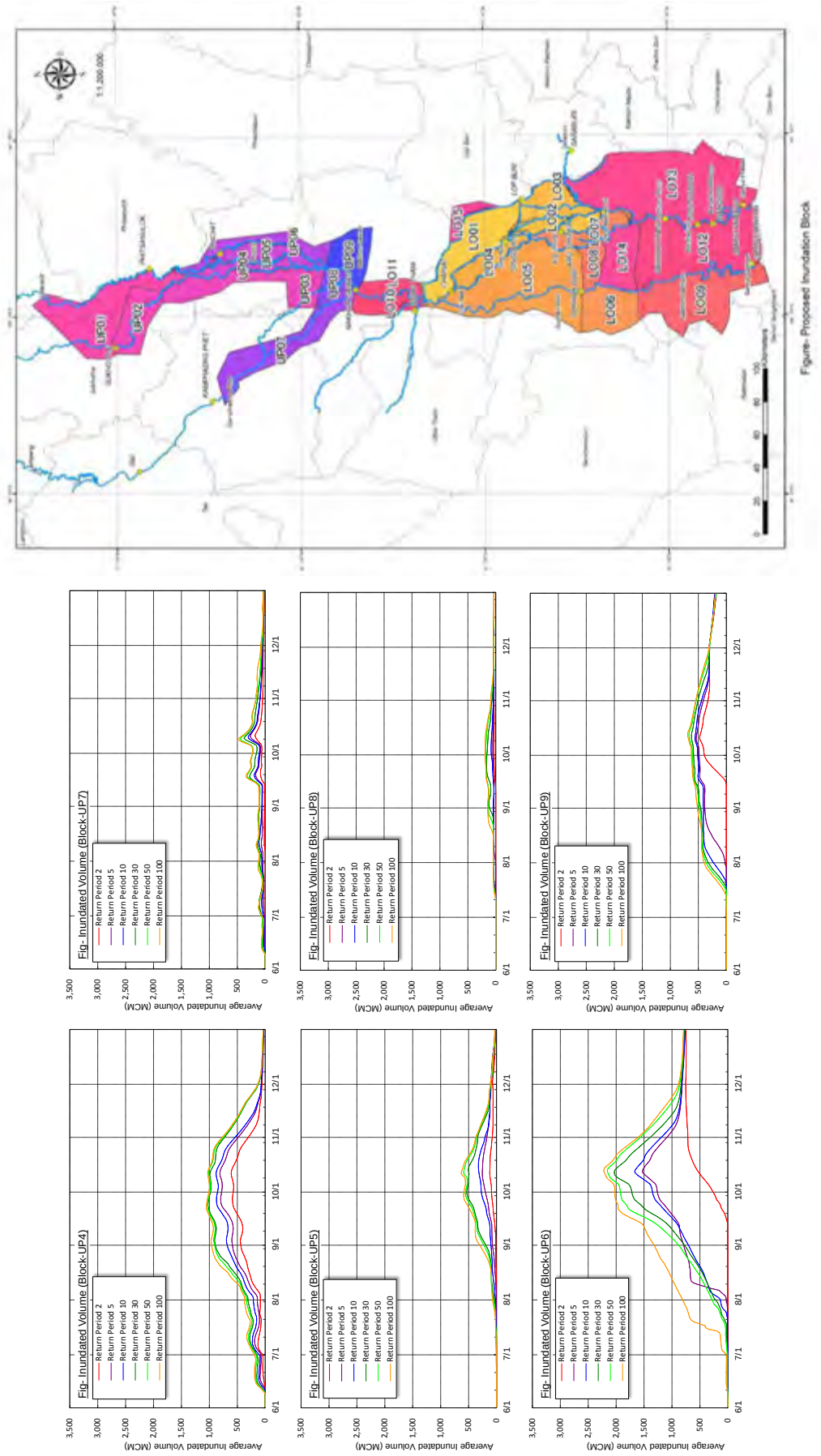


Figure K2.6.15 Inundation Volume (Case 11-1) (3/3)

K2.6.2 Inundation Depth

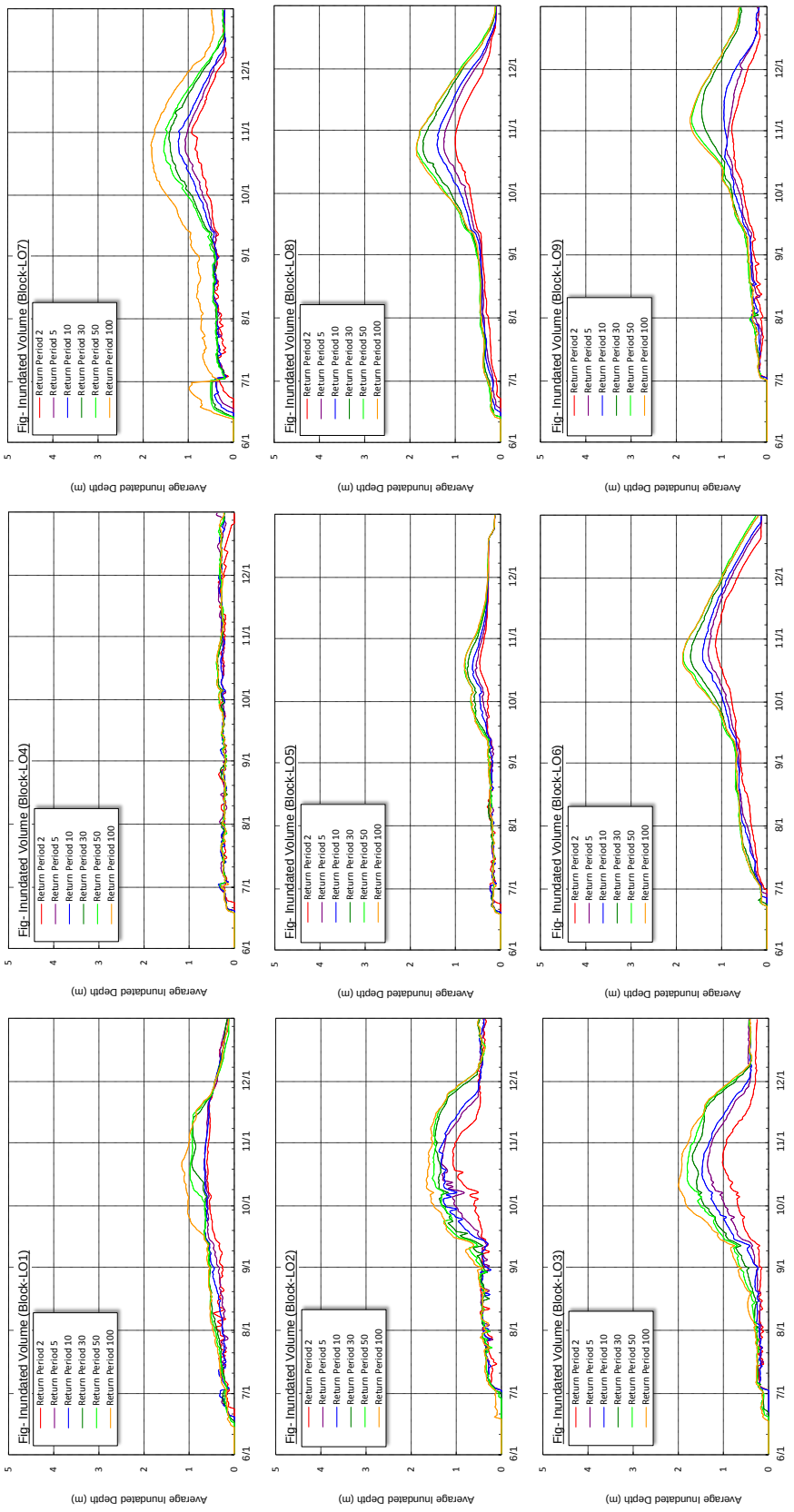


Figure K2.6.16 Inundation Depth (Case 0-1) (1/3)

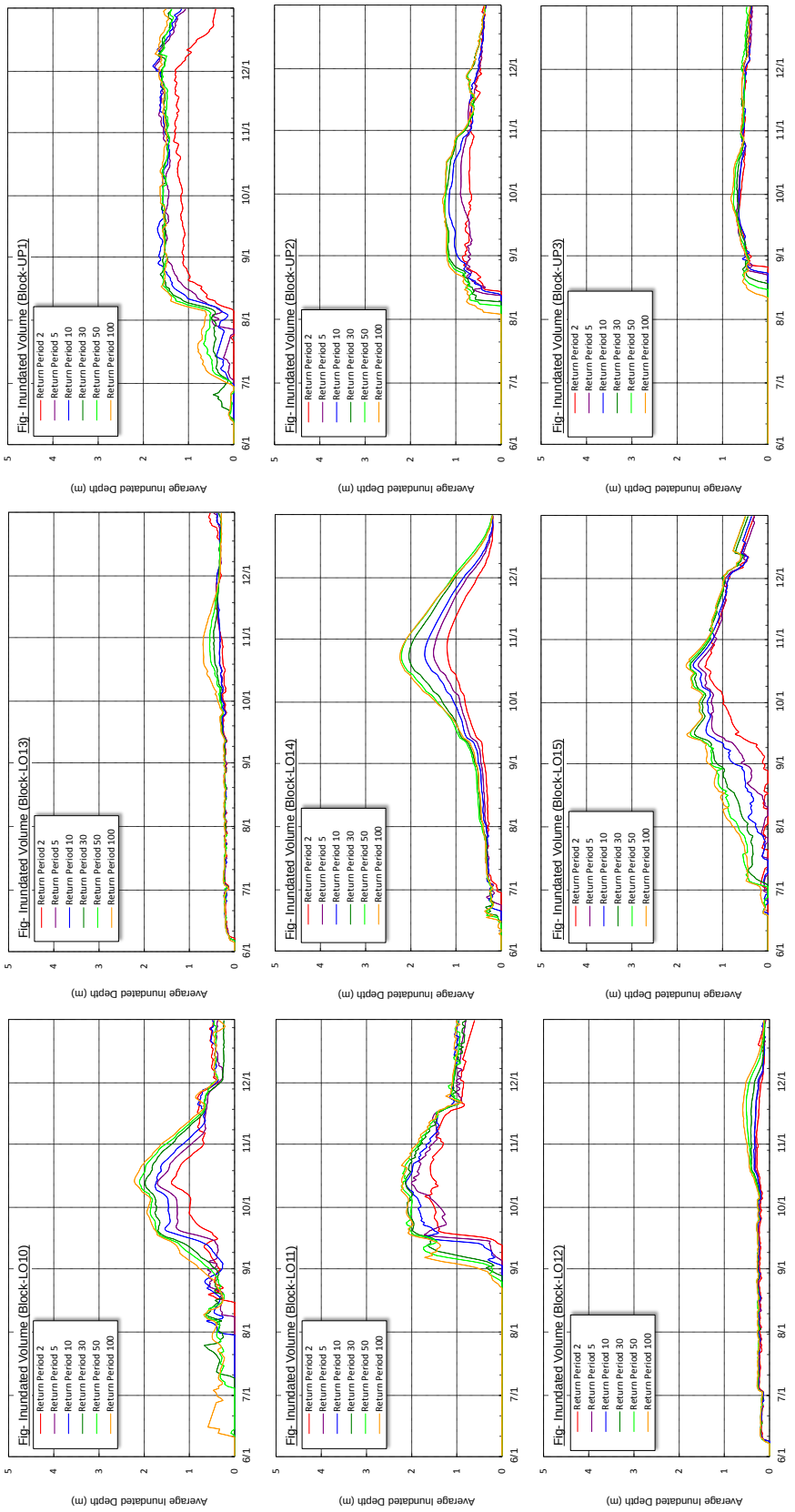


Figure K2.6.17 Inundation Depth (Case 0-1) (2/3)

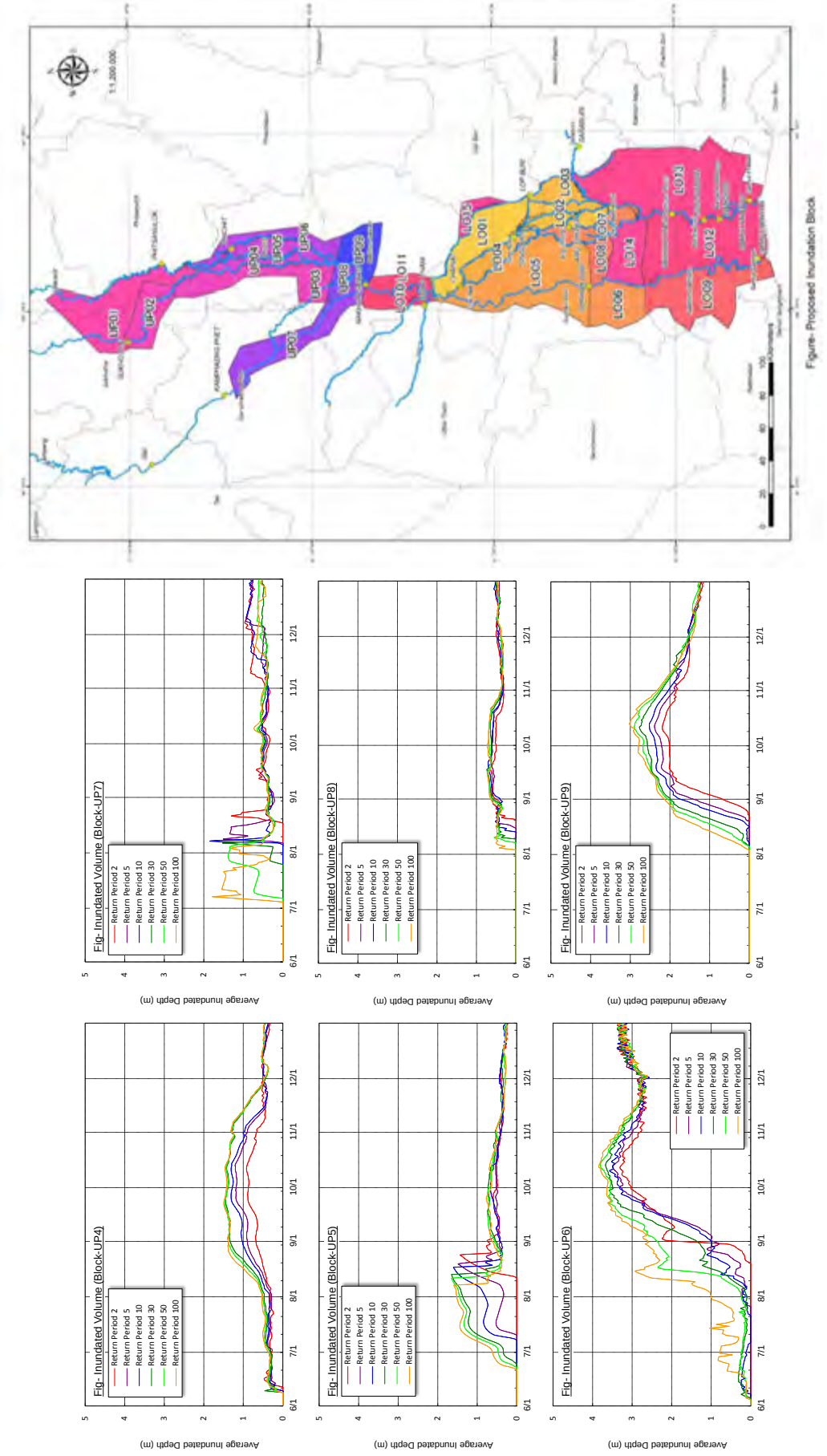


Figure K2.6.18 Inundation Depth (Case 0-1) (3/3)

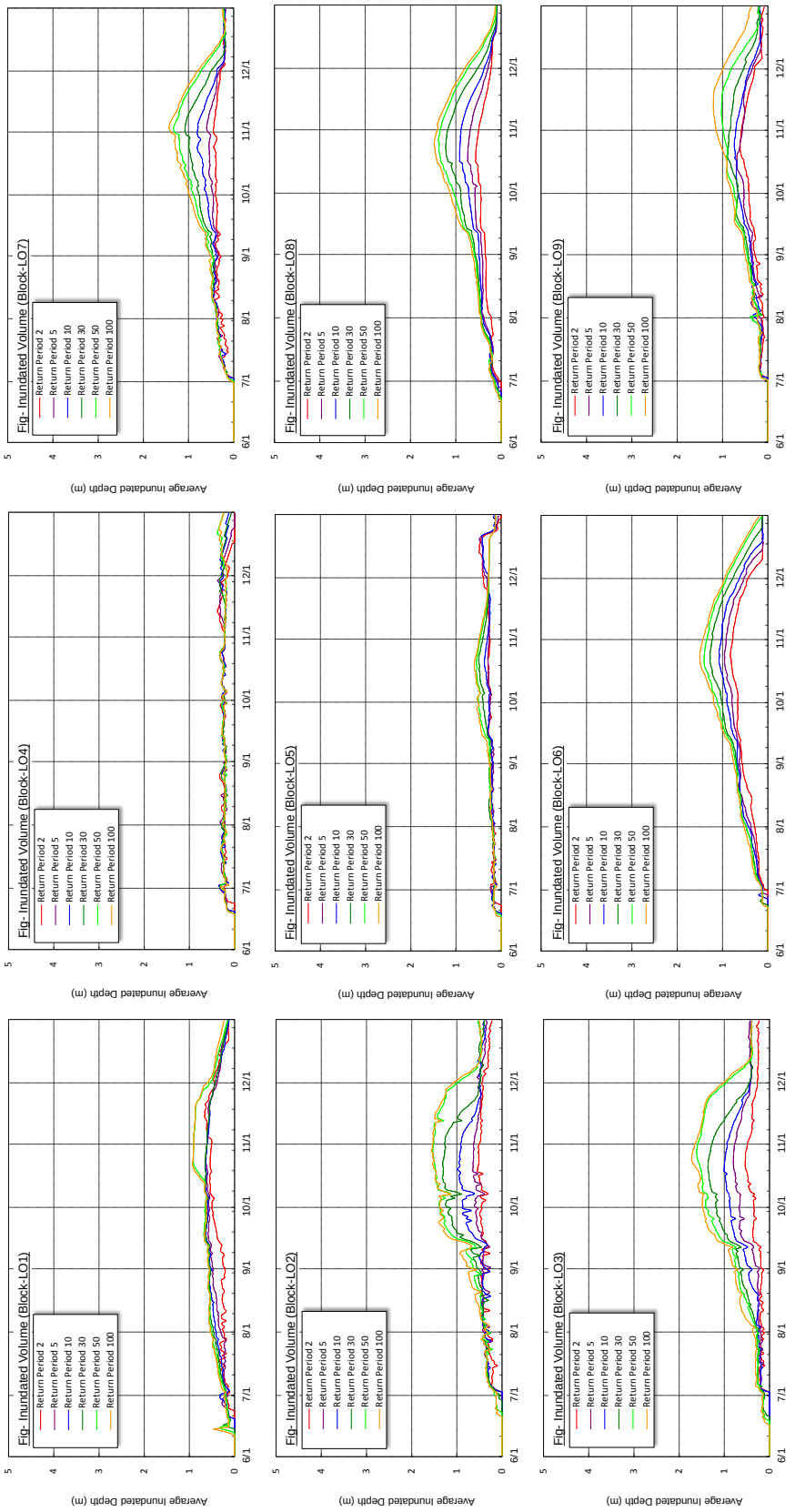


Figure K2.6.19 Inundation Depth (Case 1-0) (1/3)

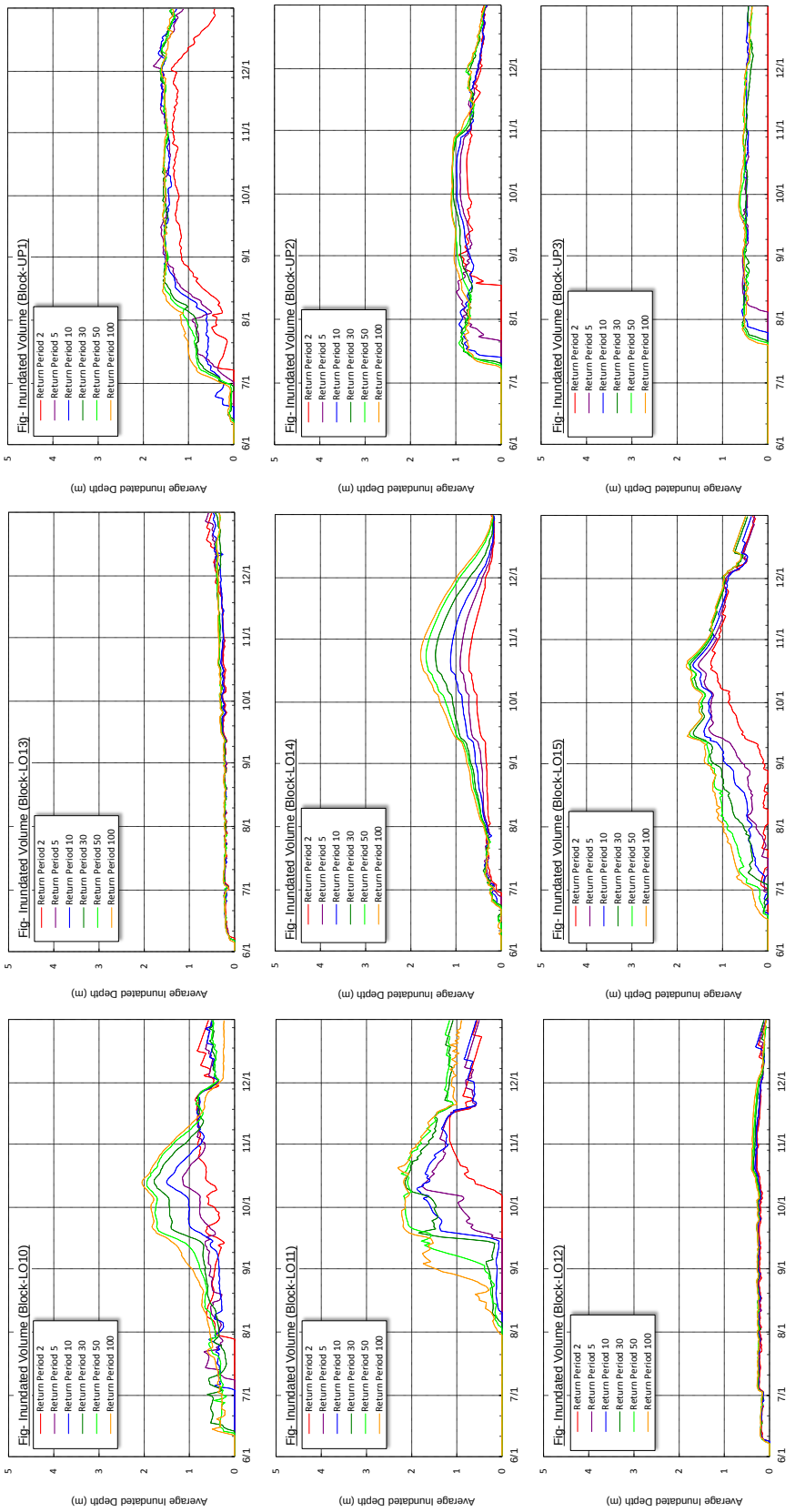


Figure K2.6.20 Inundation Depth (Case 1-0) (2/3)

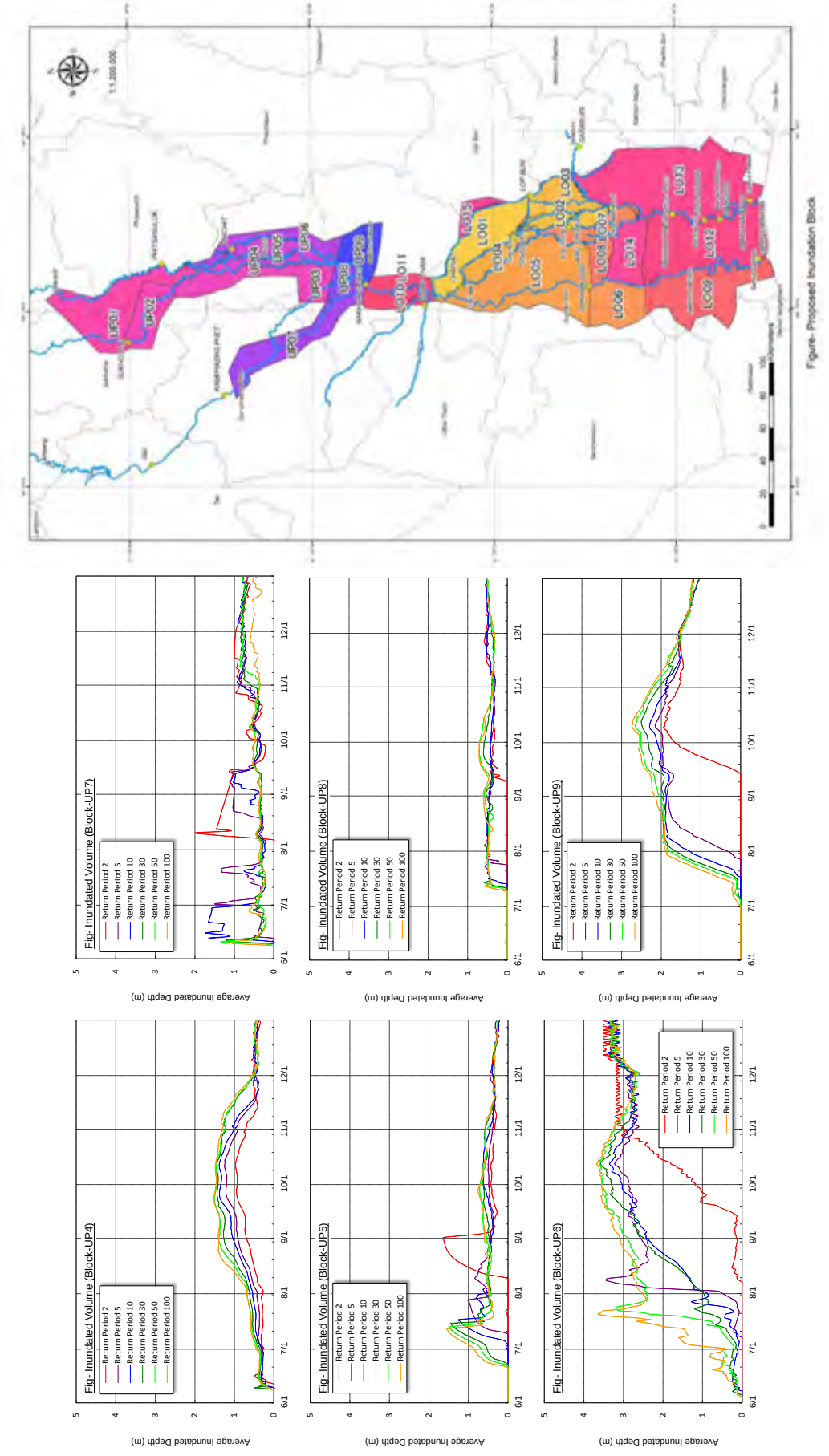


Figure K2.6.21 Inundation Depth (Case 1-0) (3/3)

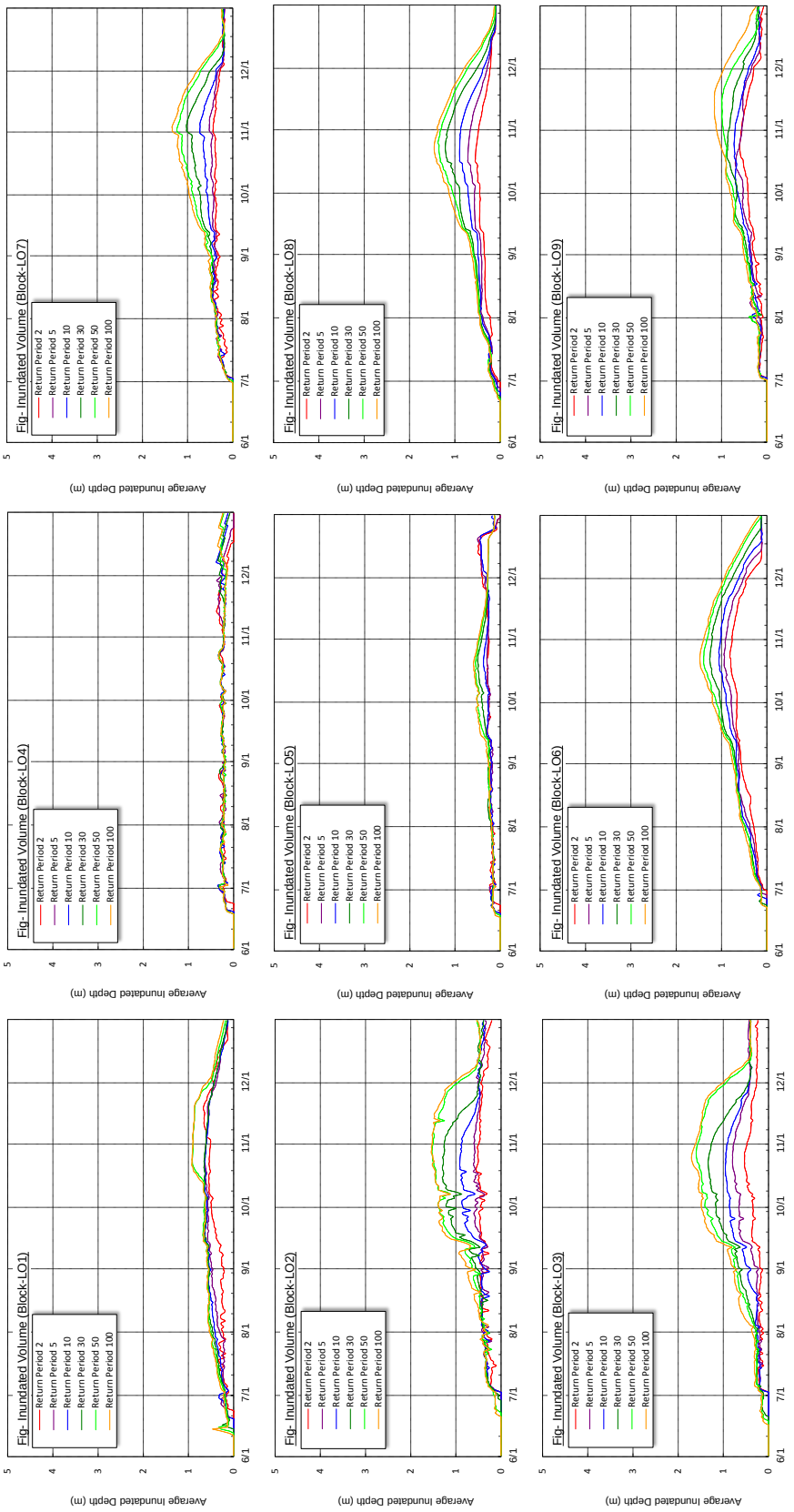


Figure K2.6.22 Inundation Depth (Case 1-1) (1/3)

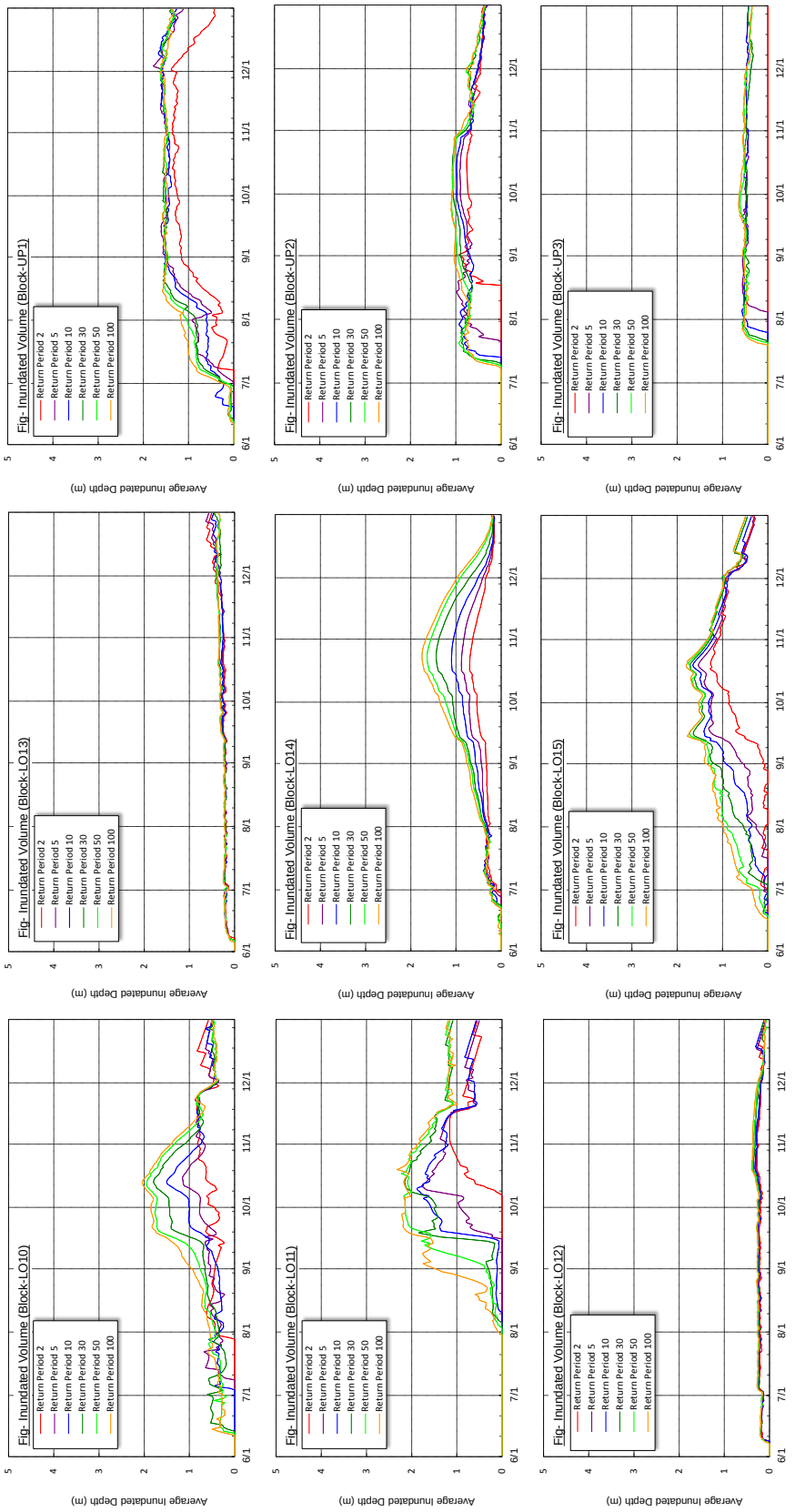


Figure K2.6.23 Inundation Depth (Case 1-1) (2/3)

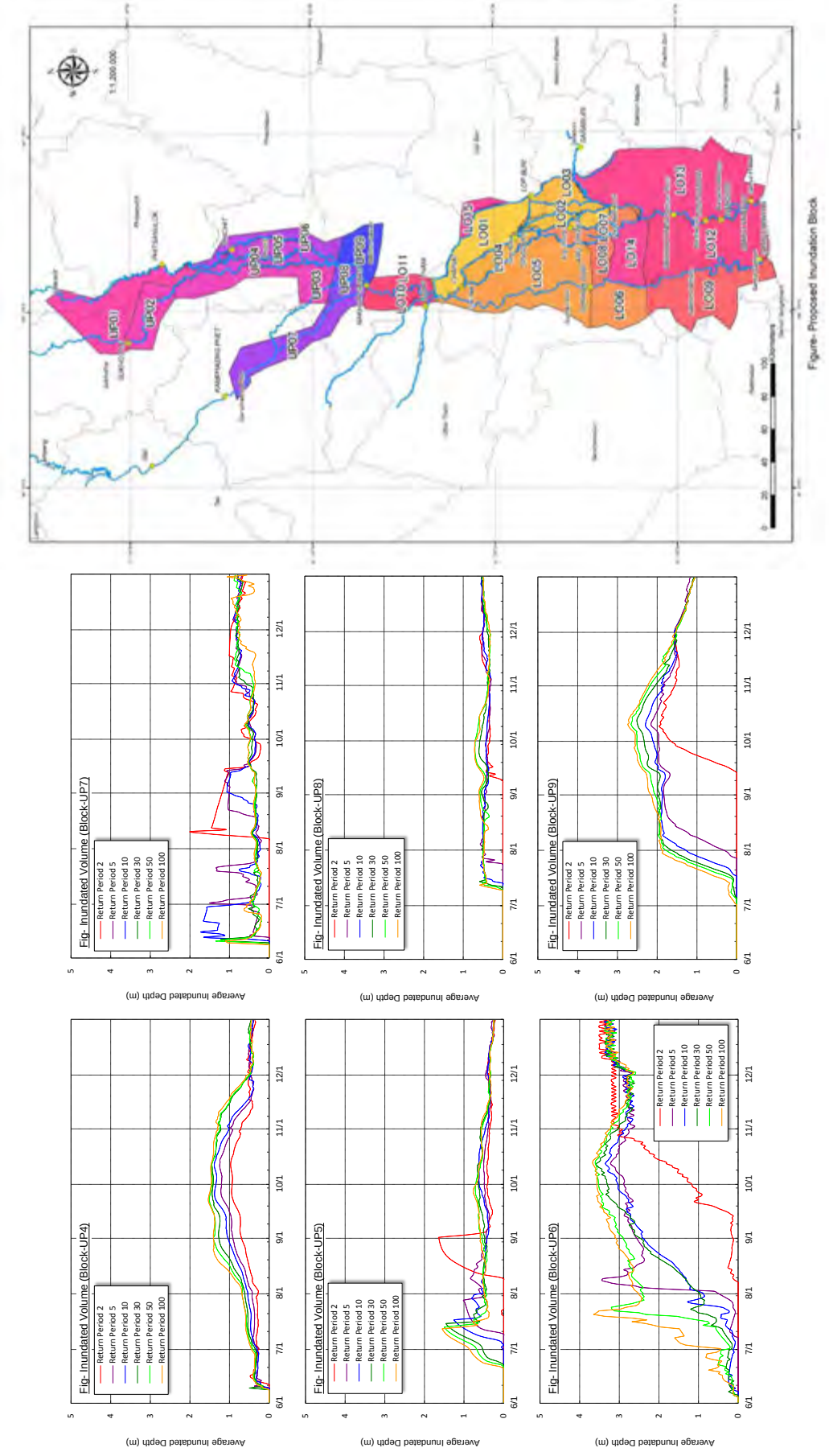


Figure K2.6.24 Inundation Depth (Case 1-1) (3/3)

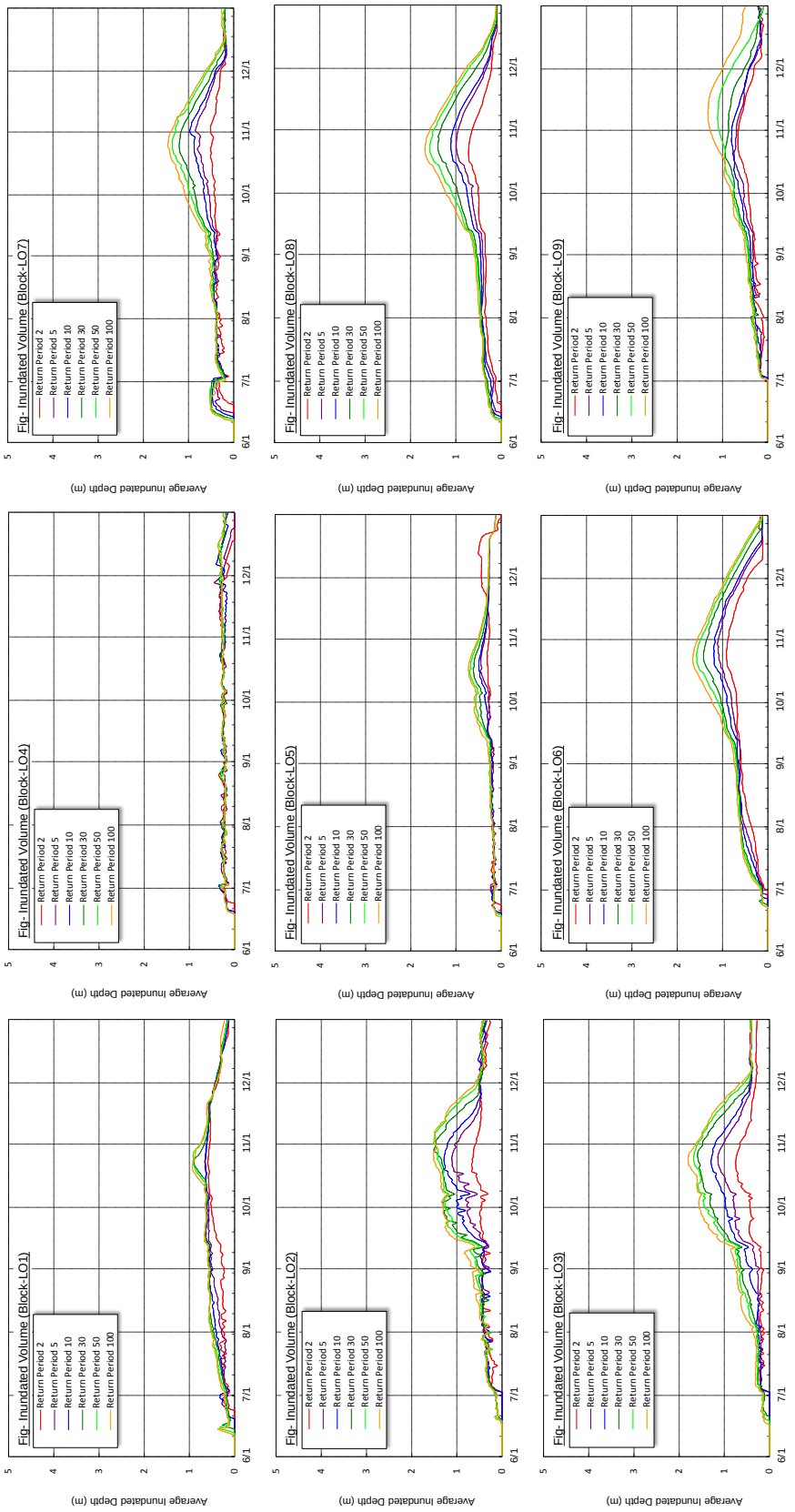


Figure K2.6.25 Inundation Depth (Case 11-0) (1/3)

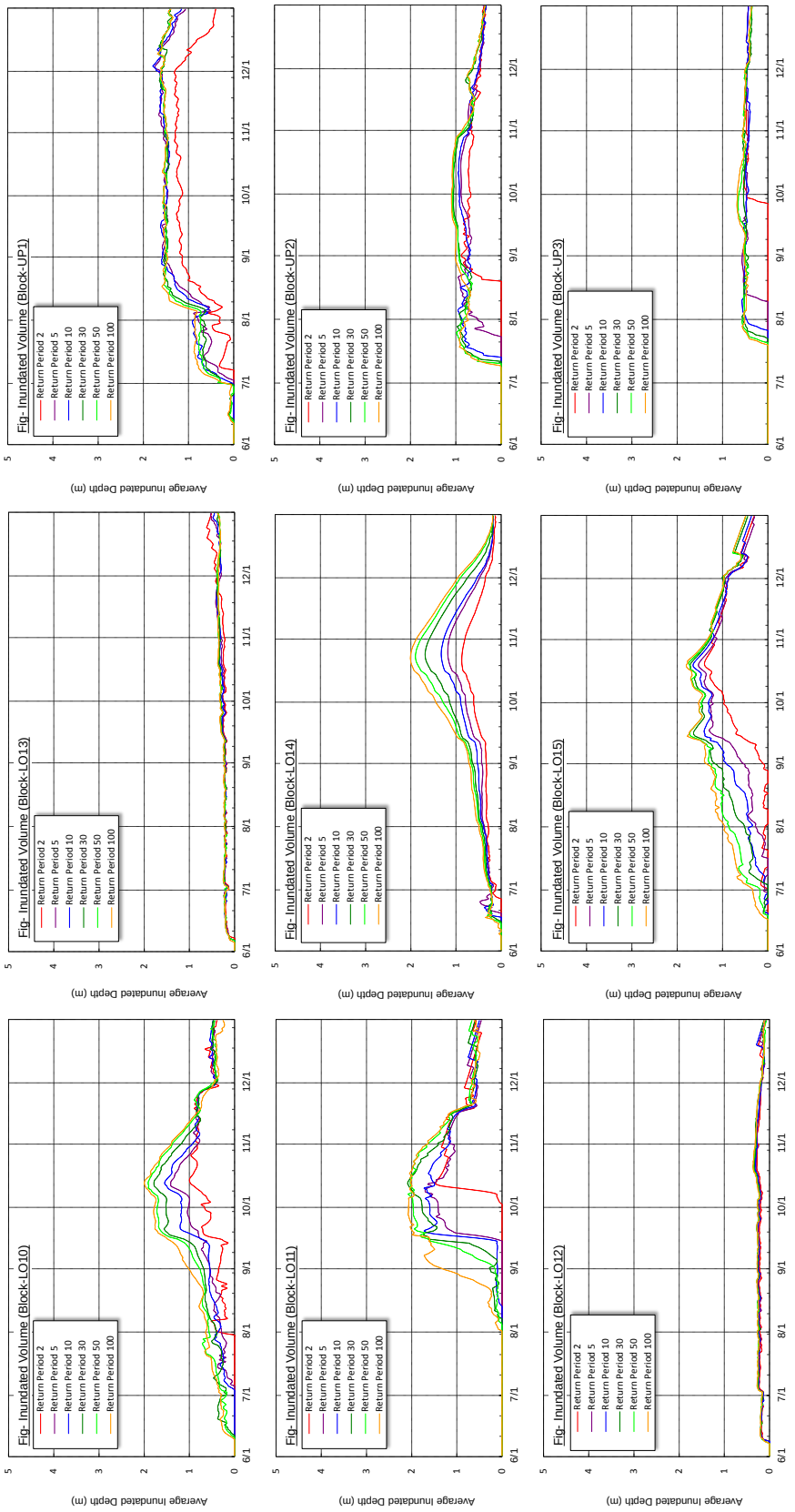


Figure K2.6.26 Inundation Depth (Case 11-0) (2/3)

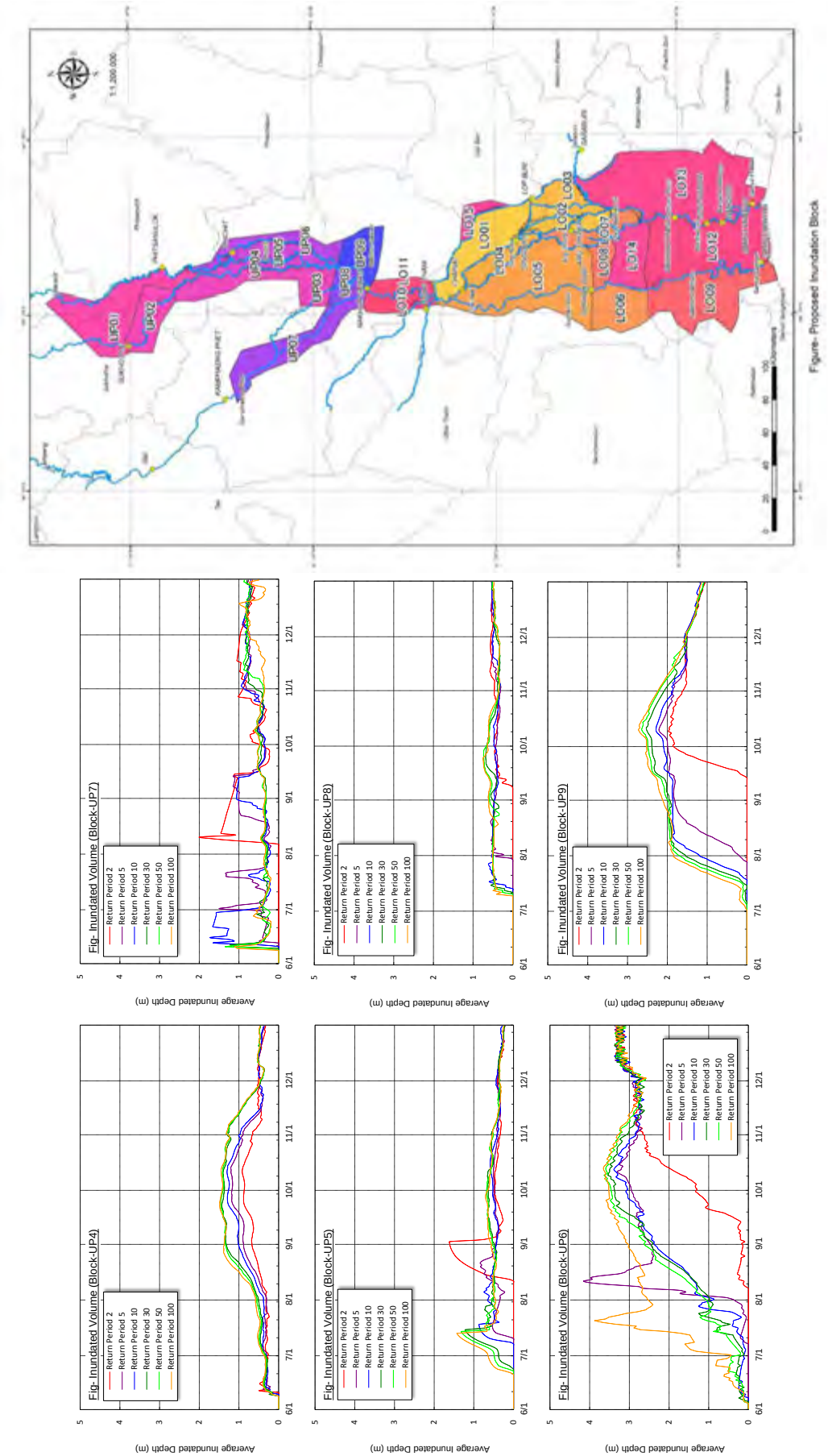


Figure K2.6.27 Inundation Depth (Case 11-0) (3/3)

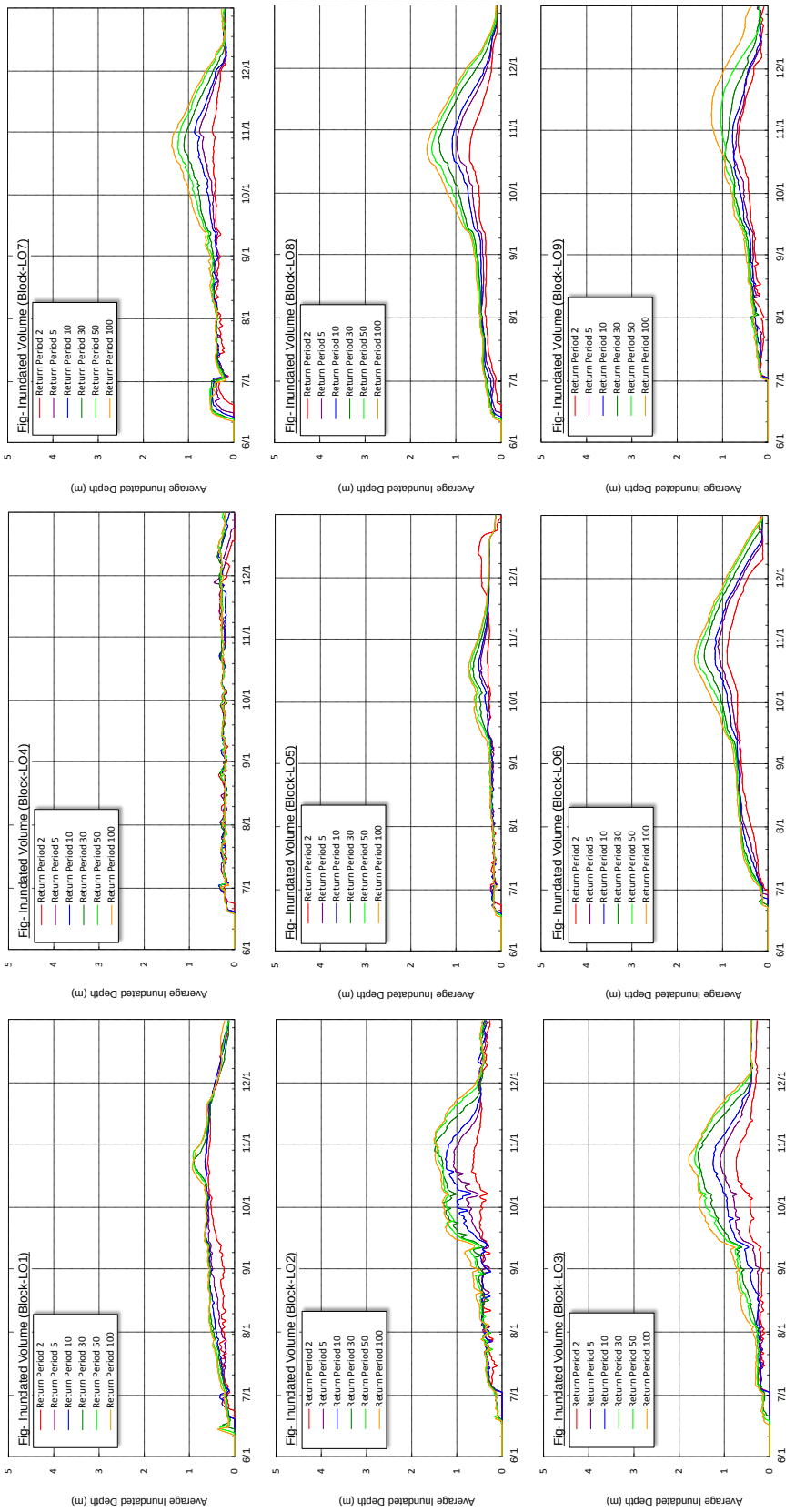


Figure K2.6.28 Inundation Depth (Case 11-1) (1/3)

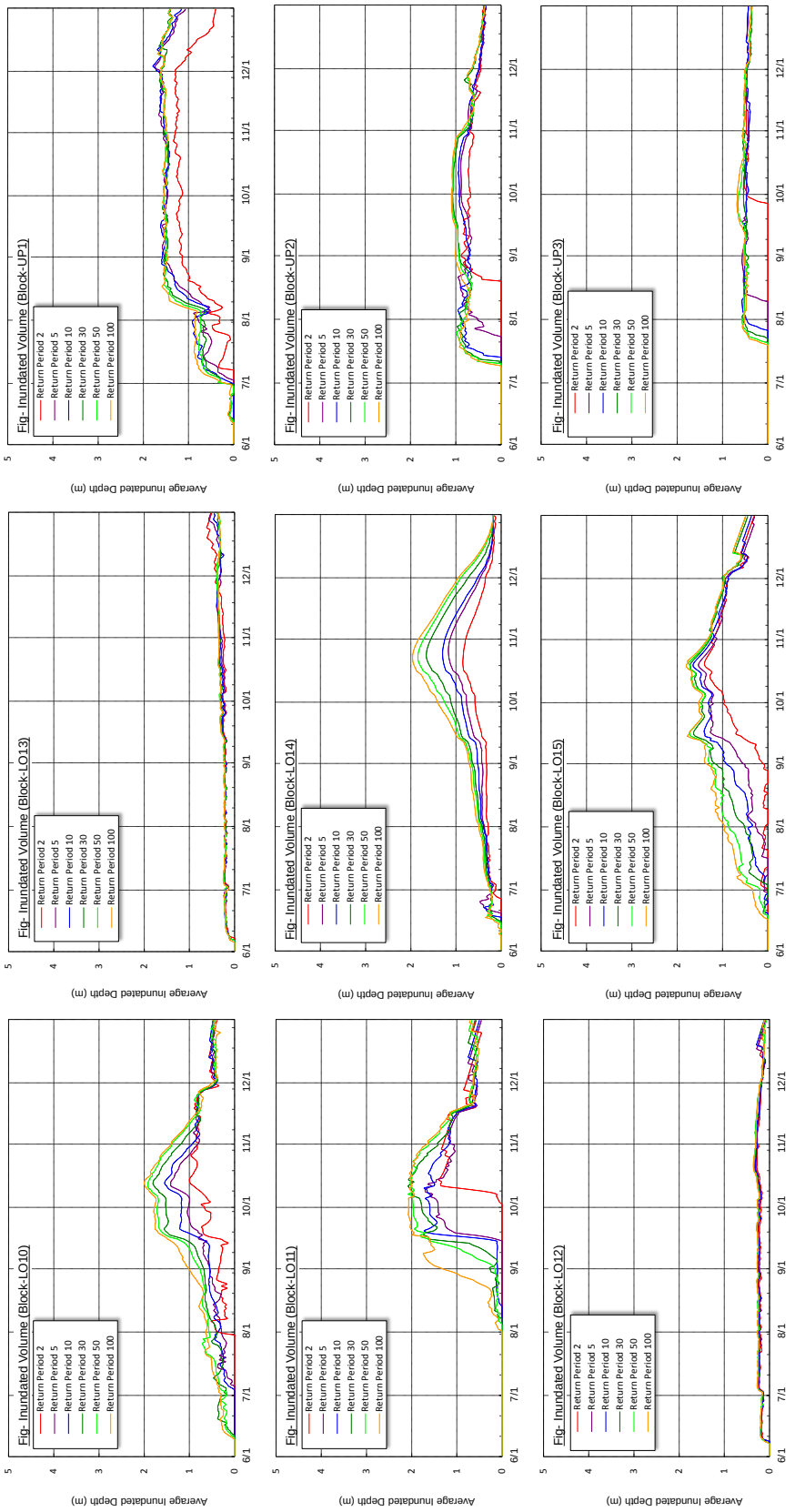


Figure K2.6.29 Inundation Depth (Case 11-1) (2/3)

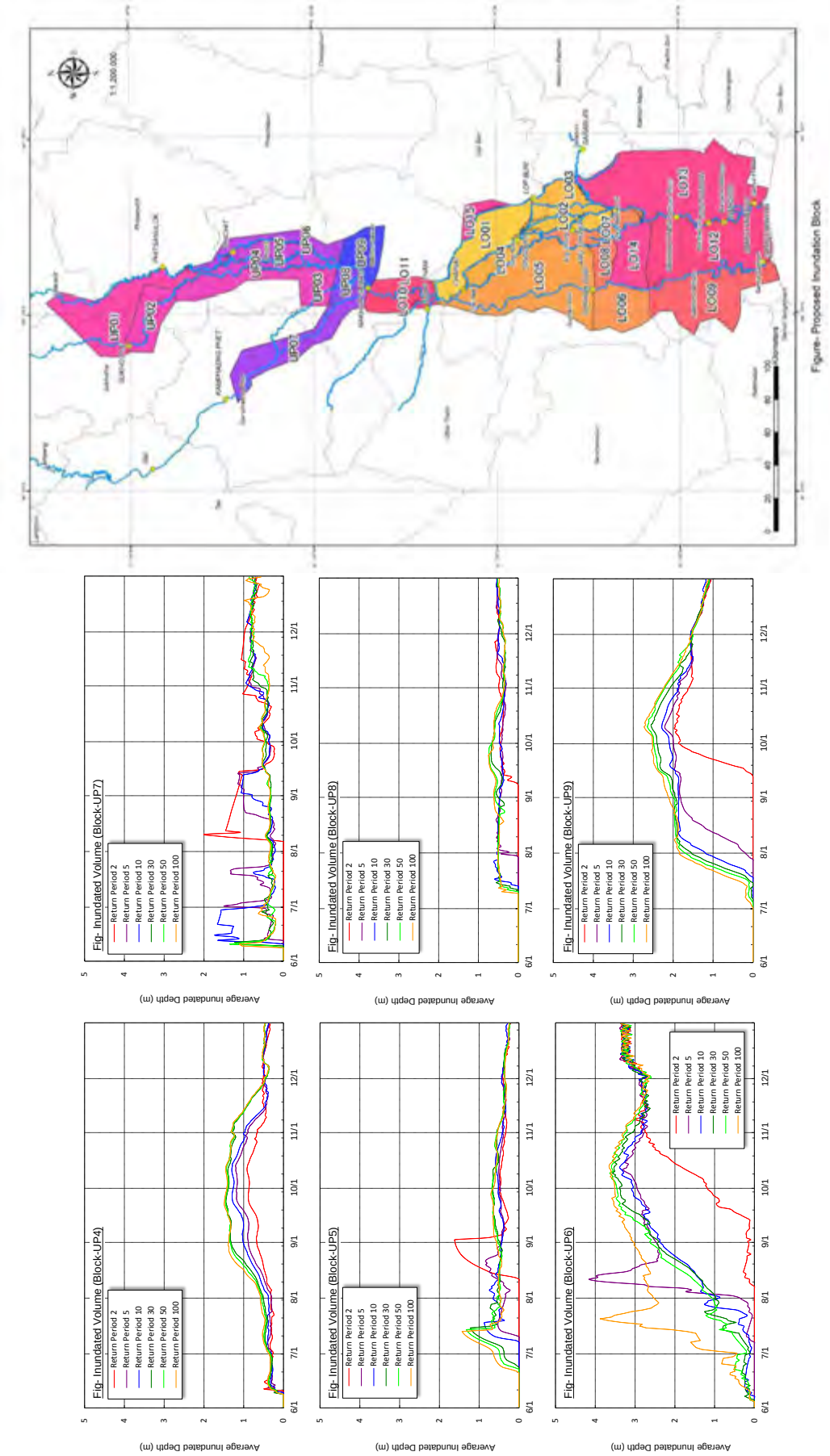


Figure K2.6.30 Inundation Depth (Case 11-1) (3/3)

K2.6.3 Inundation Area

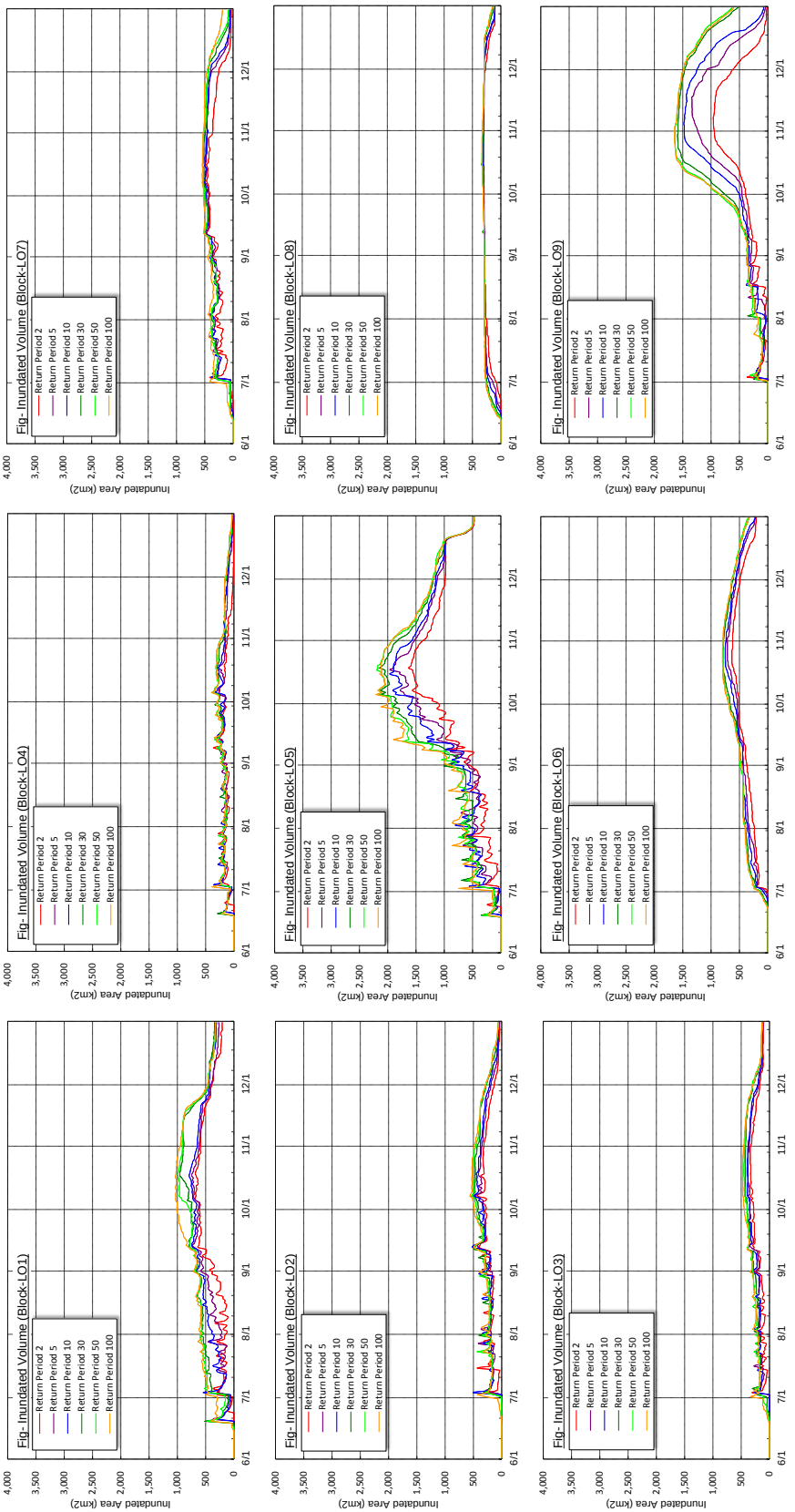


Figure K2.6.31 Inundation Area (Case 0-1) (1/3)

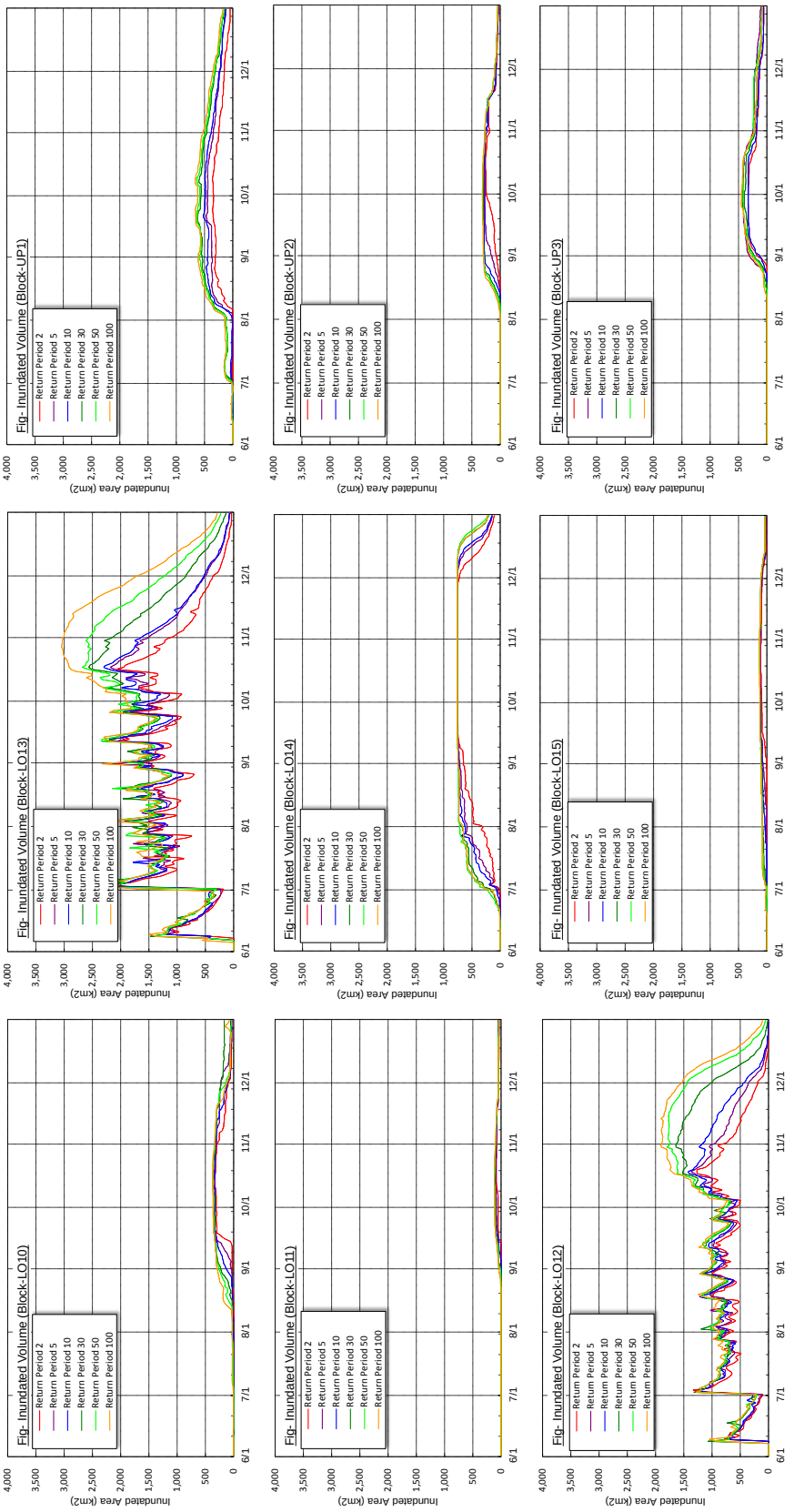


Figure K2.6.32 Inundation Area (Case 0-1) (2/3)

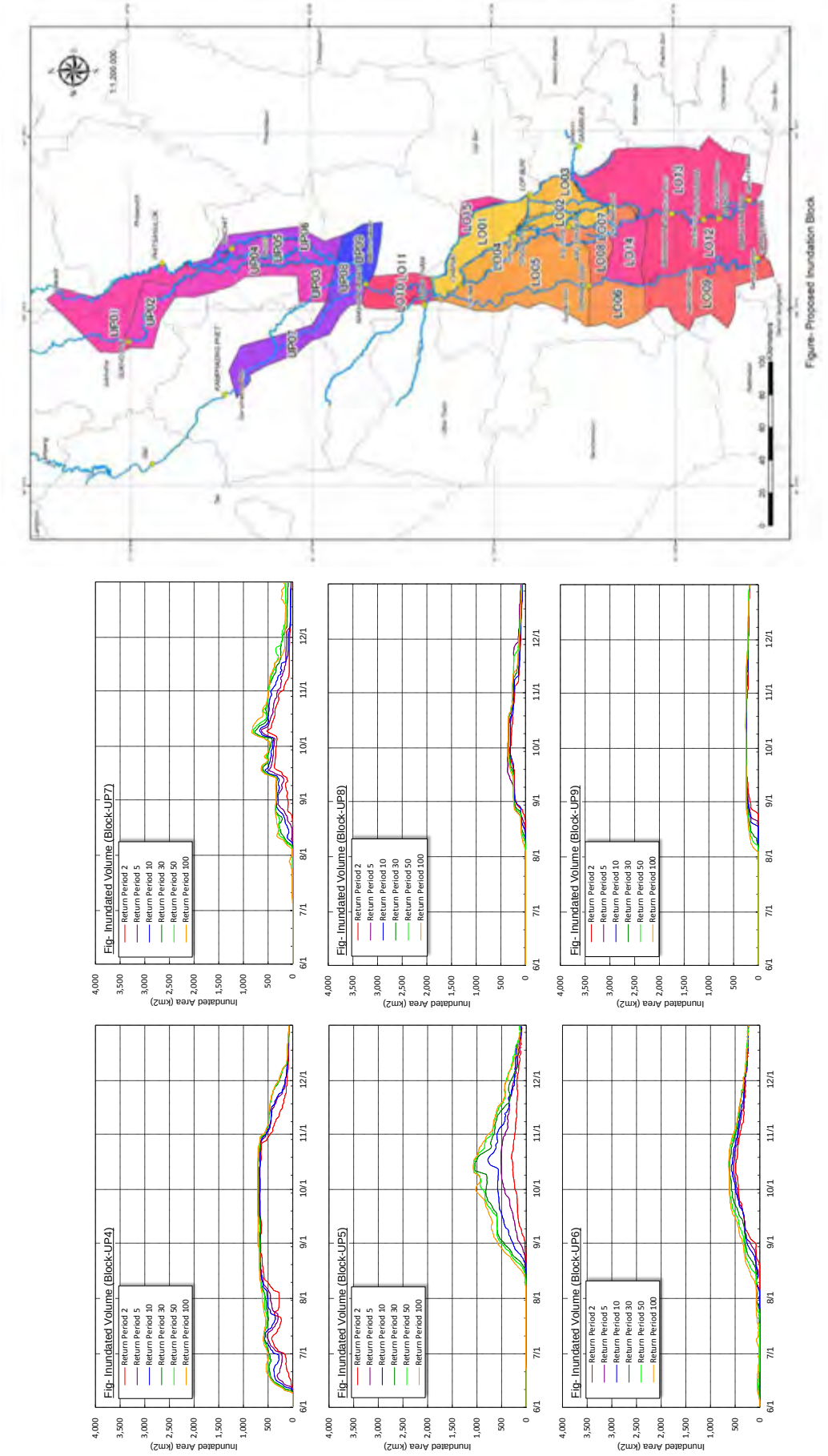


Figure K2.6.33 Inundation Area (Case 0-1) (3/3)

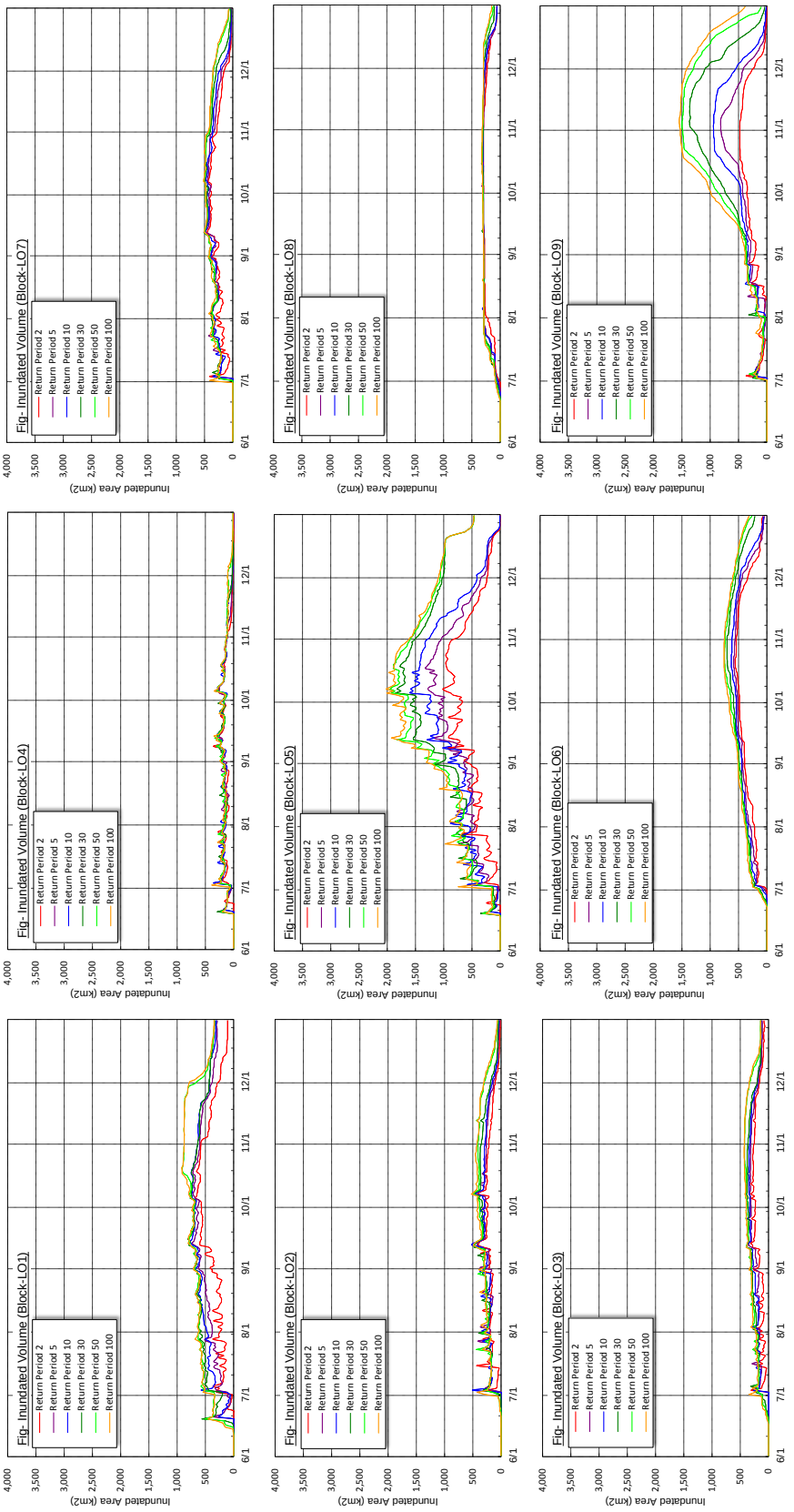


Figure K2.6.34 Inundation Area (Case 1-0) (1/3)

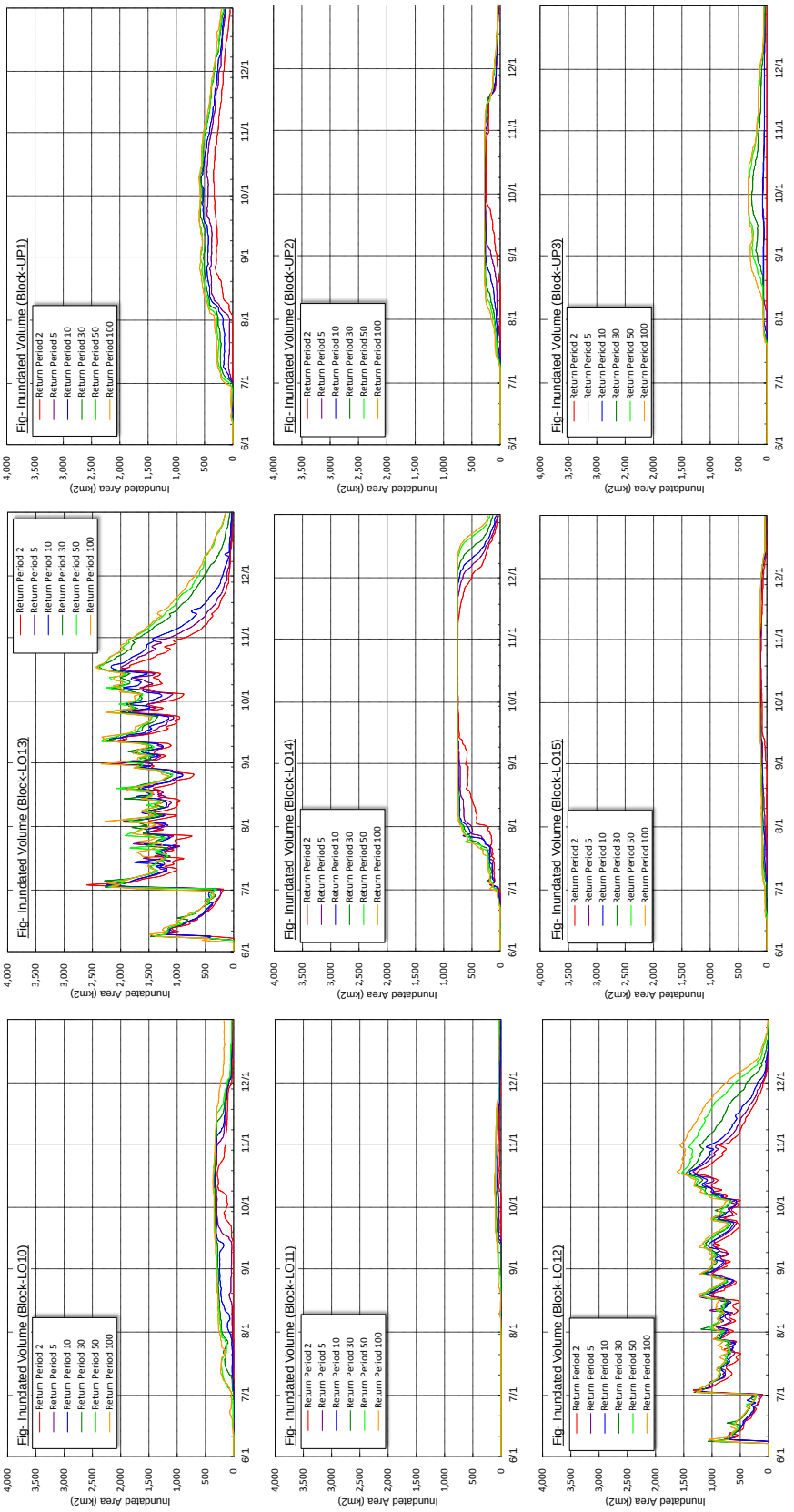


Figure K2.6.35 Inundation Area (Case 1-0) (2/3)

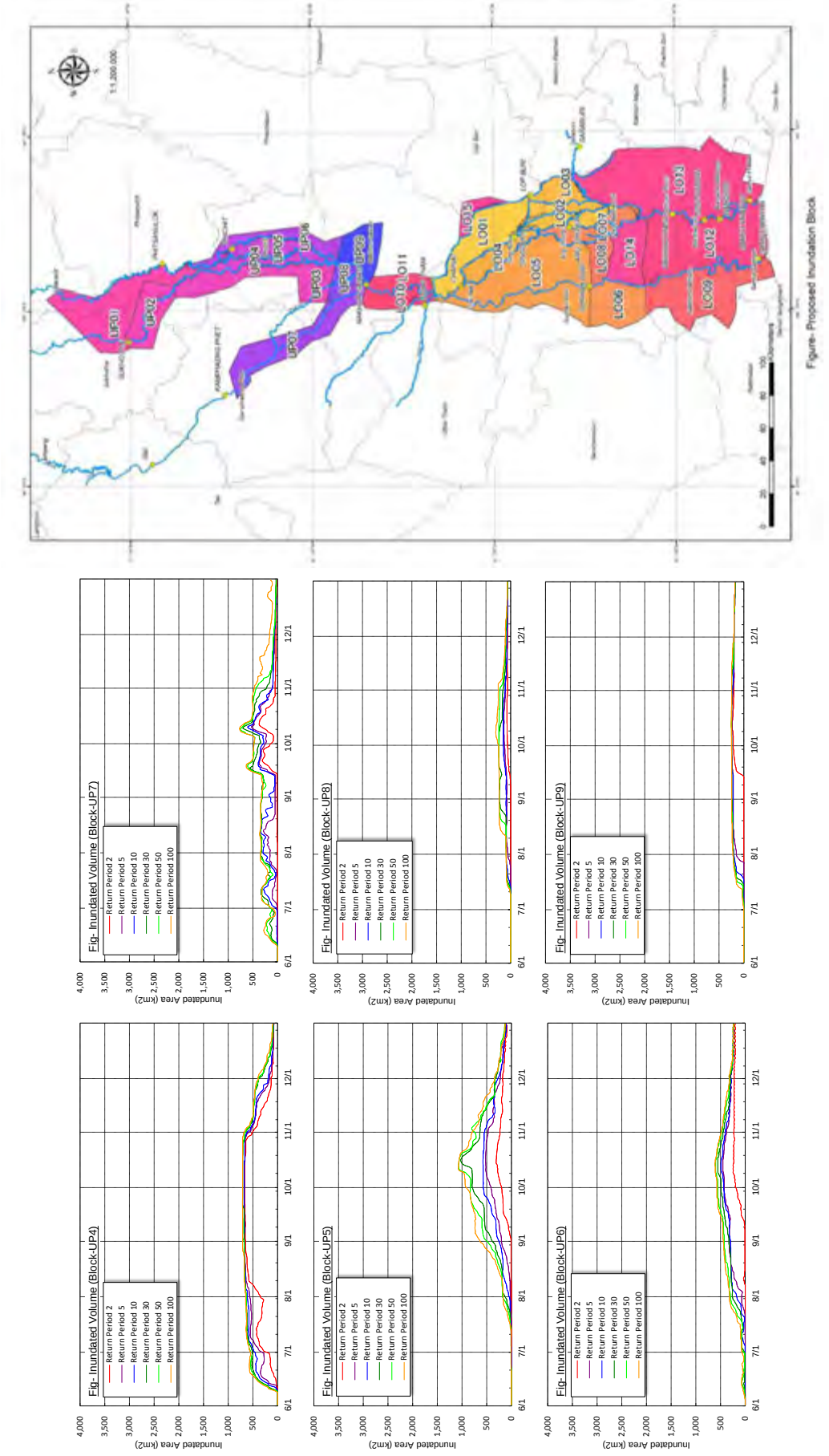


Figure K2.6.36 Inundation Area (Case 1-0) (3/3)

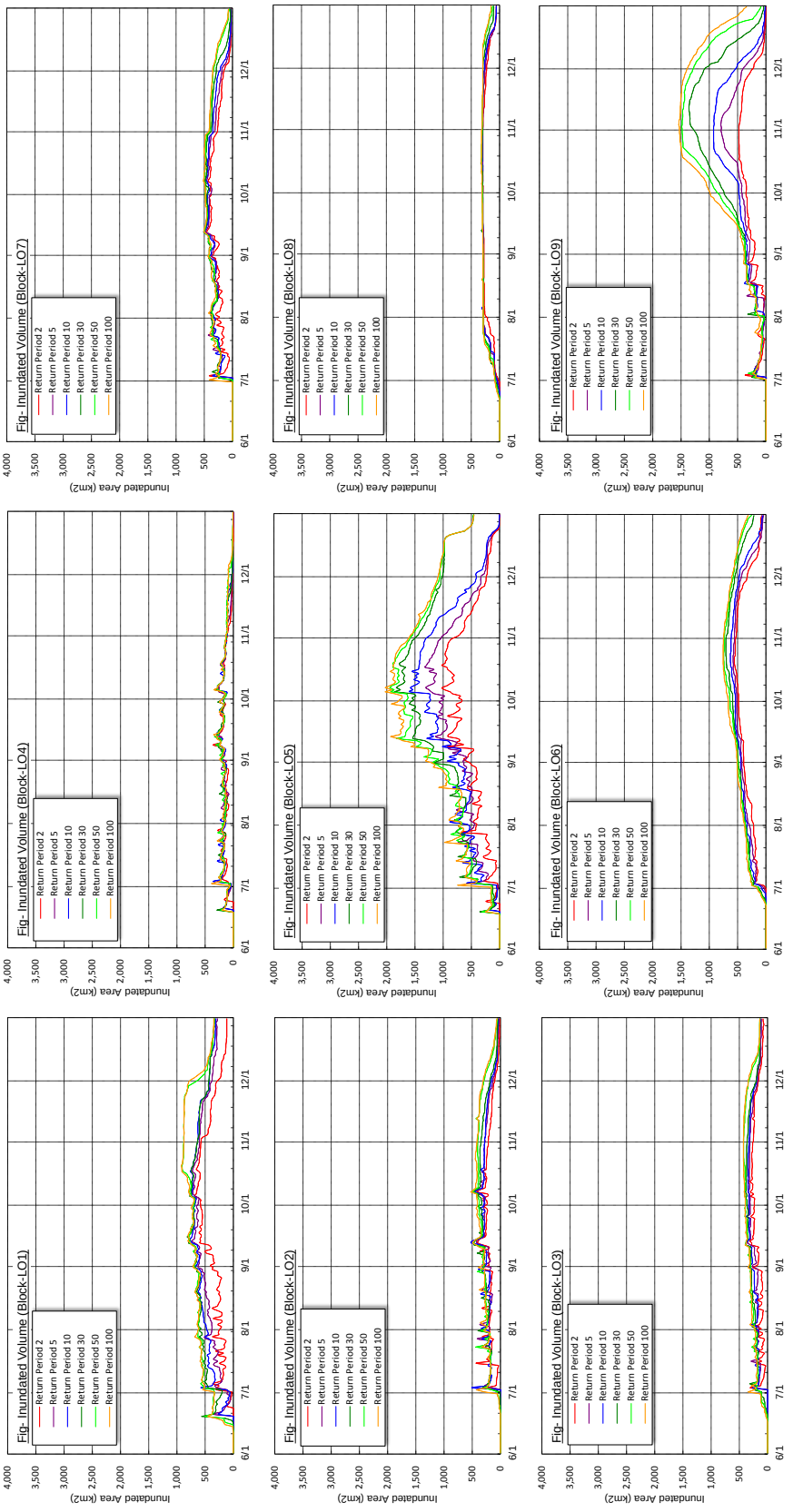


Figure K2.6.37 Inundation Area (Case 1-1) (1/3)

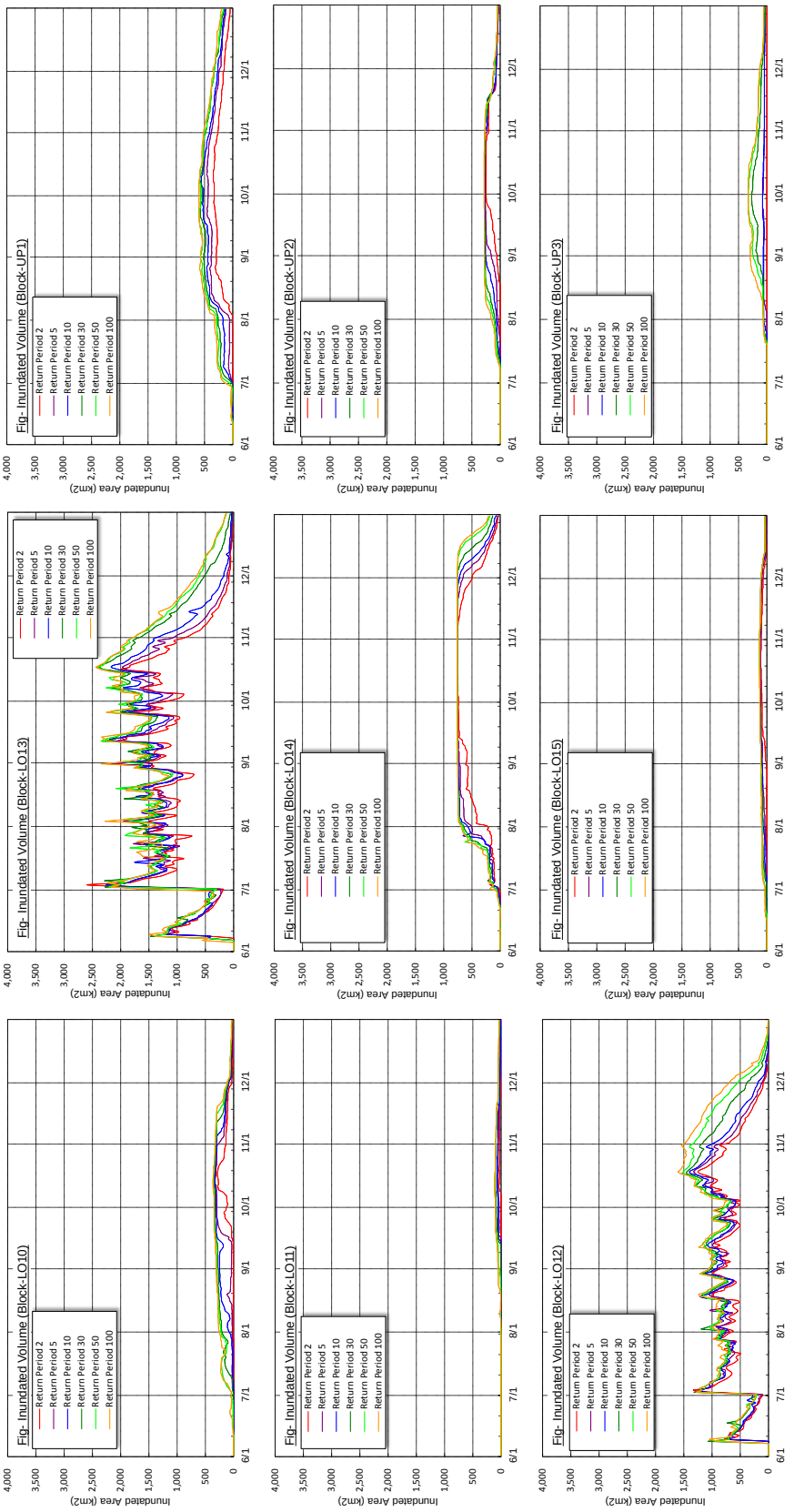


Figure K2.6.38 Inundation Area (Case 1-1) (2/3)

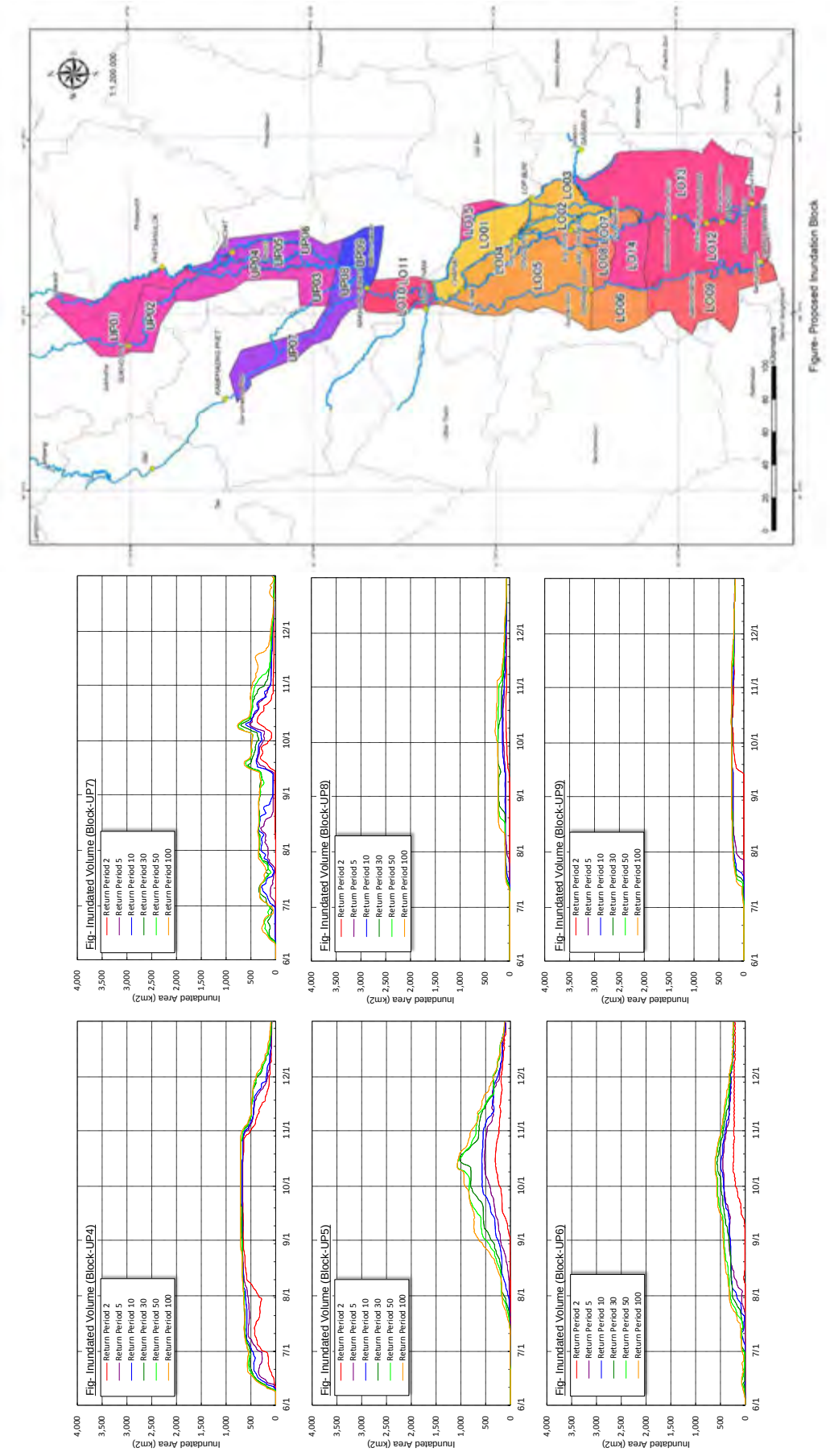


Figure K2.6.39 Inundation Area (Case 1-1) (3/3)

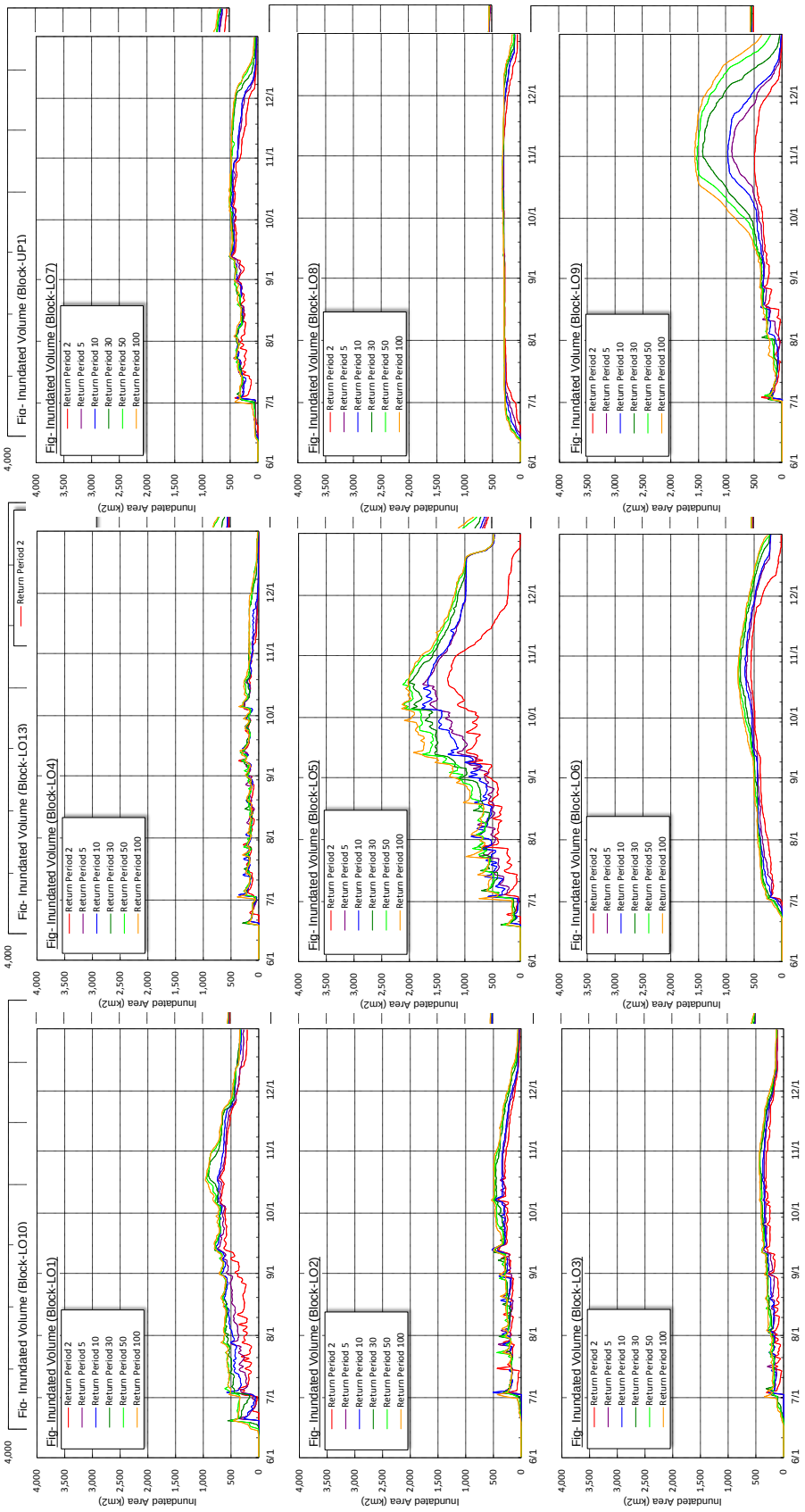


Figure K2.6.40 Inundation Area (Case 11-0) (1/3)

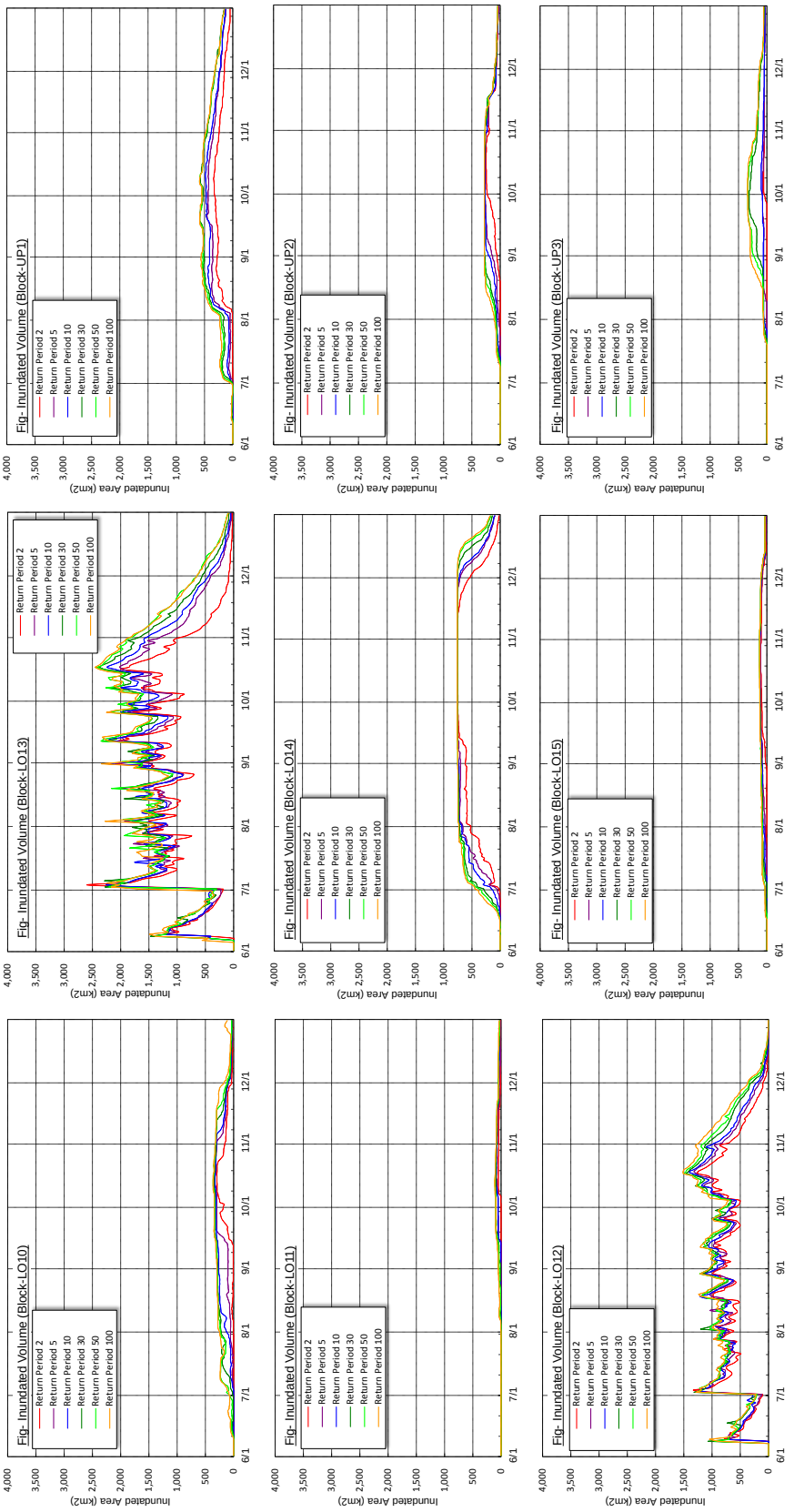


Figure K2.6.41 Inundation Area (Case 11-0) (2/3)

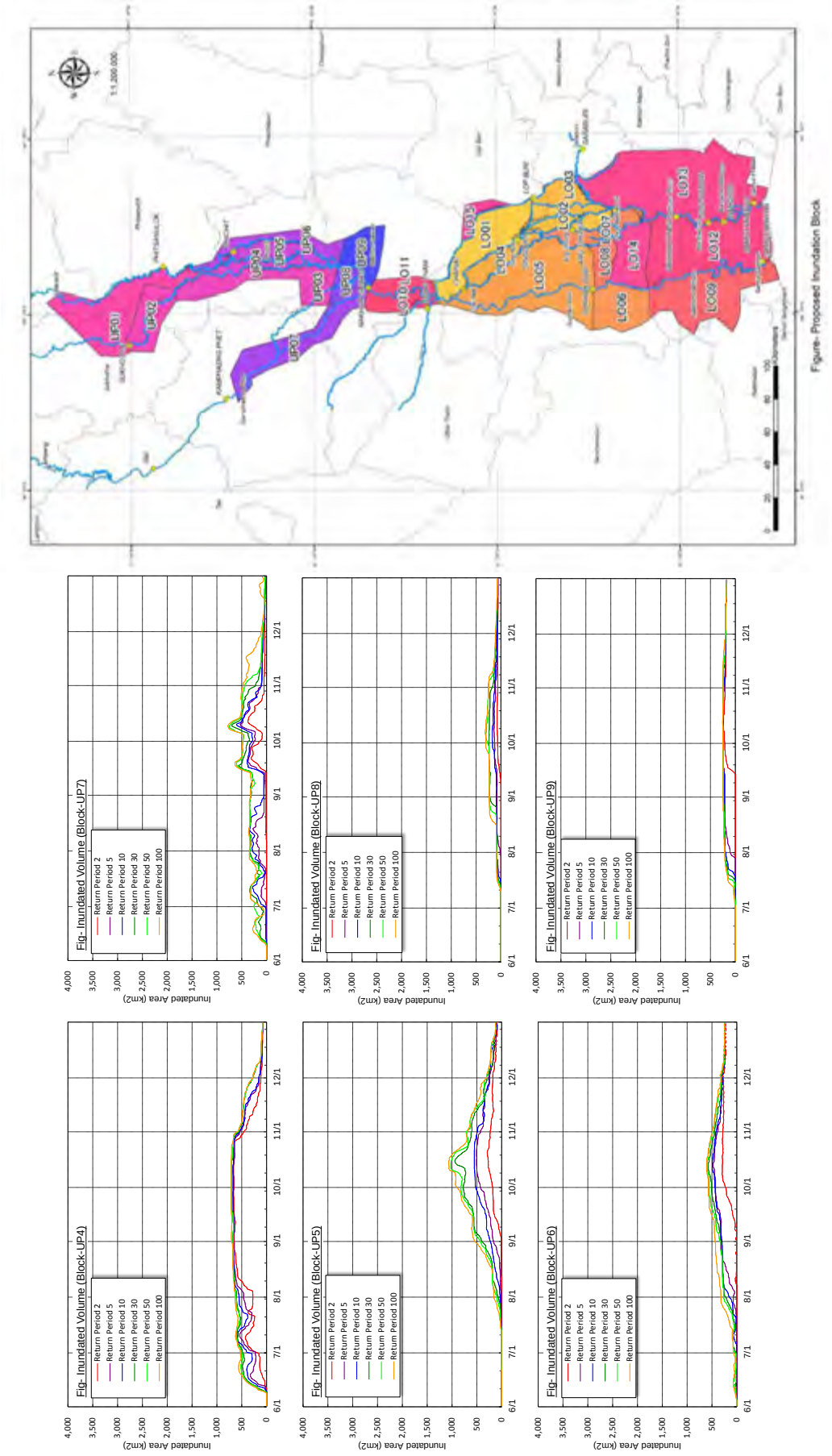


Figure K2.6.42 Inundation Area (Case 11-0) (3/3)

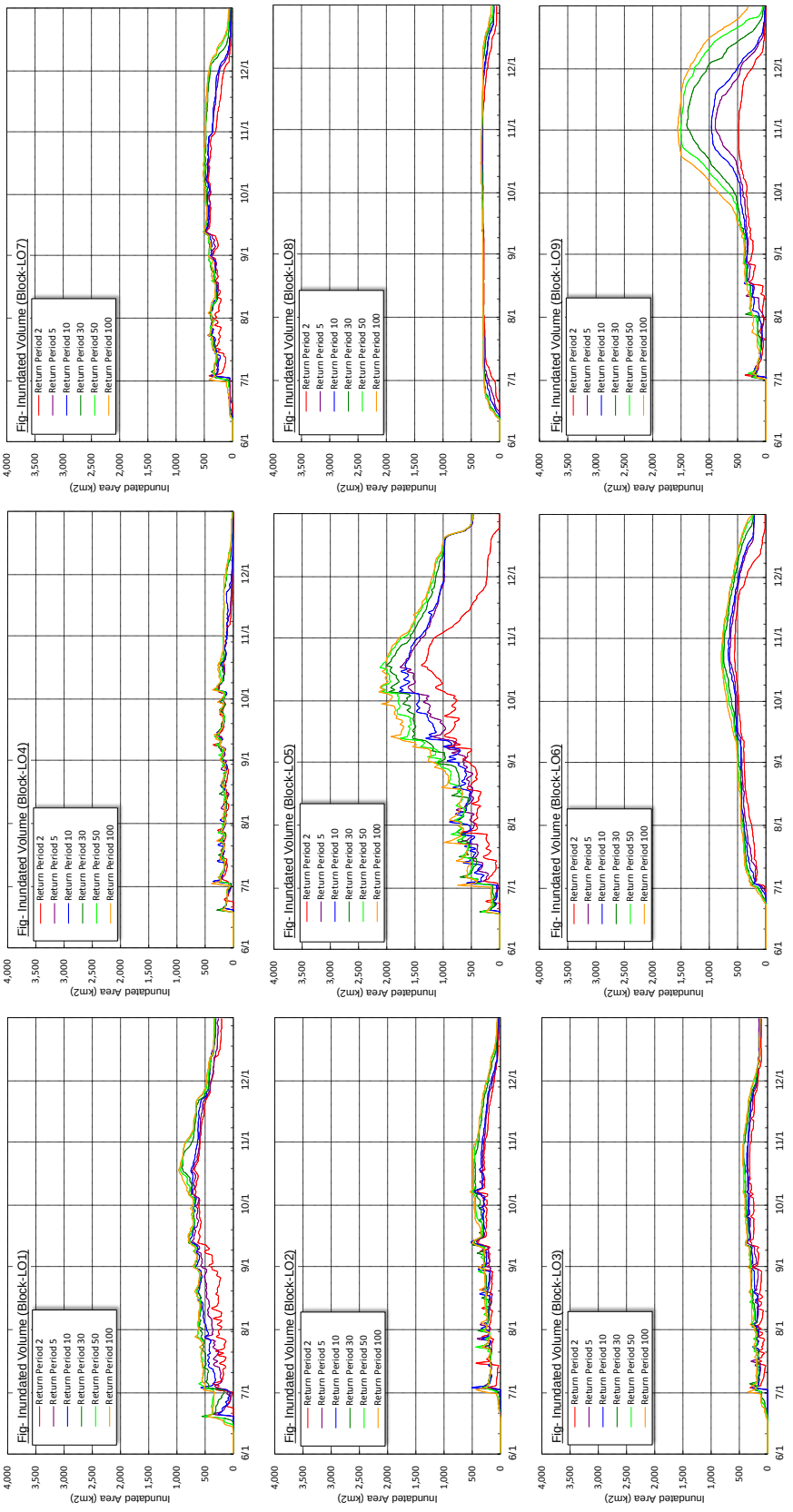


Figure K2.6.43 Inundation Area (Case 11-1) (1/3)

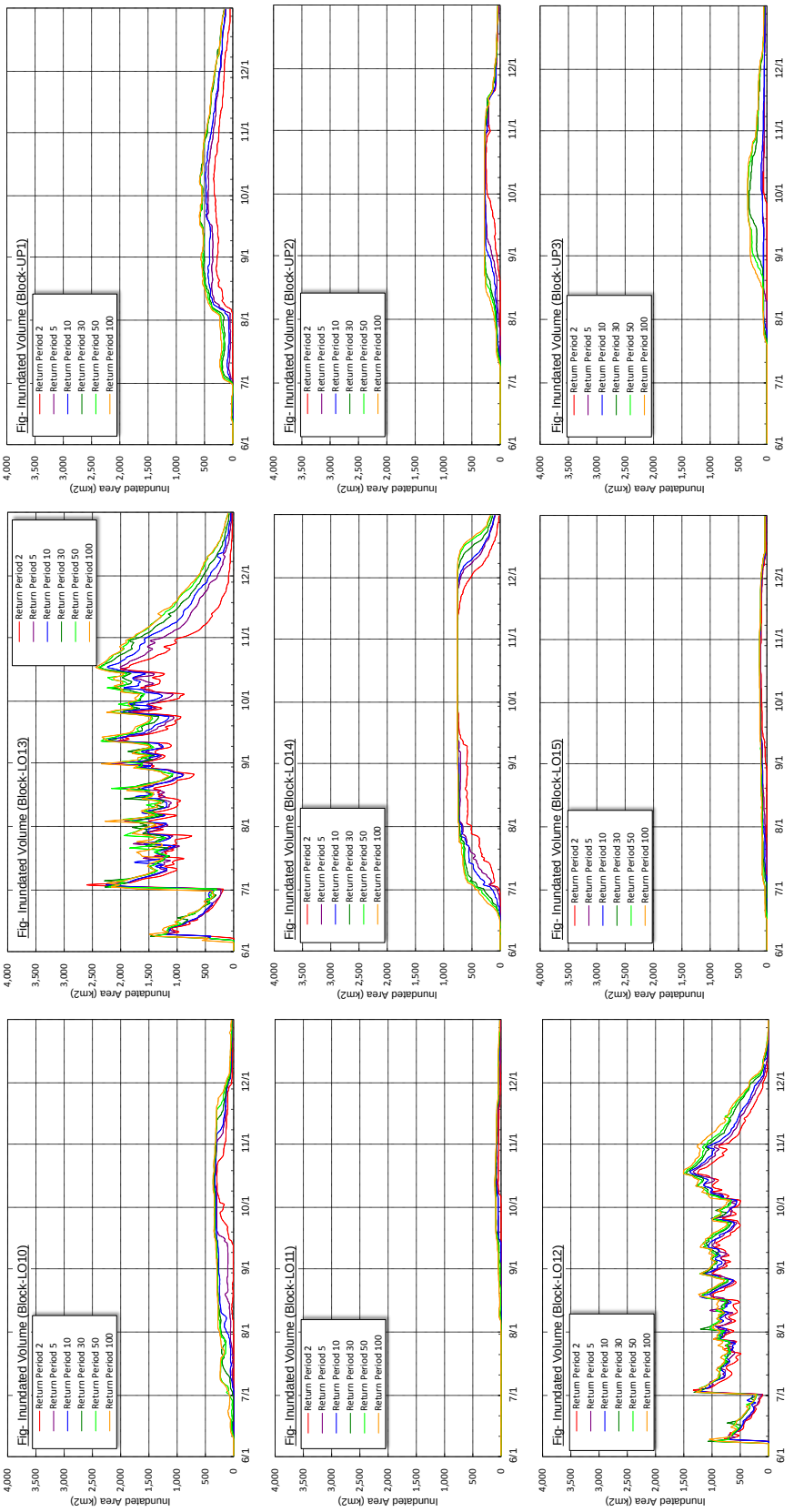


Figure K2.6.44 Inundation Area (Case 11-1) (2/3)

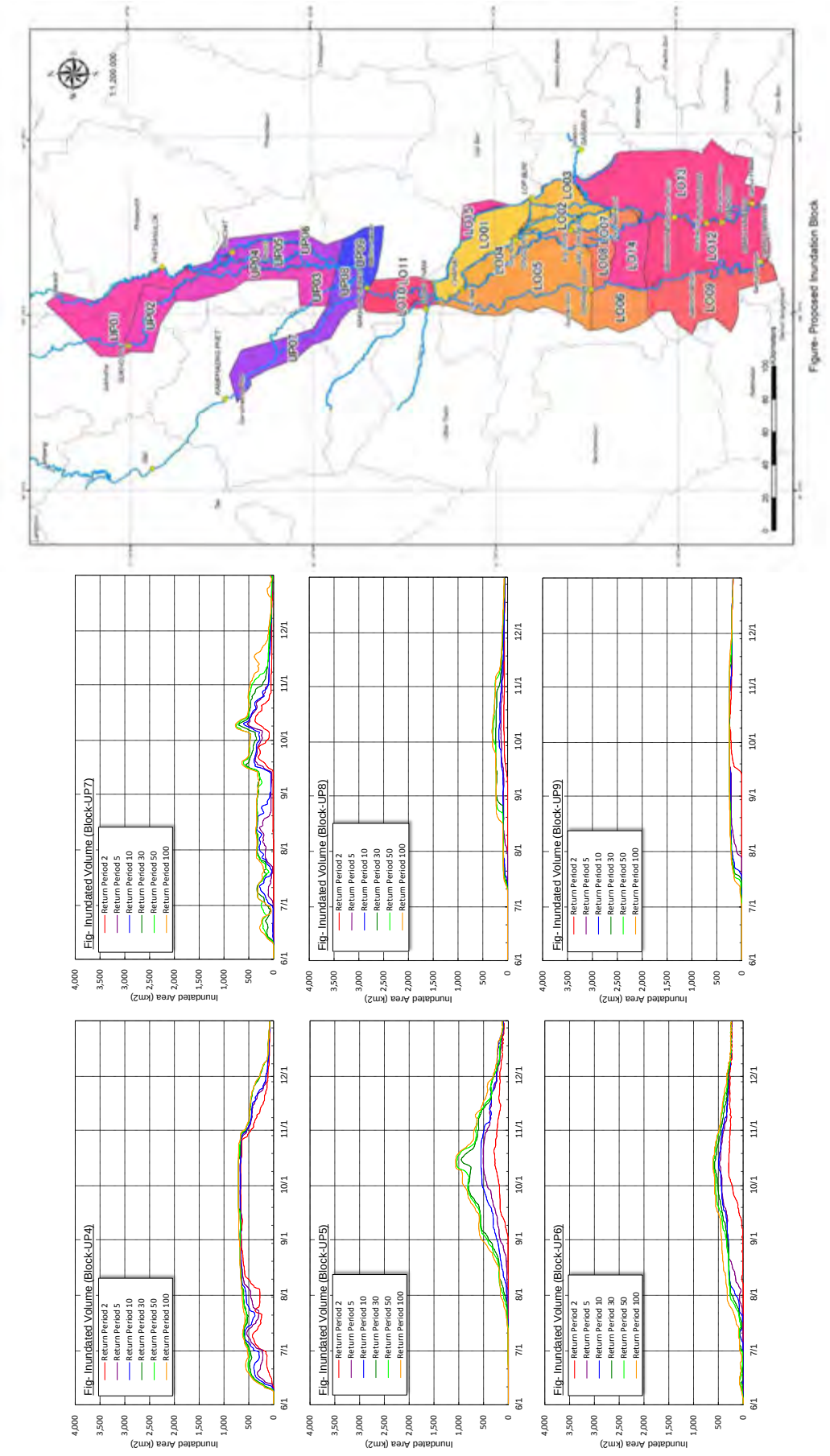


Figure K2.6.45 Inundation Area (Case 11-1) (3/3)

K2.7 Inundation Volume, Average Depth and Area (by Return Period)

K2.7.1 Inundation Volume

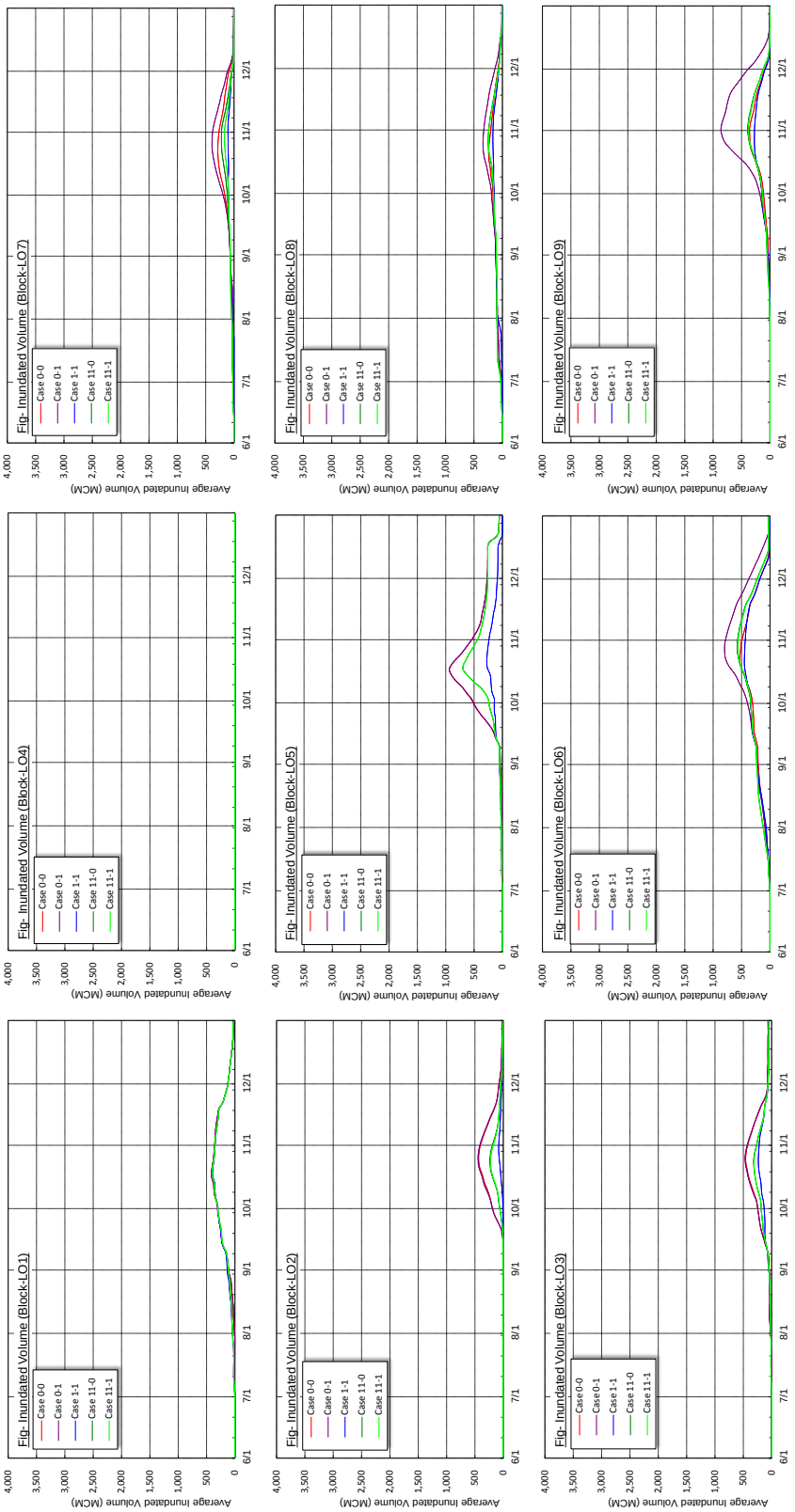


Figure K2.7.1 Inundation Volume (5-year Return Period) (1/3)

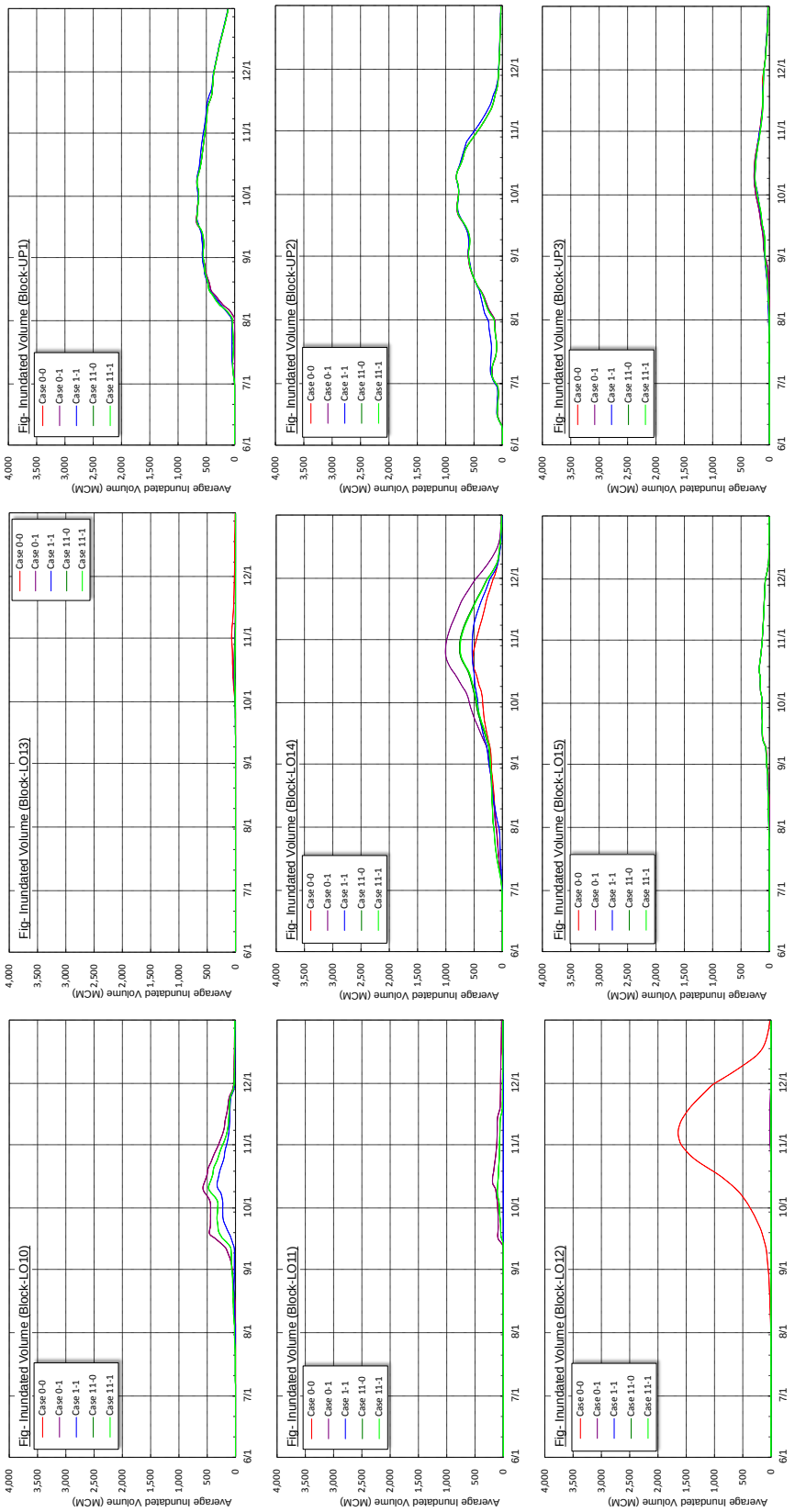


Figure K2.7.2 Inundation Volume (5-year Return Period) (2/3)

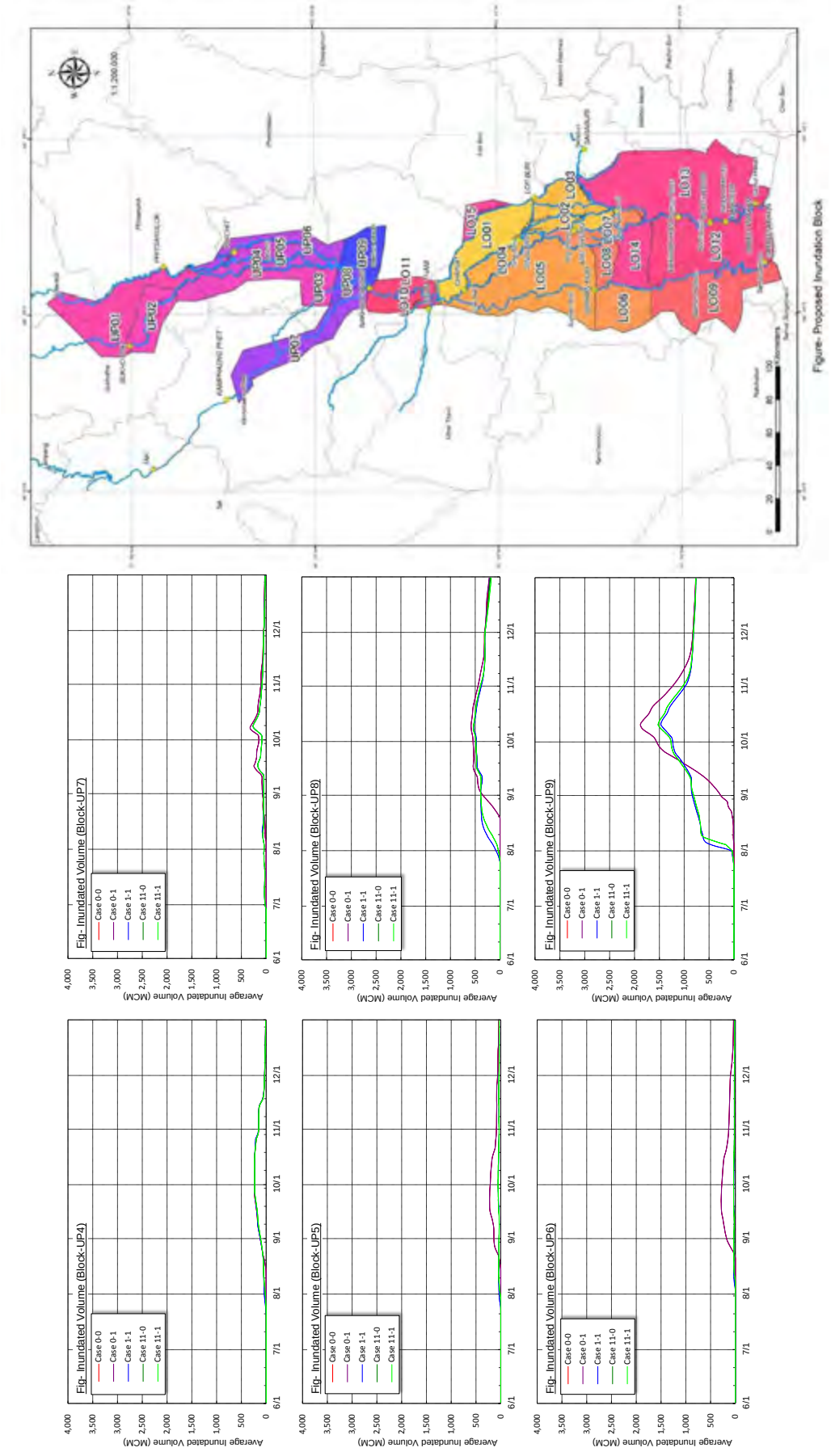


Figure K2.7.3 Inundation Volume (5-year Return Period) (3/3)

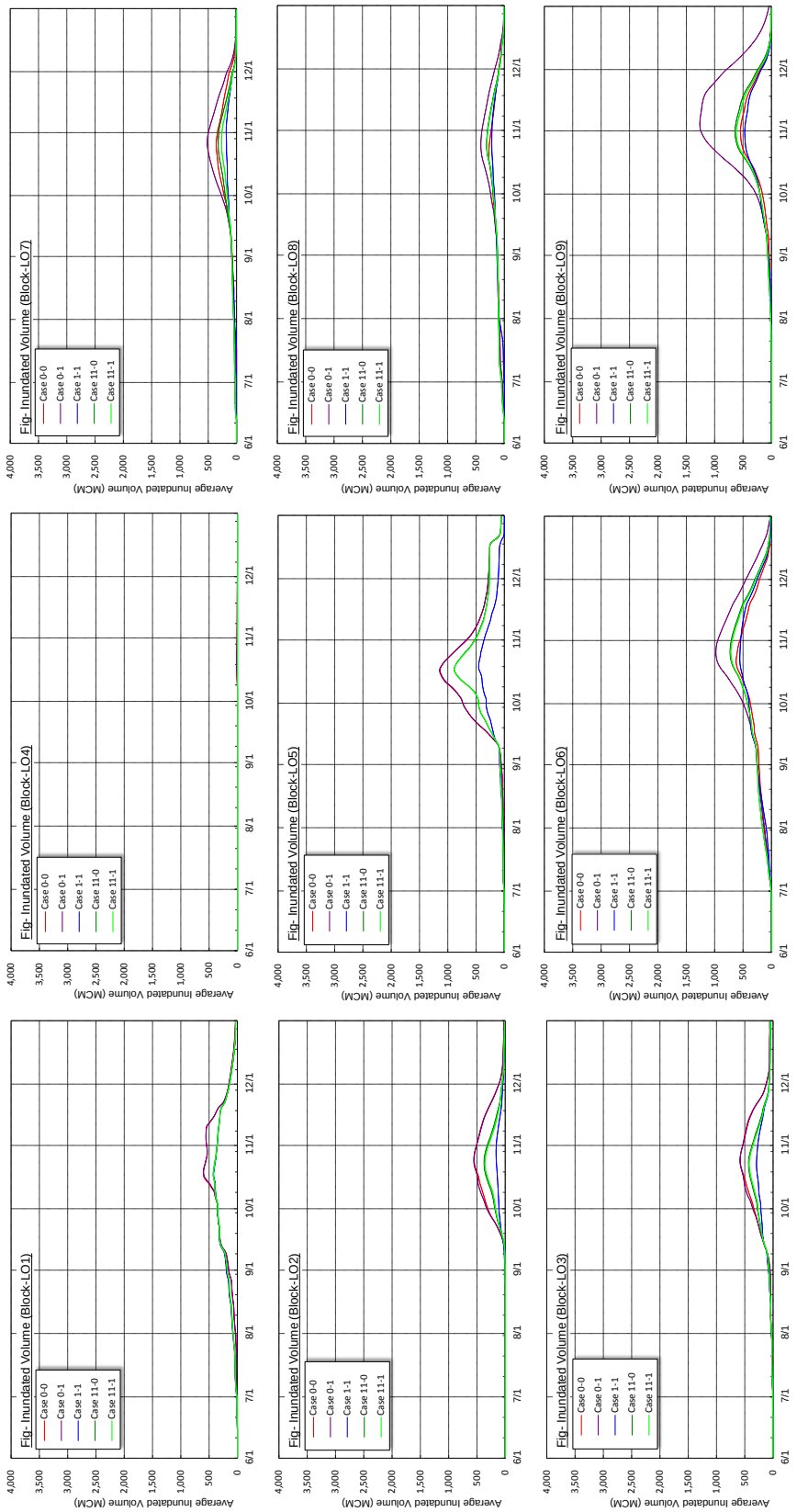


Figure K2.7.4 Inundation Volume (10-year Return Period) (1/3)

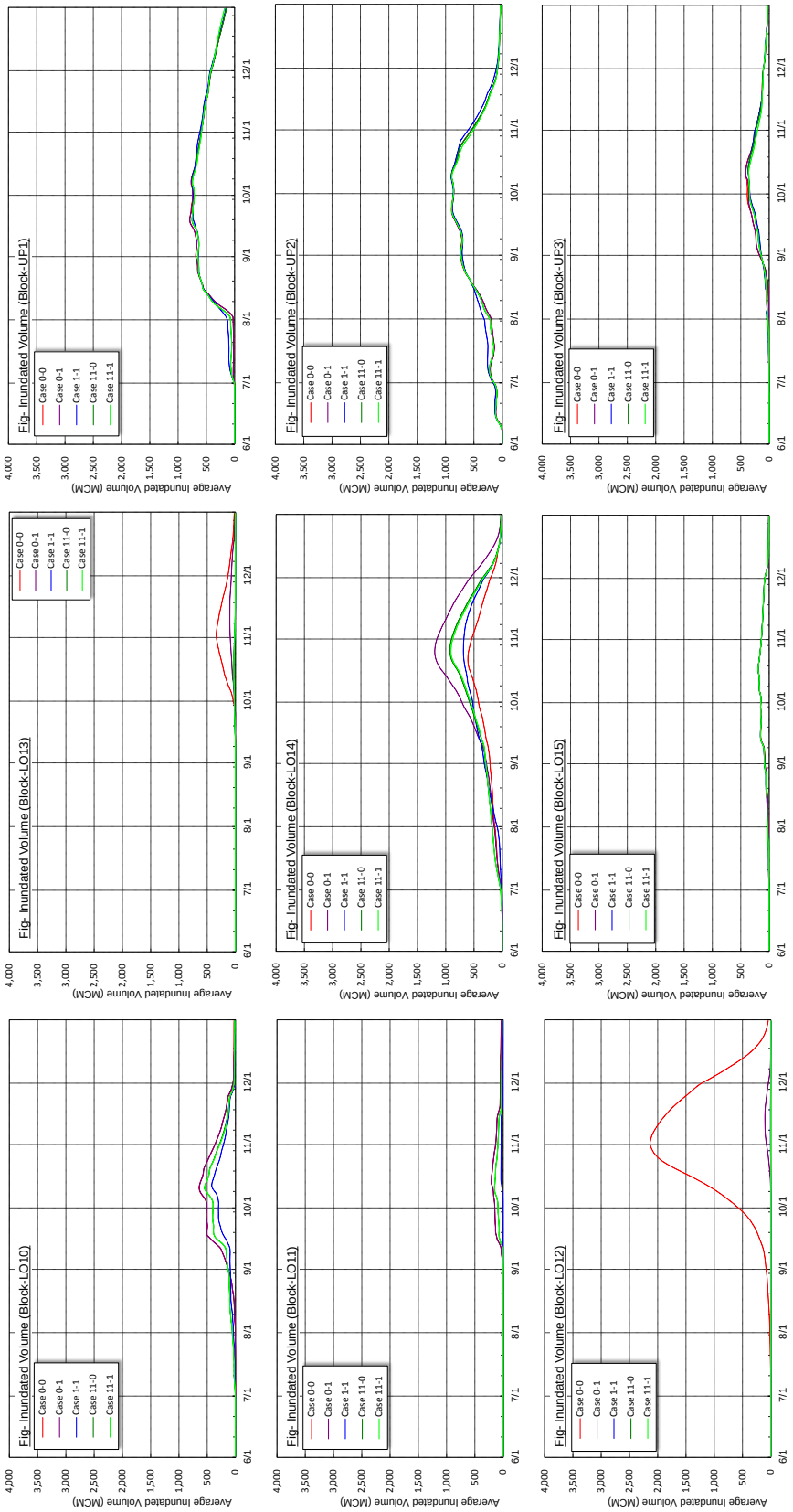


Figure K2.7.5 Inundation Volume (10-year Return Period) (2/3)

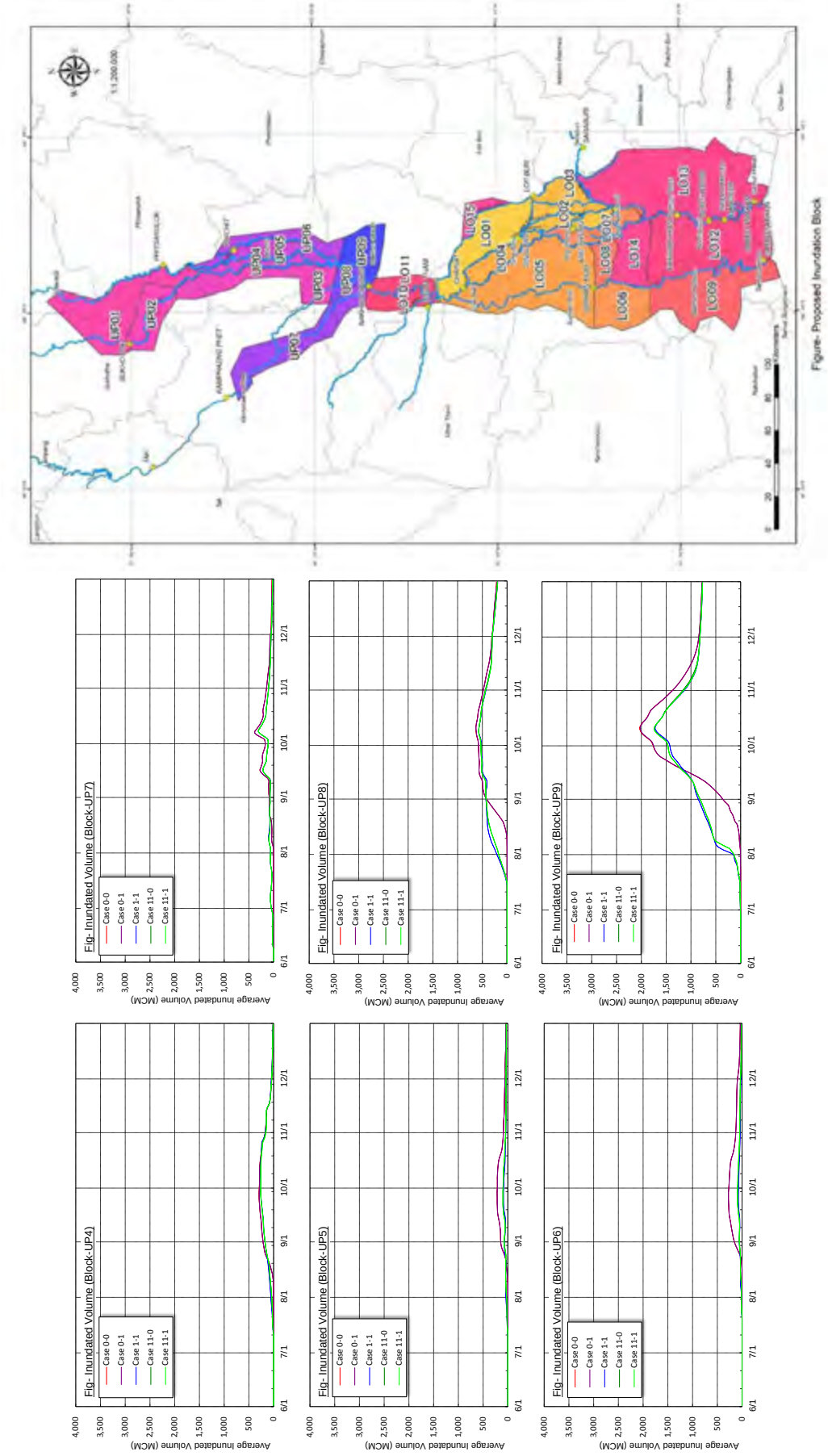


Figure K2.7.6 Inundation Volume (10-year Return Period) (3/3)

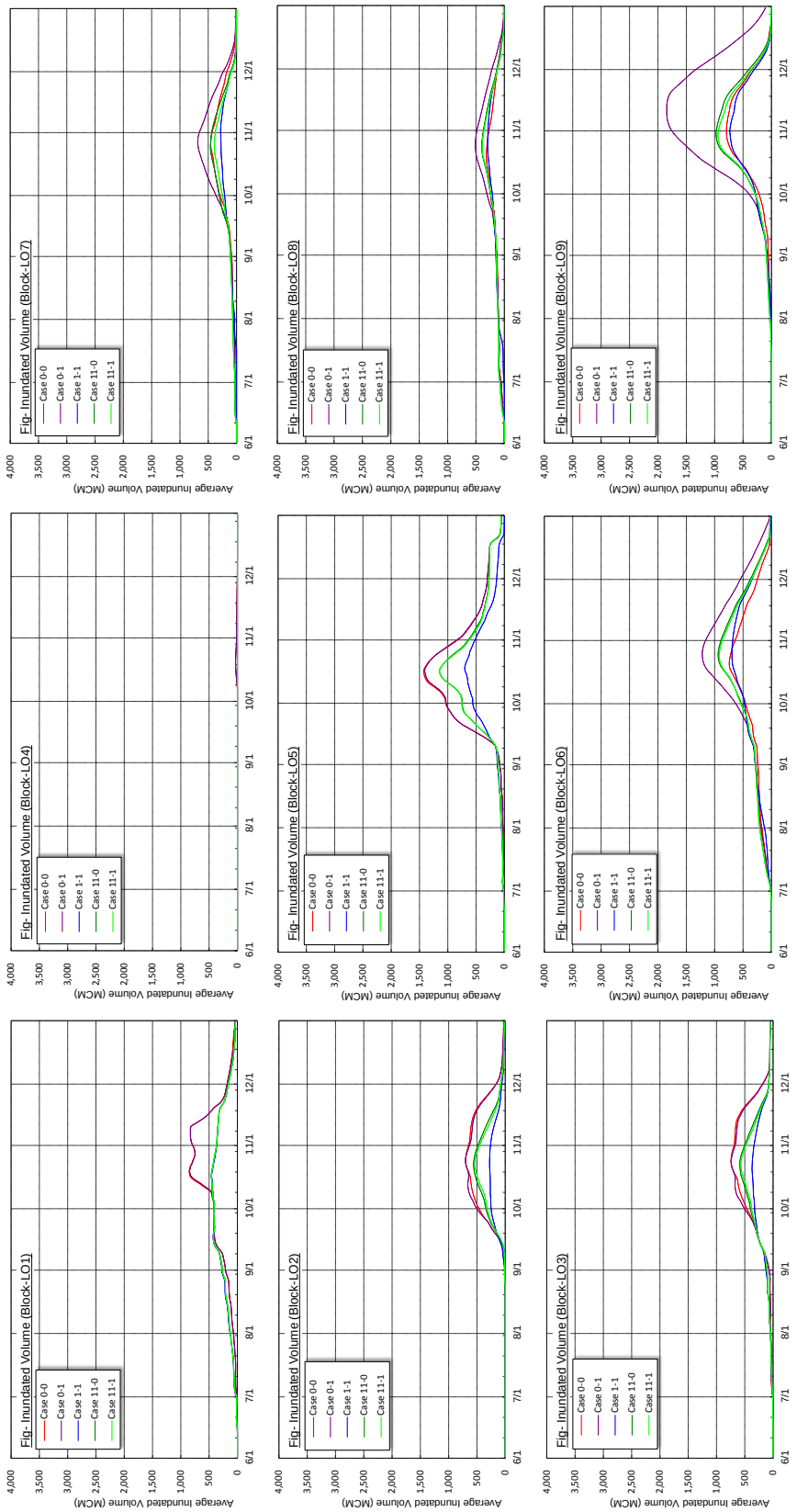


Figure K2.7.7 Inundation Volume (30-year Return Period) (1/3)

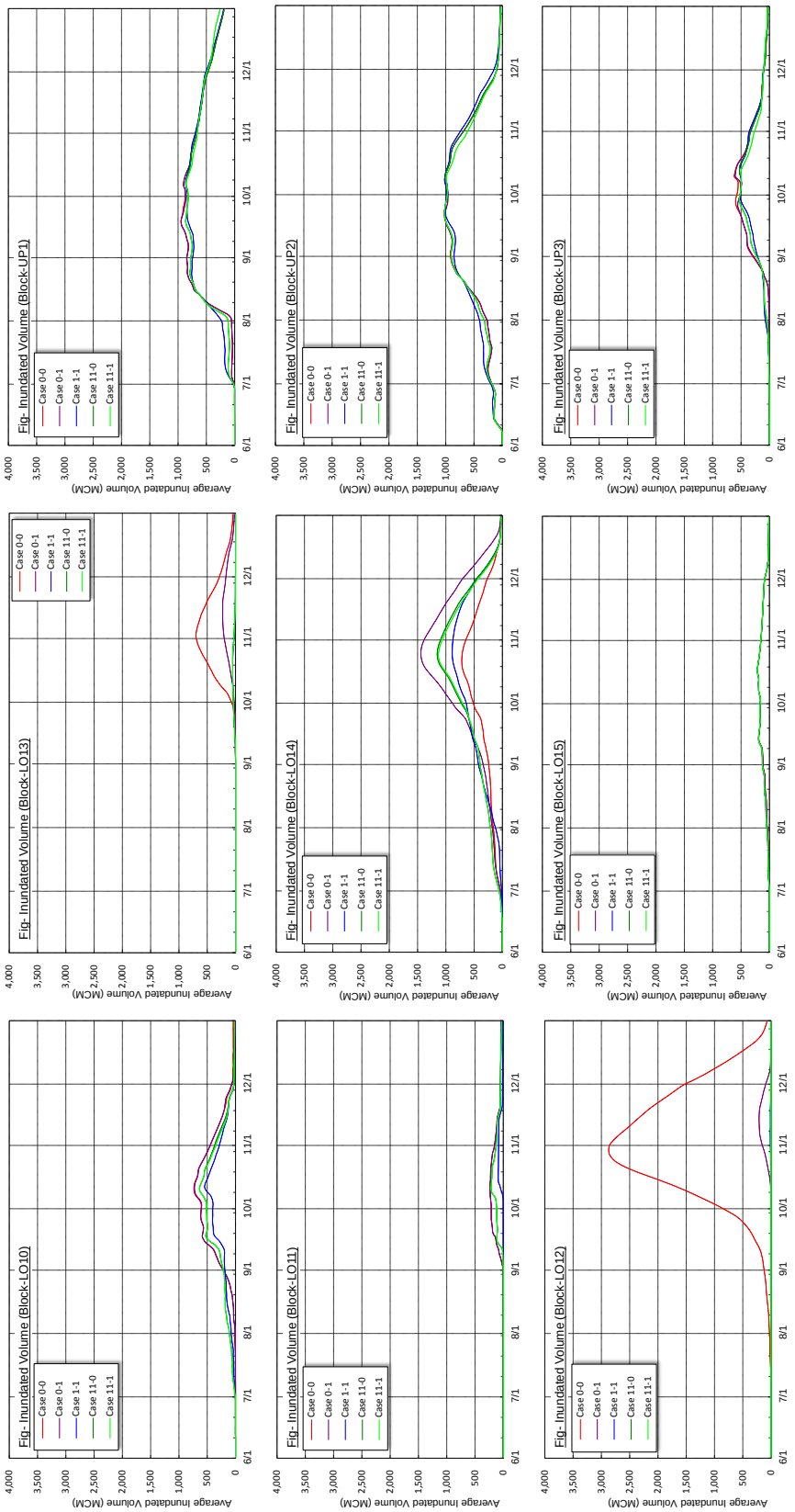


Figure K2.7.8 Inundation Volume (30-year Return Period) (2/3)

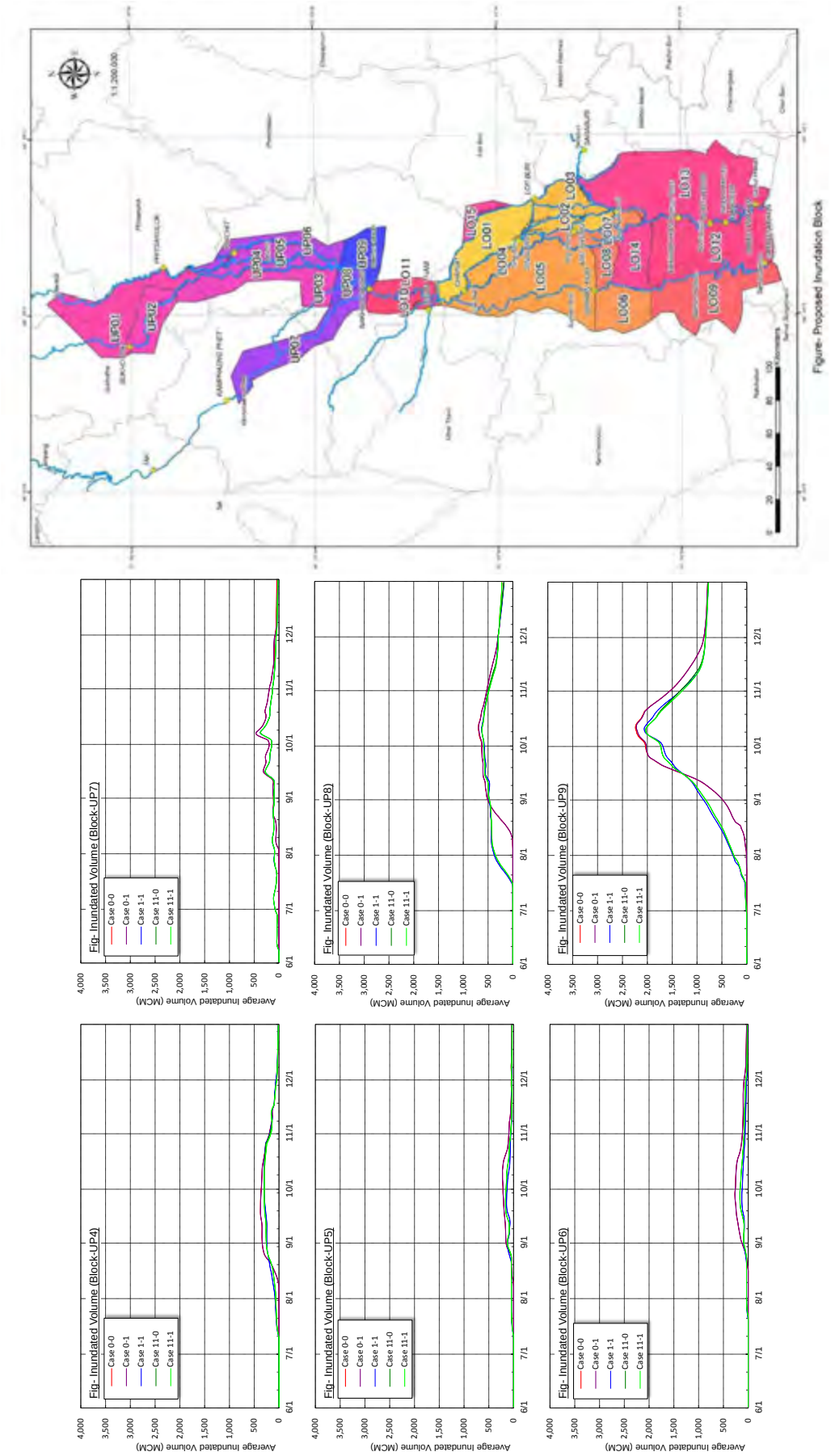


Figure K2.7.9 Inundation Volume (30-year Return Period) (3/3)

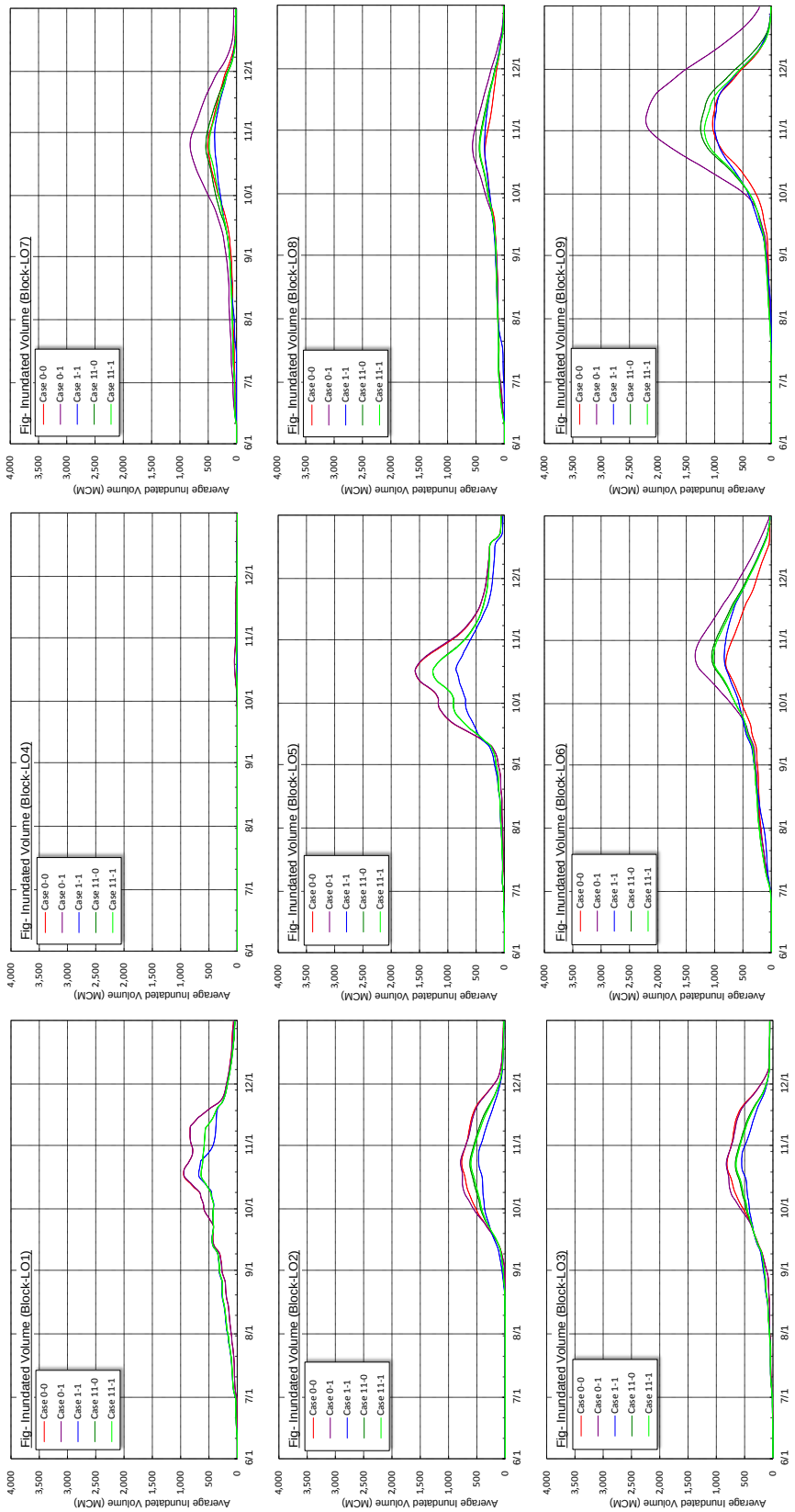


Figure K2.7.10 Inundation Volume (50-year Return Period) (1/3)

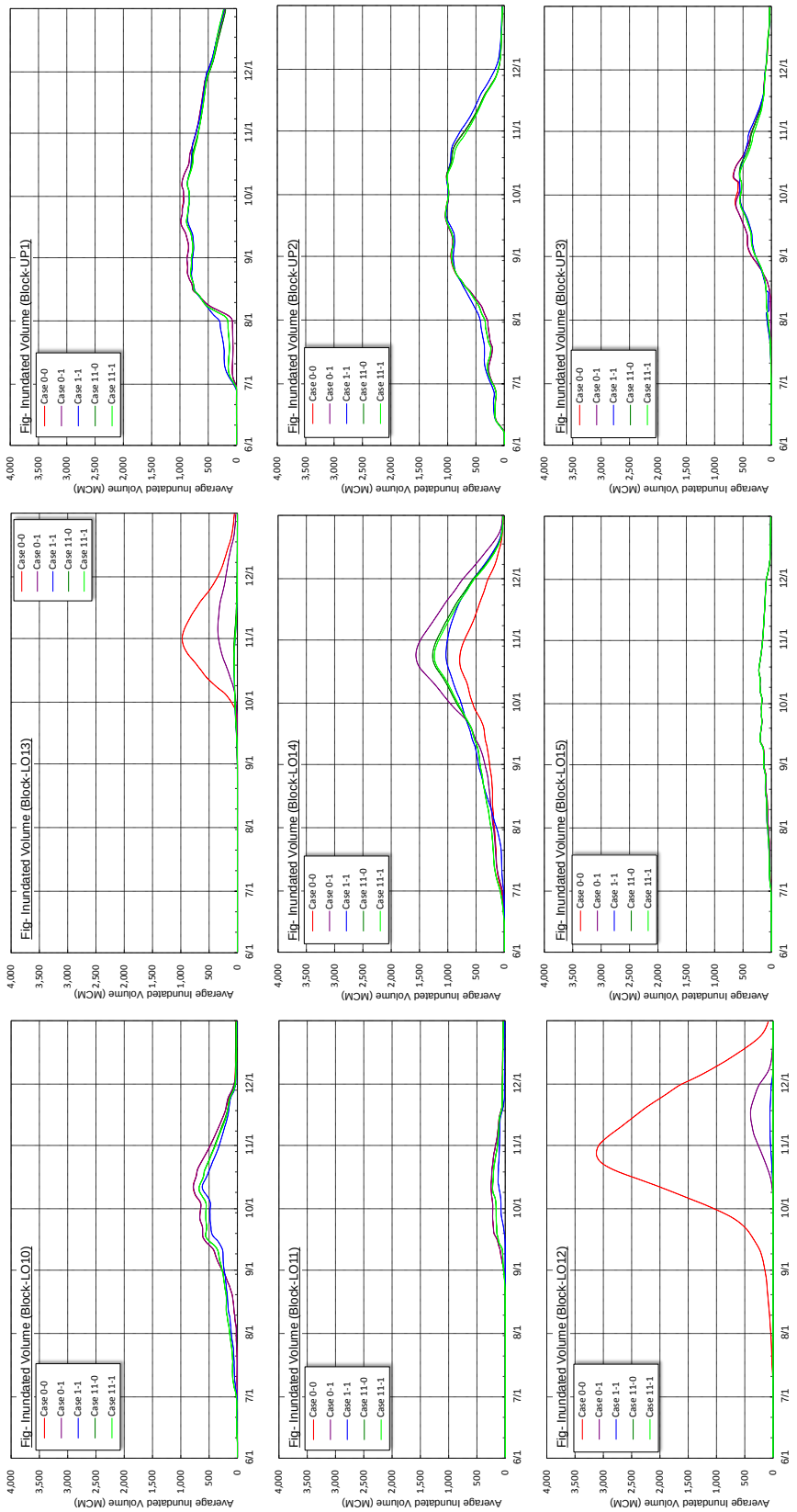


Figure K2.7.11 Inundation Volume (50-year Return Period) (2/3)

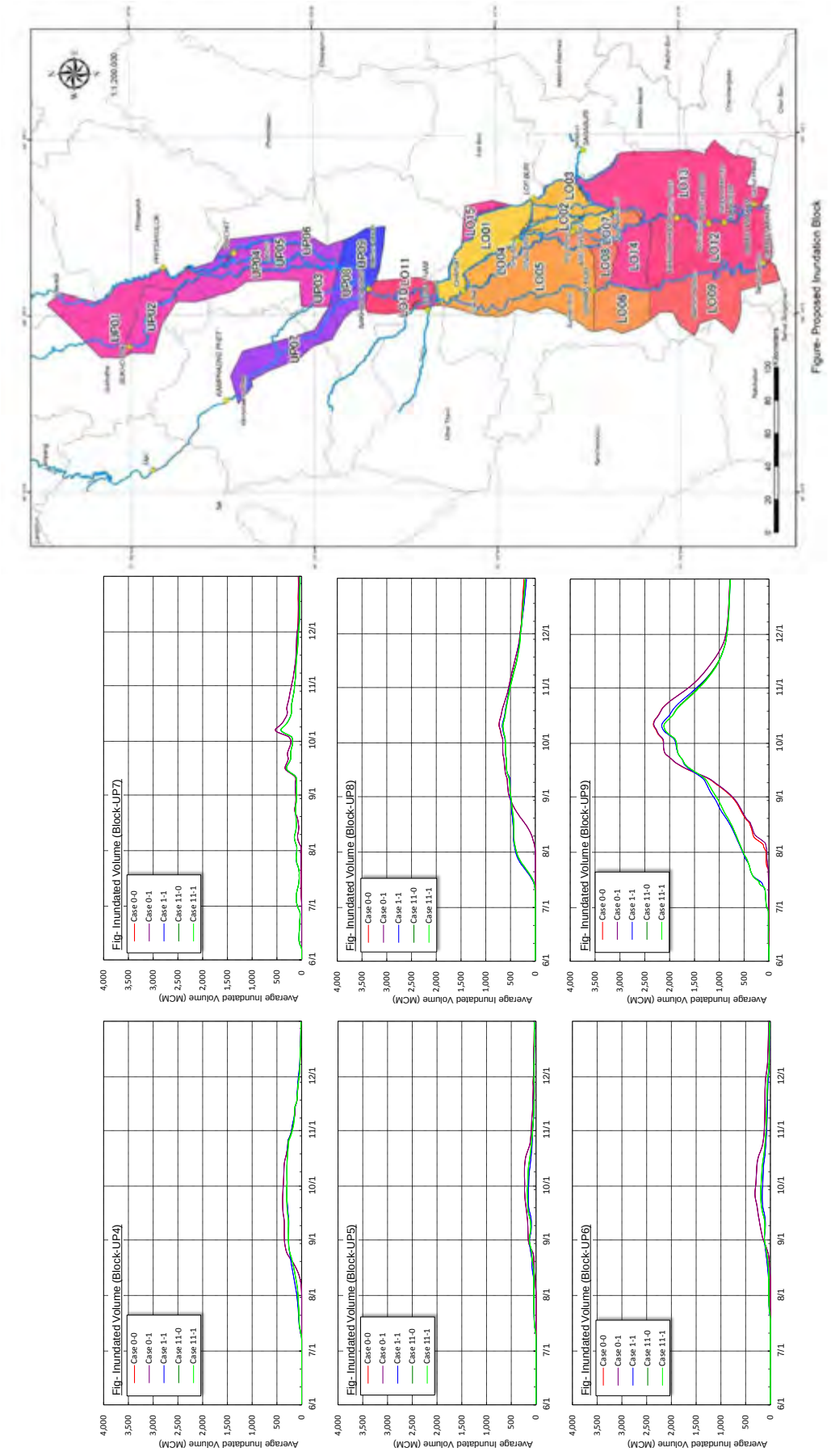


Figure K2.7.12 Inundation Volume (50-year Return Period) (3/3)

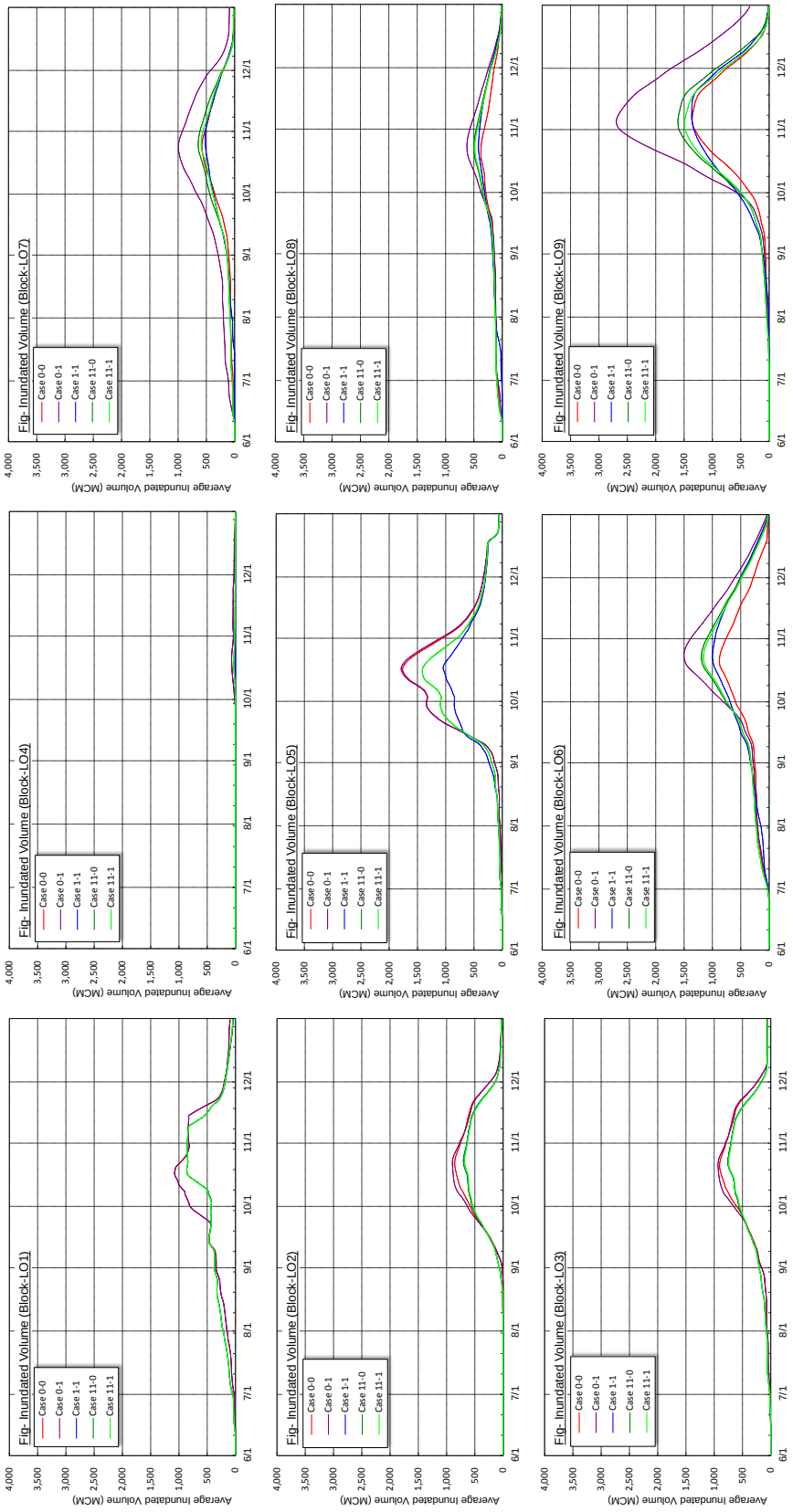


Figure K2.7.13 Inundation Volume (100-year Return Period) (1/3)

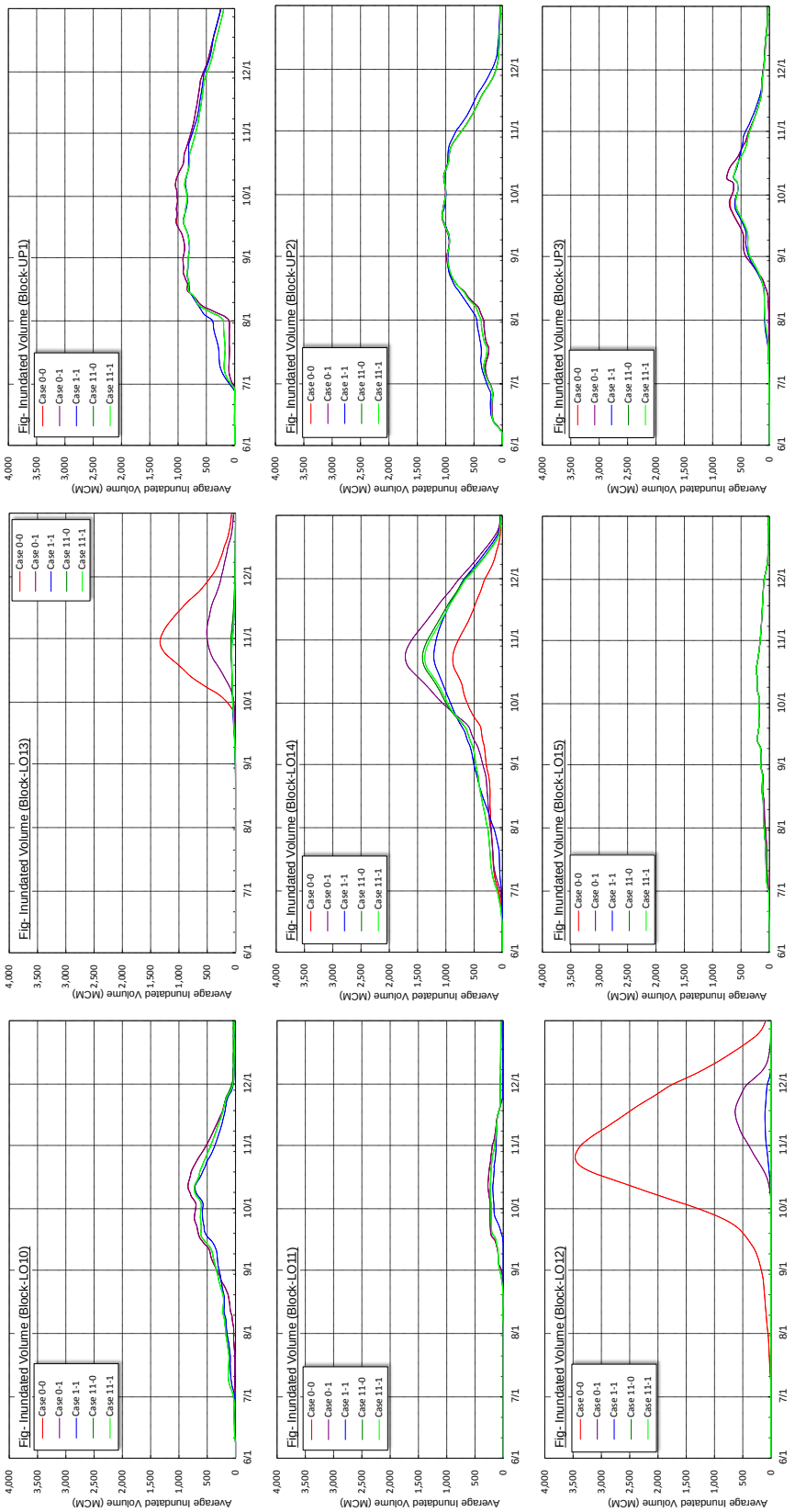


Figure K2.7.14 Inundation Volume (100-year Return Period) (2/3)

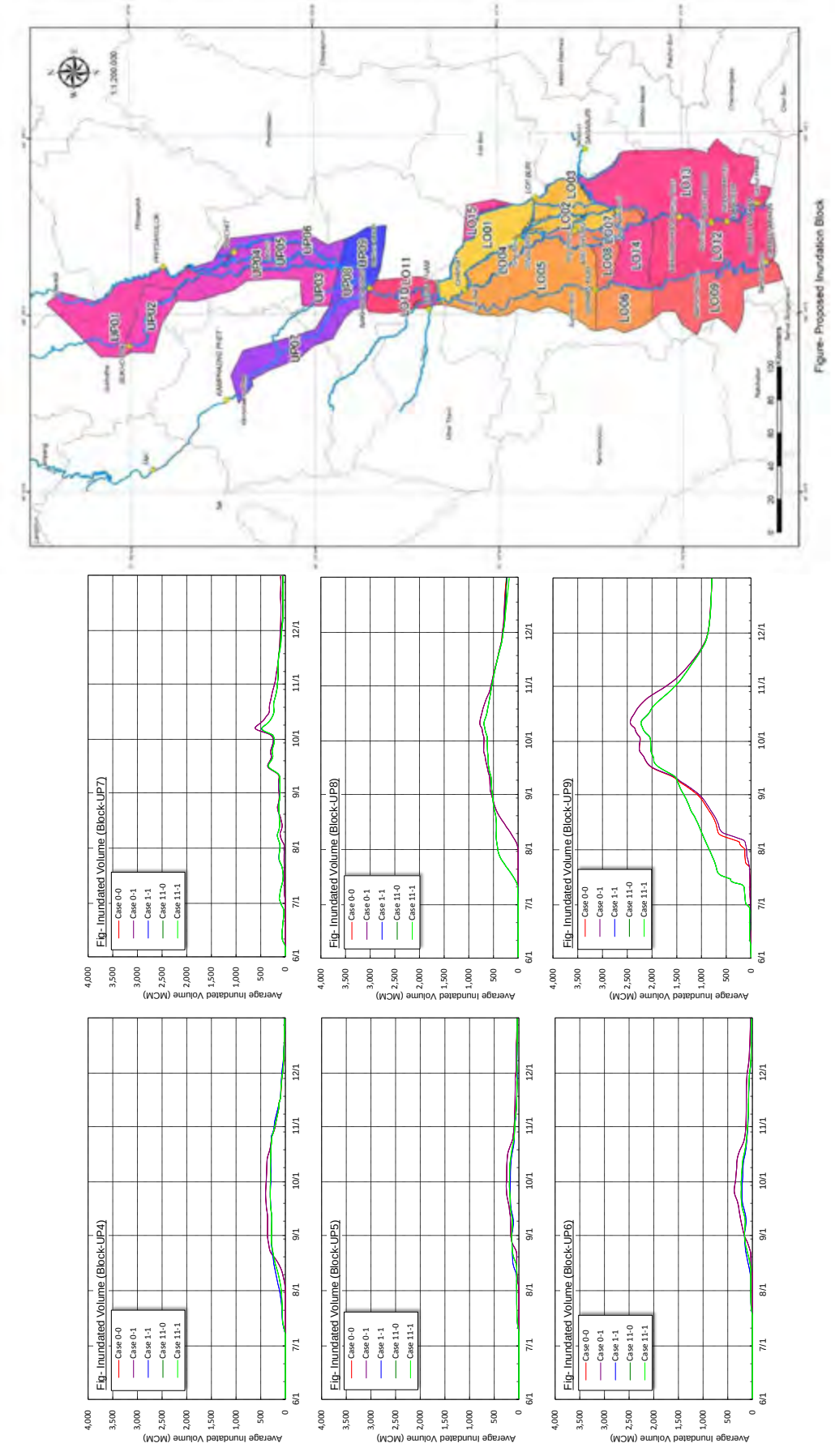


Figure K2.7.15 Inundation Volume (100-year Return Period) (3/3)

K2.7.2 Inundation Depth

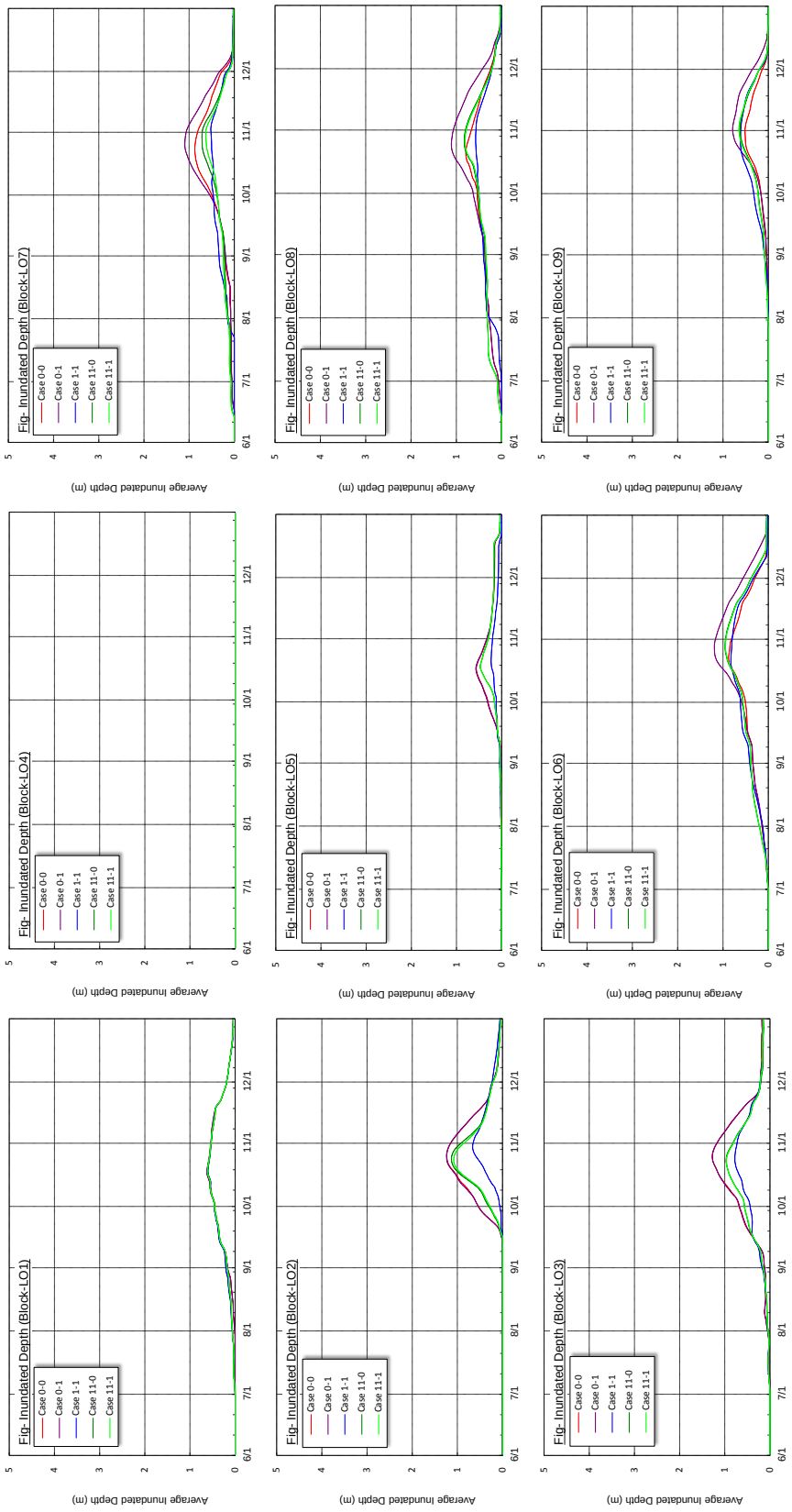


Figure K2.7.16 Inundation Depth (5-year Return Period) (1/3)

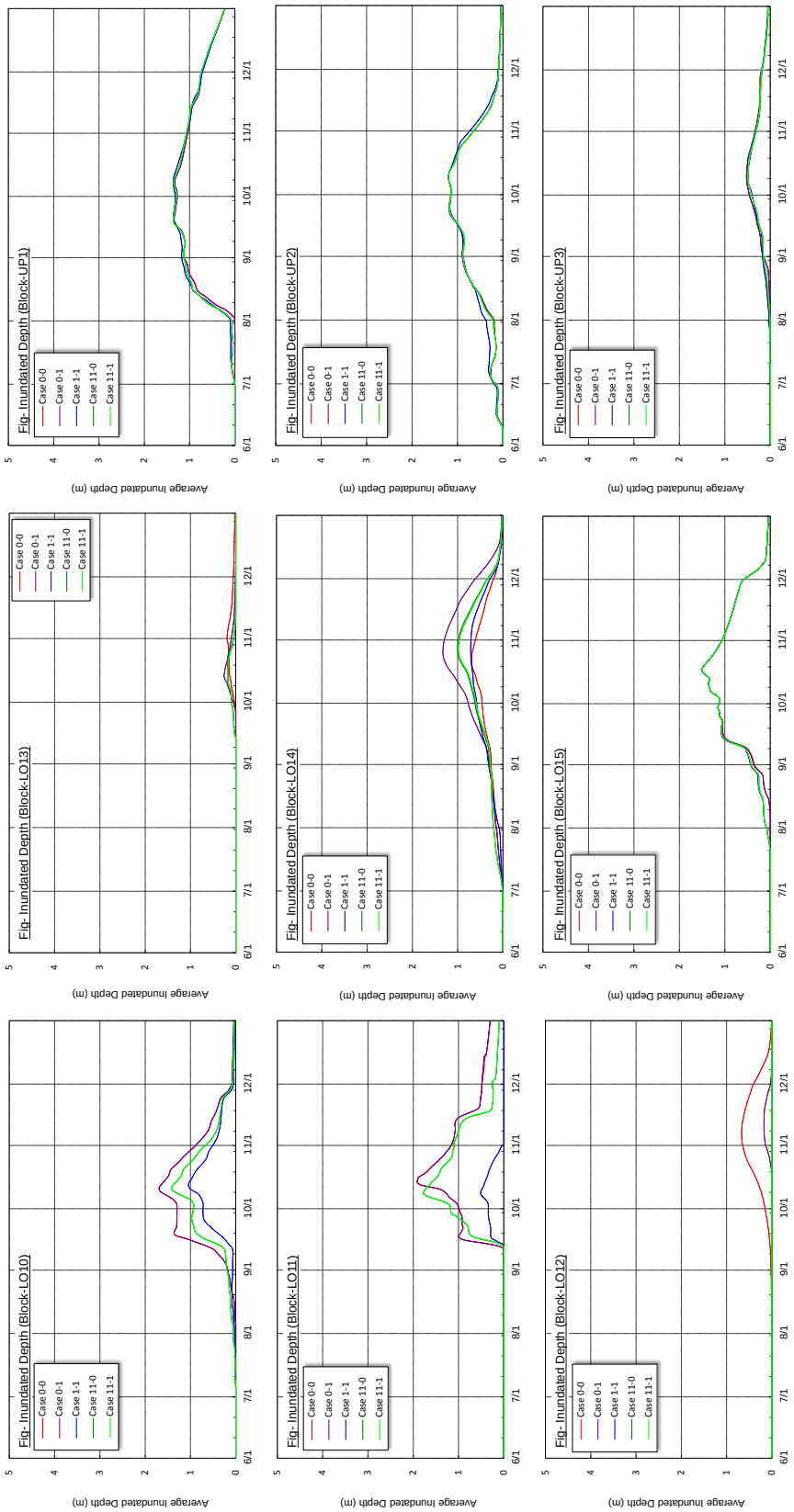


Figure K2.7.17 Inundation Depth (5-year Return Period) (2/3)

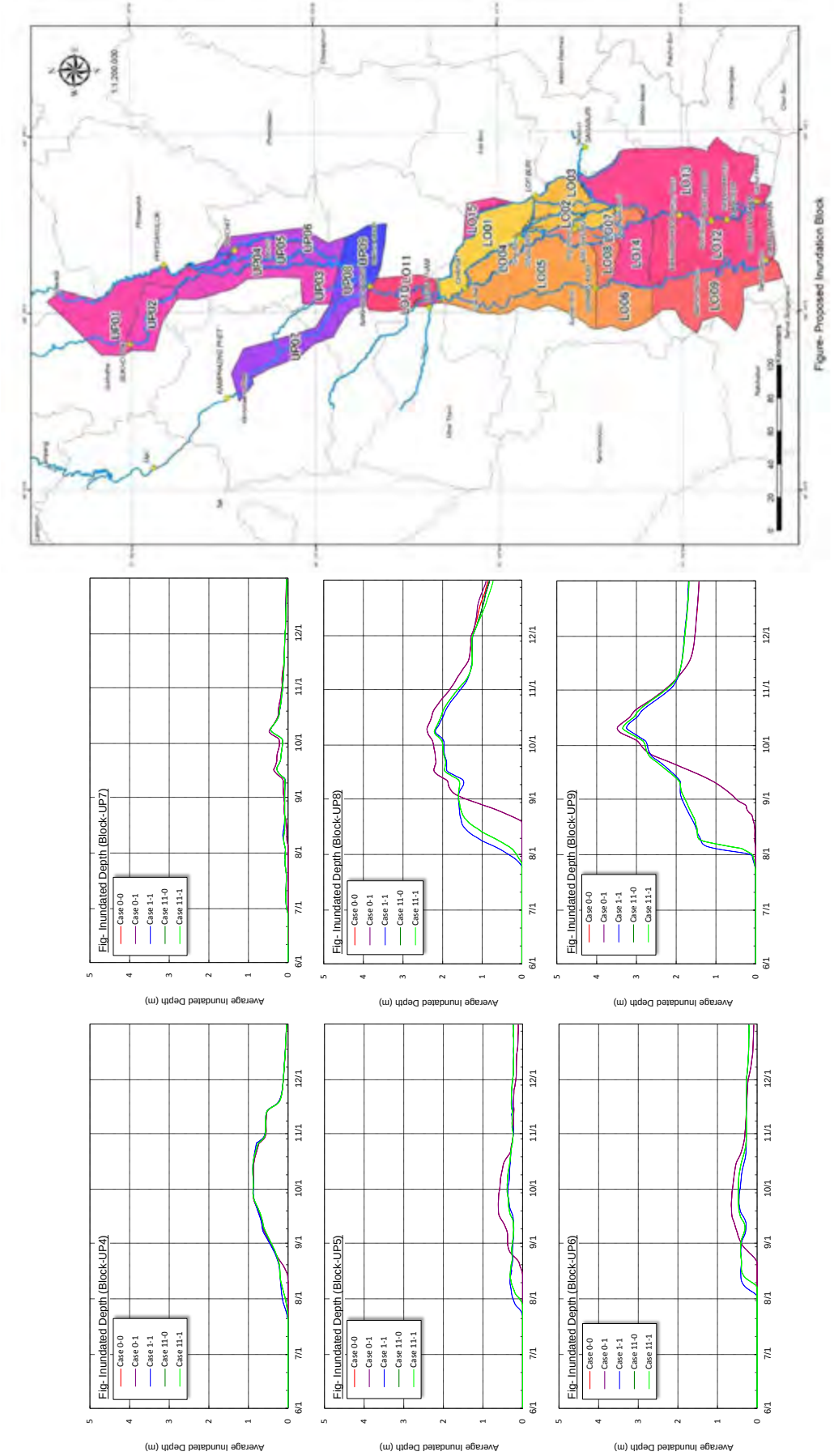


Figure K2.7.18 Inundation Depth (5-year Return Period) (3/3)

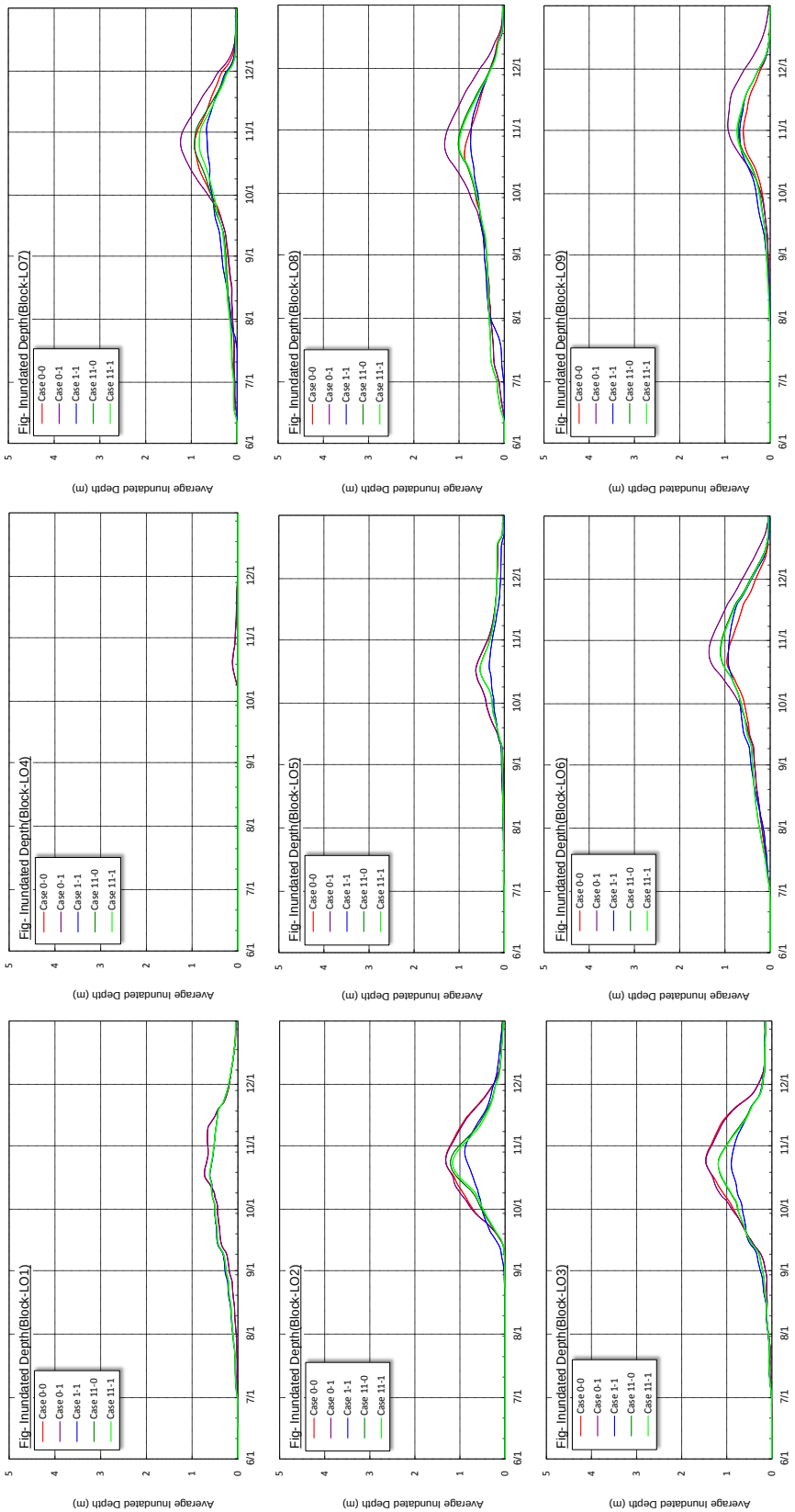


Figure K2.7.19 Inundation Depth (10-year Return Period) (1/3)

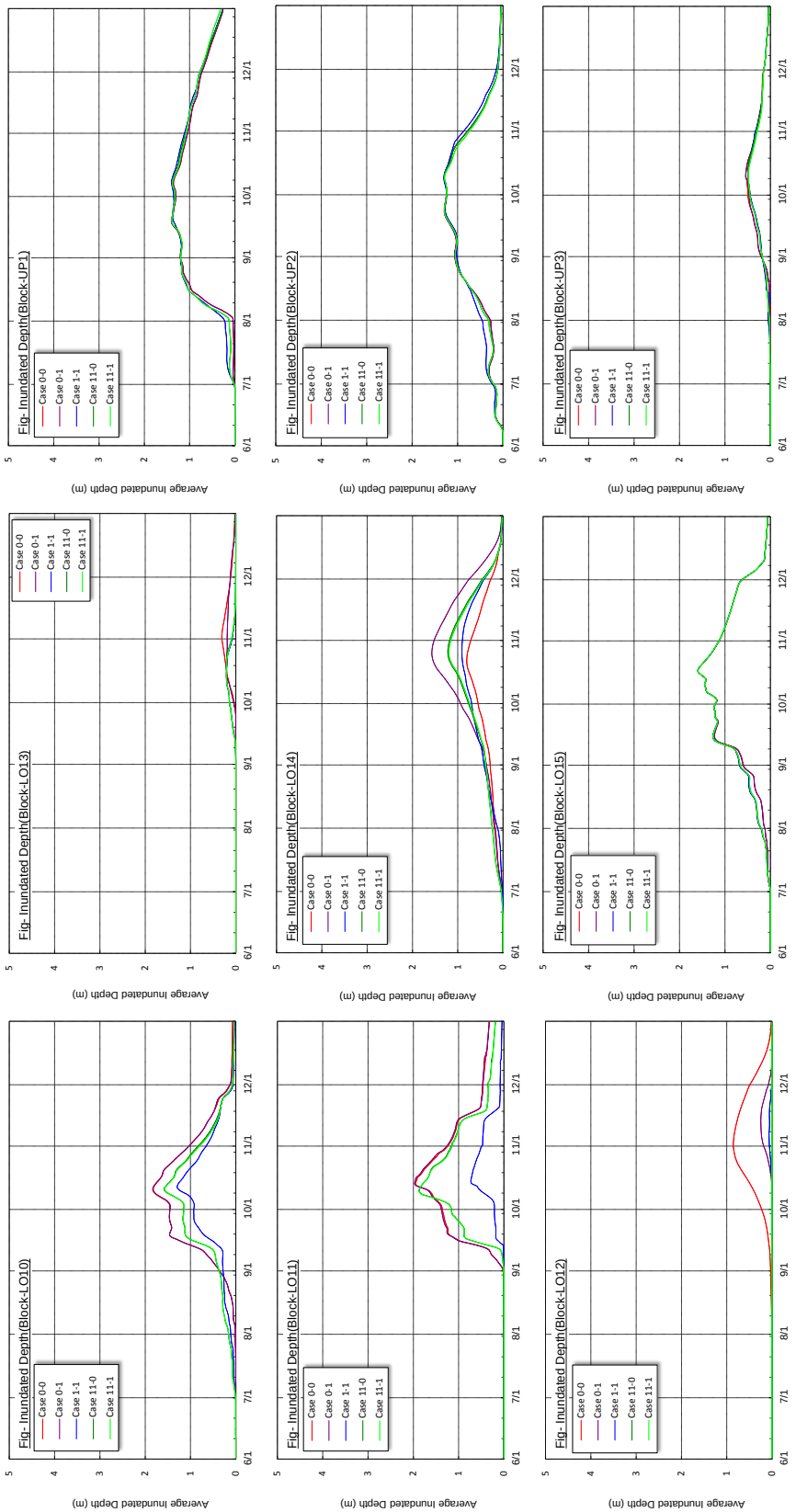


Figure K2.7.20 Inundation Depth (10-year Return Period) (2/3)

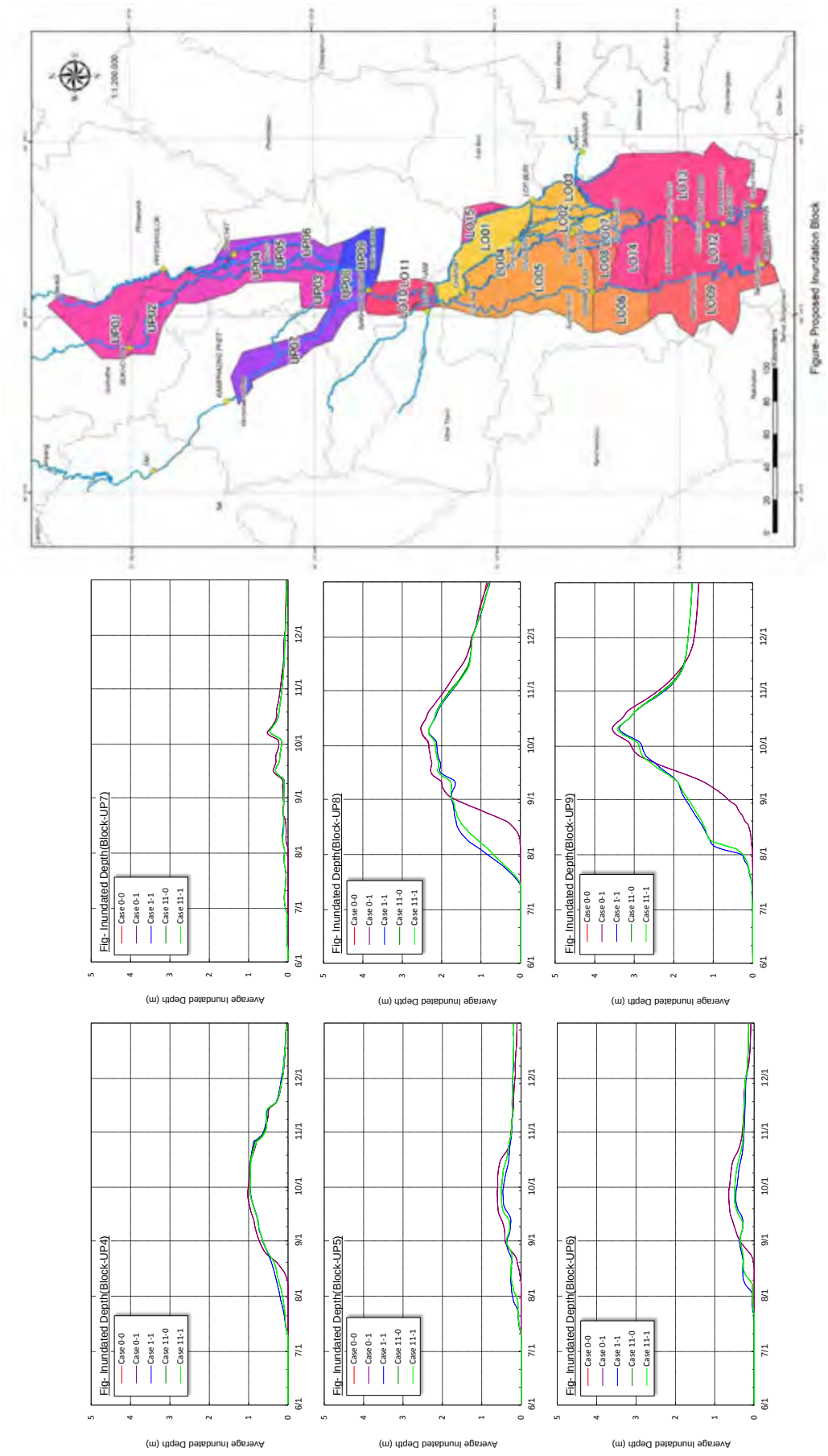


Figure K2.7.21 Inundation Depth (10-year Return Period) (3/3)

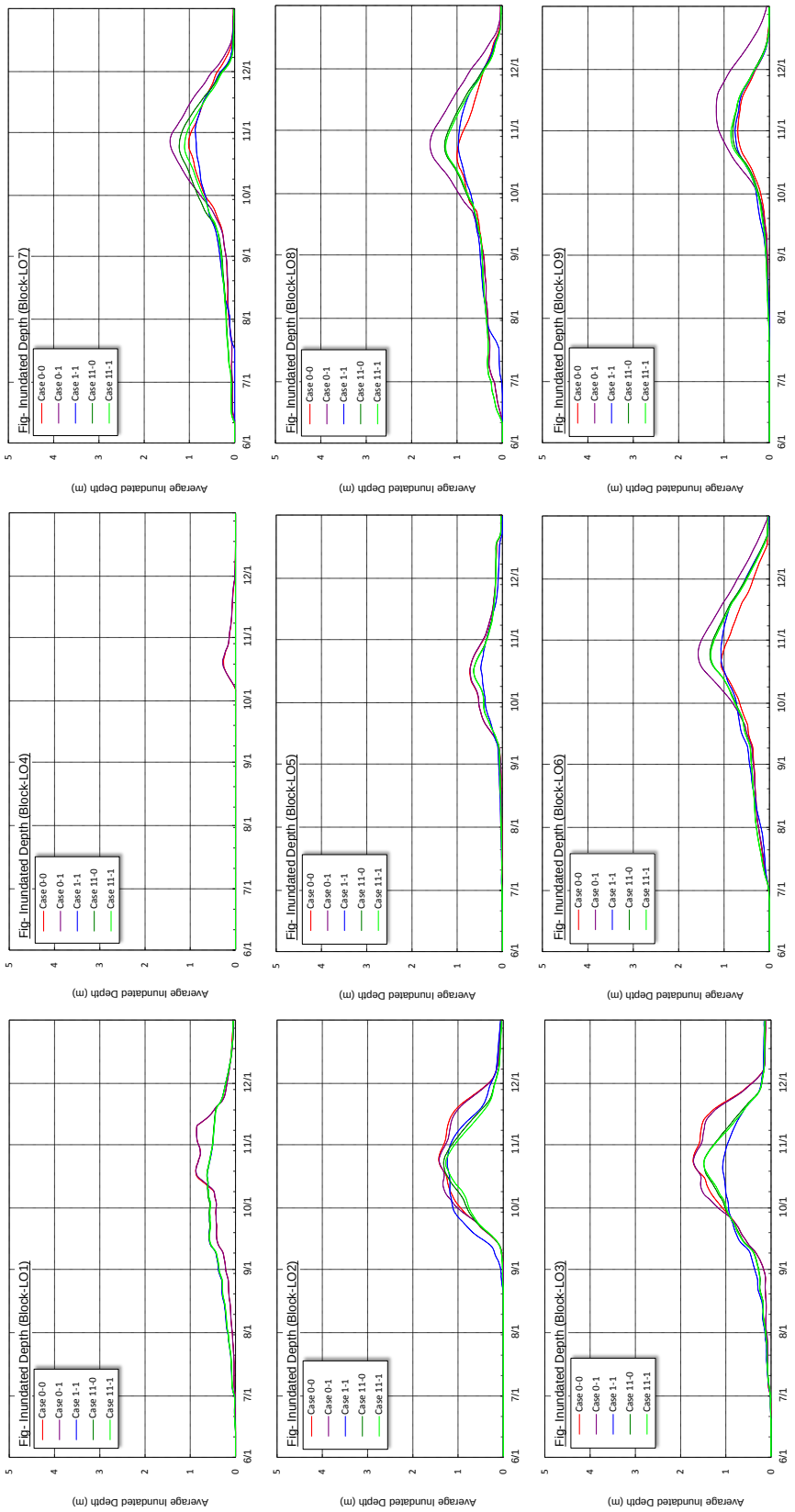


Figure K2.7.22 Inundation Depth (30-year Return Period) (1/3)

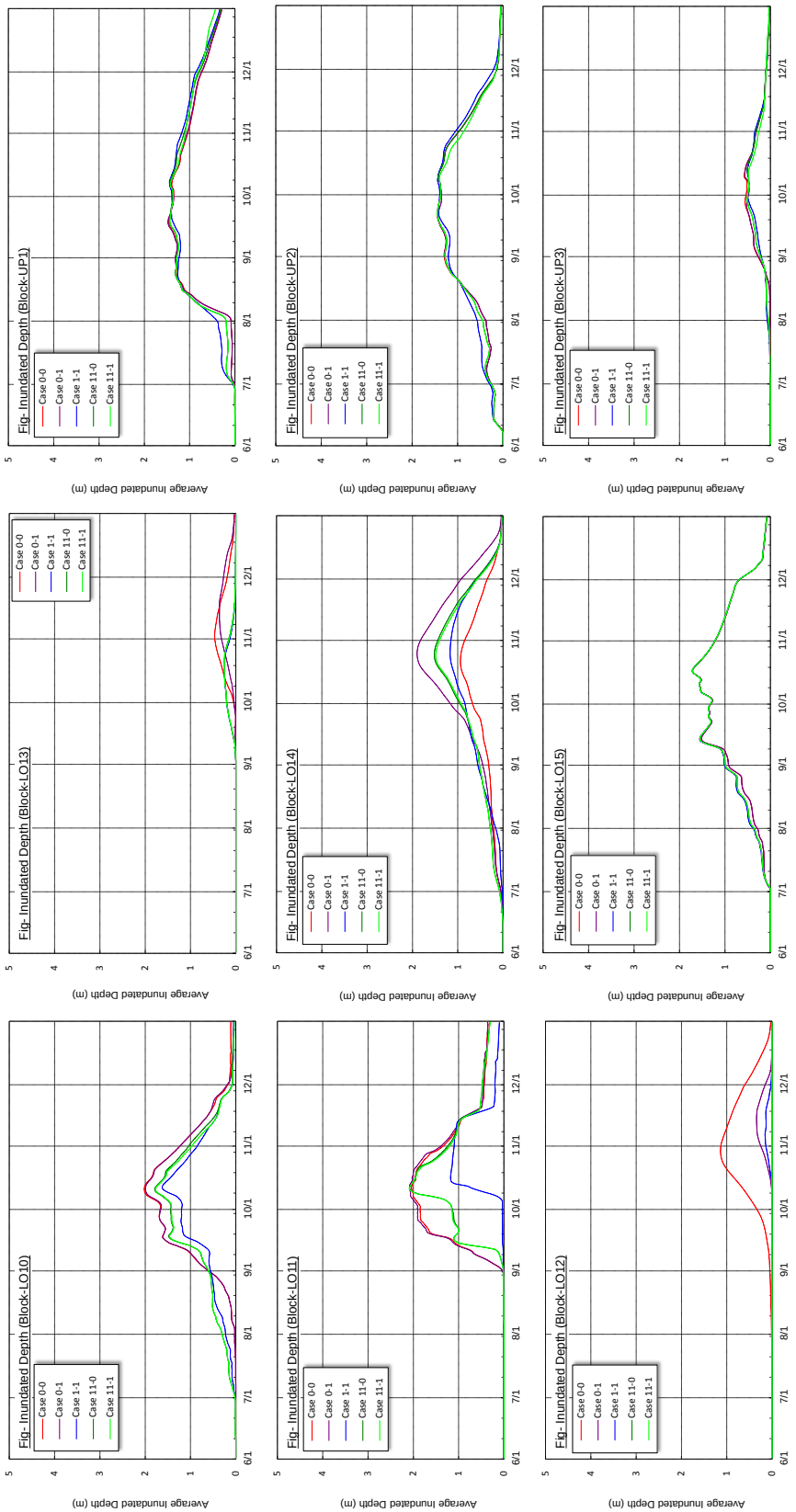


Figure K2.7.23 Inundation Depth (30-year Return Period) (2/3)

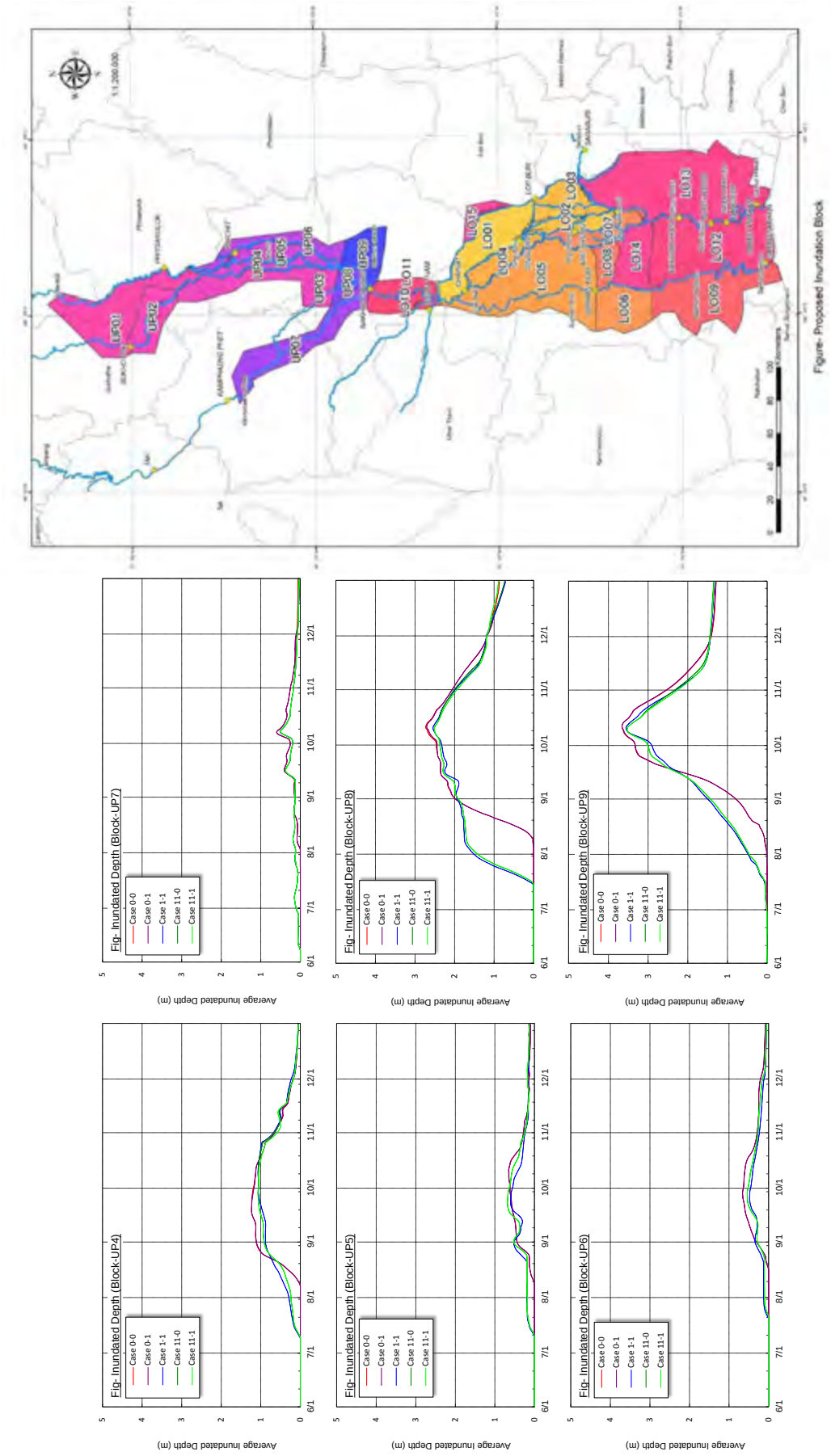


Figure K2.7.24 Inundation Depth (30-year Return Period) (3/3)

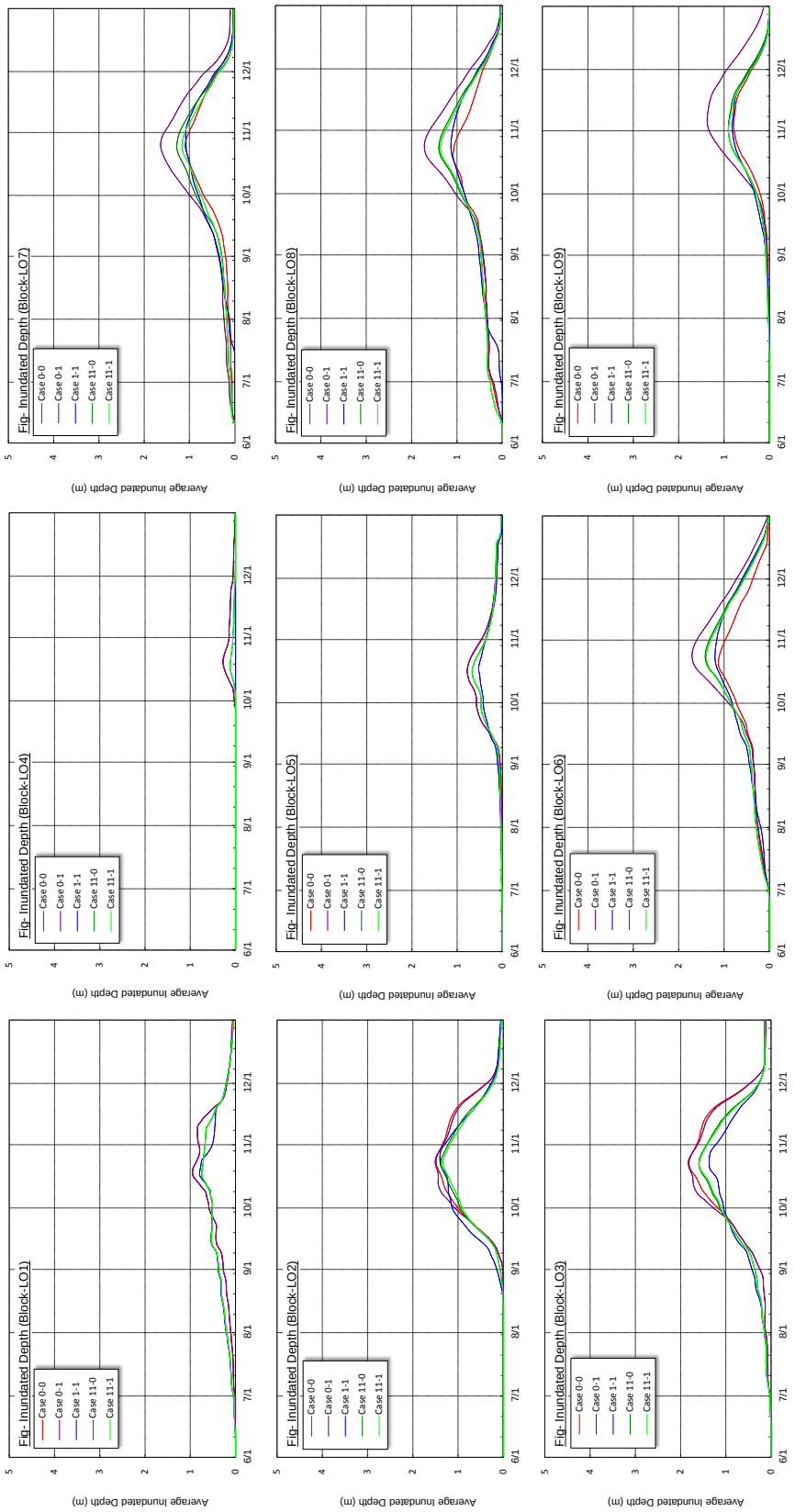


Figure K2.7.25 Inundation Depth (50-year Return Period) (1/3)

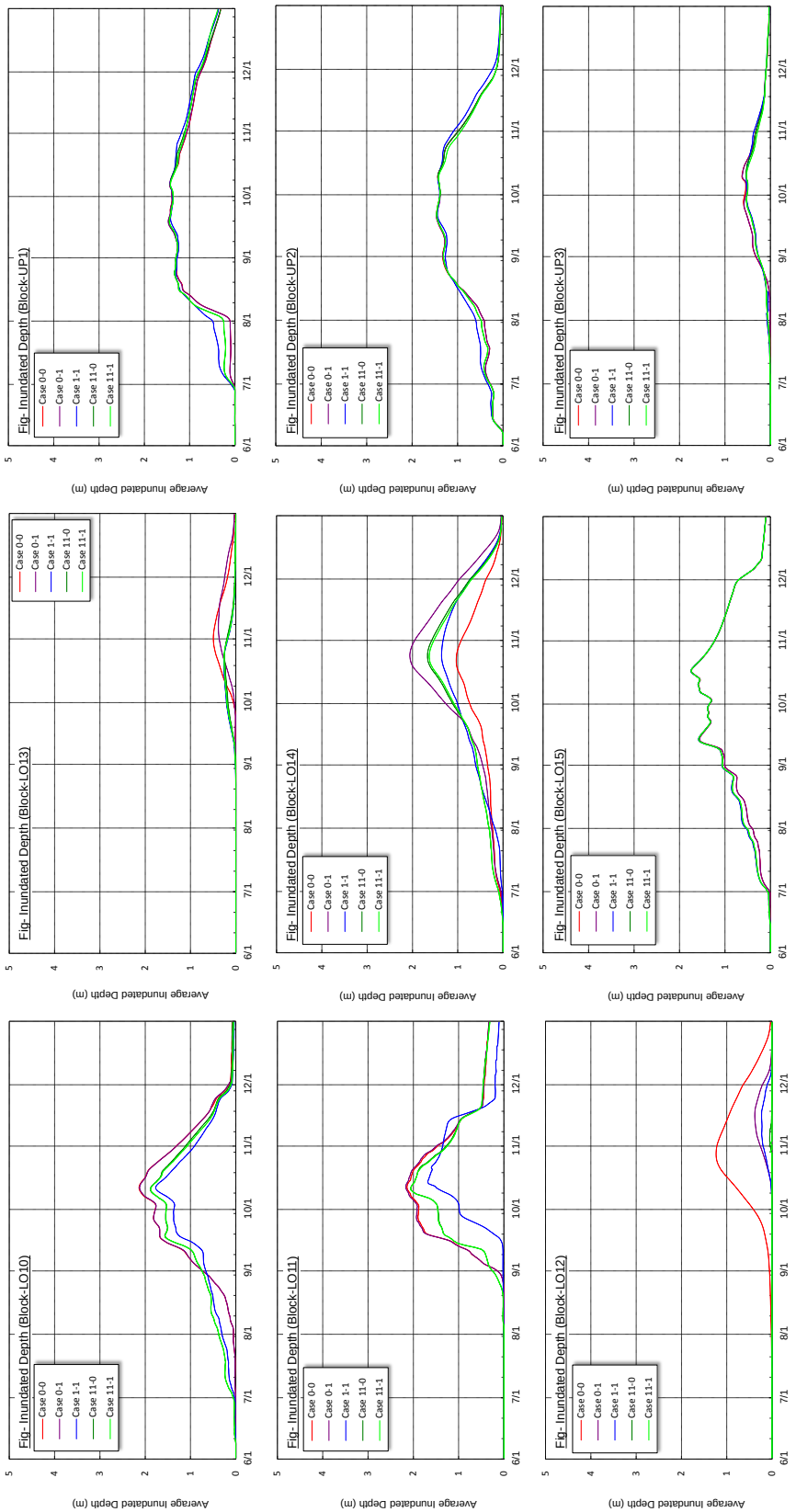


Figure K2.7.26 Inundation Depth (50-year Return Period) (2/3)

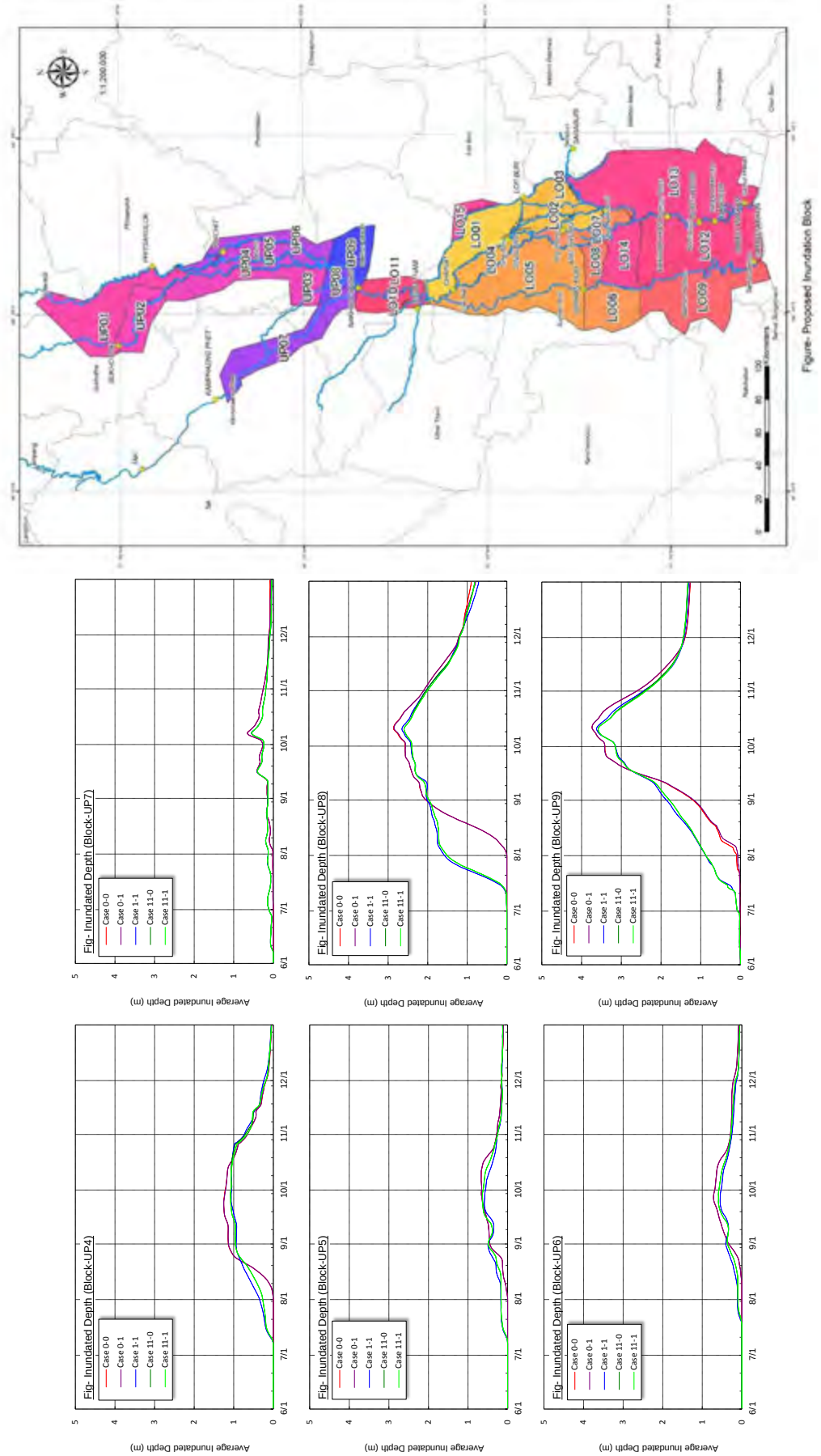


Figure K2.7.27 Inundation Depth (50-year Return Period) (3/3)

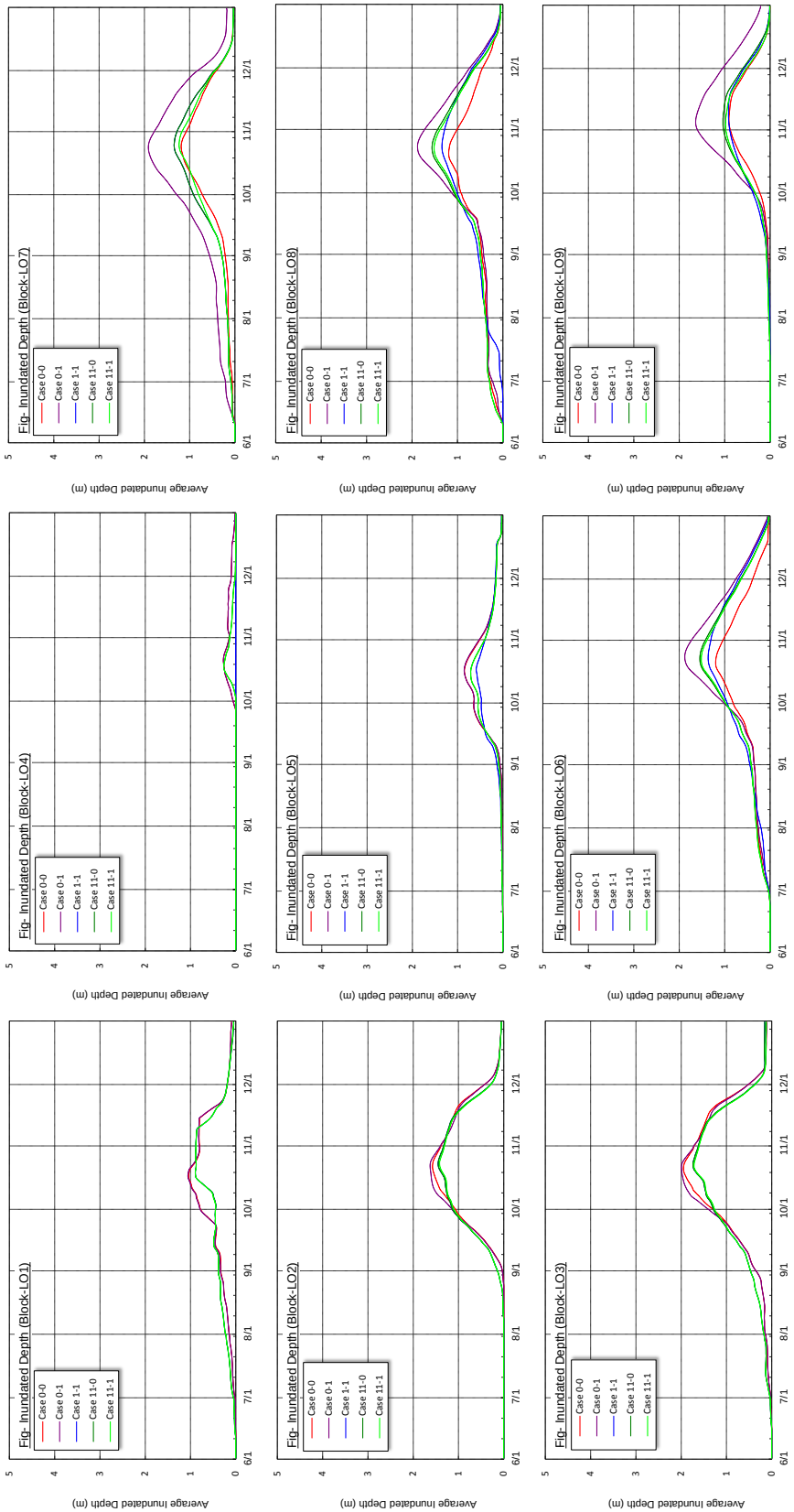


Figure K2.7.28 Inundation Depth (100-year Return Period) (1/3)

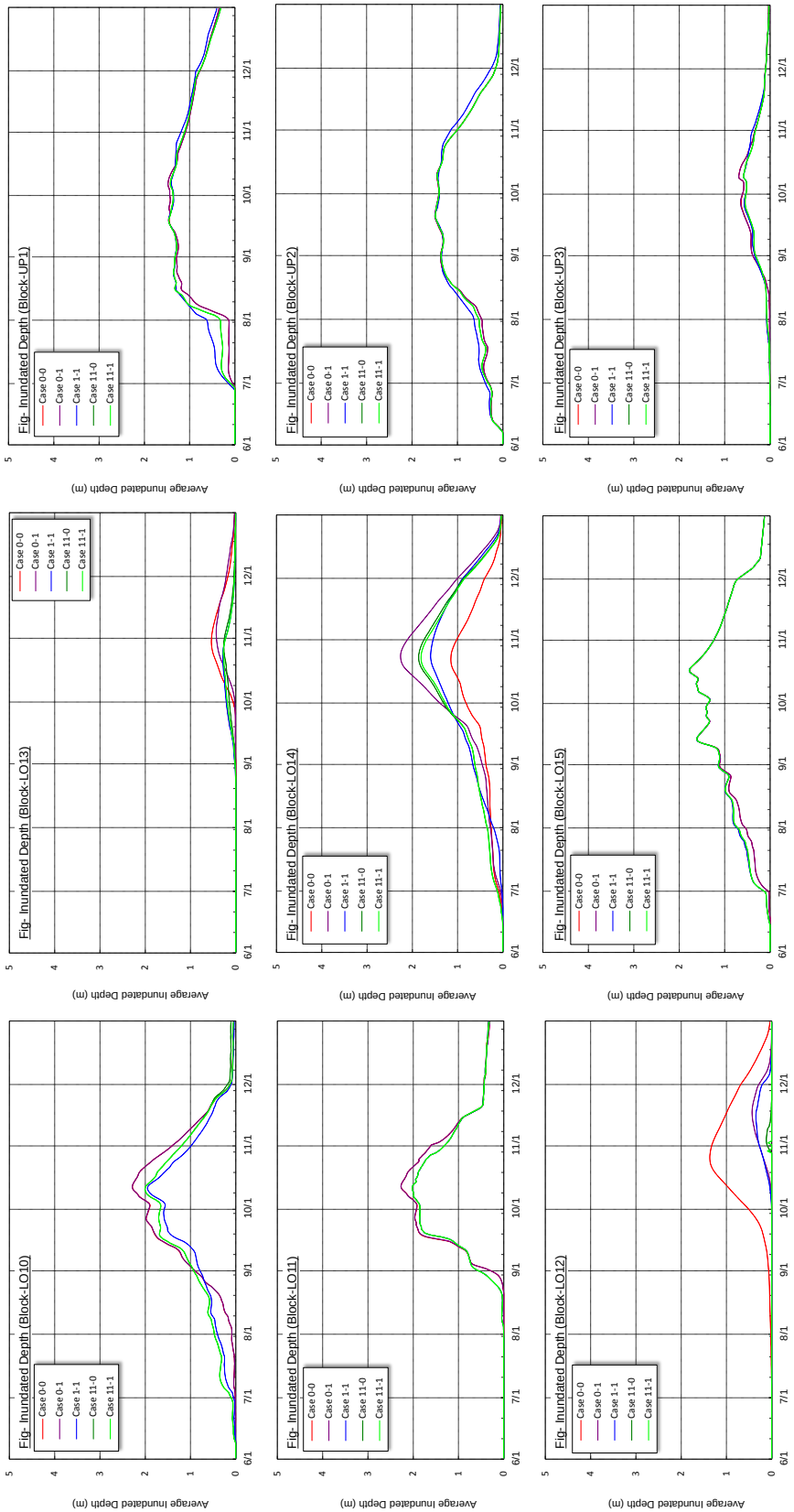


Figure K2.7.29 Inundation Depth (100-year Return Period) (2/3)

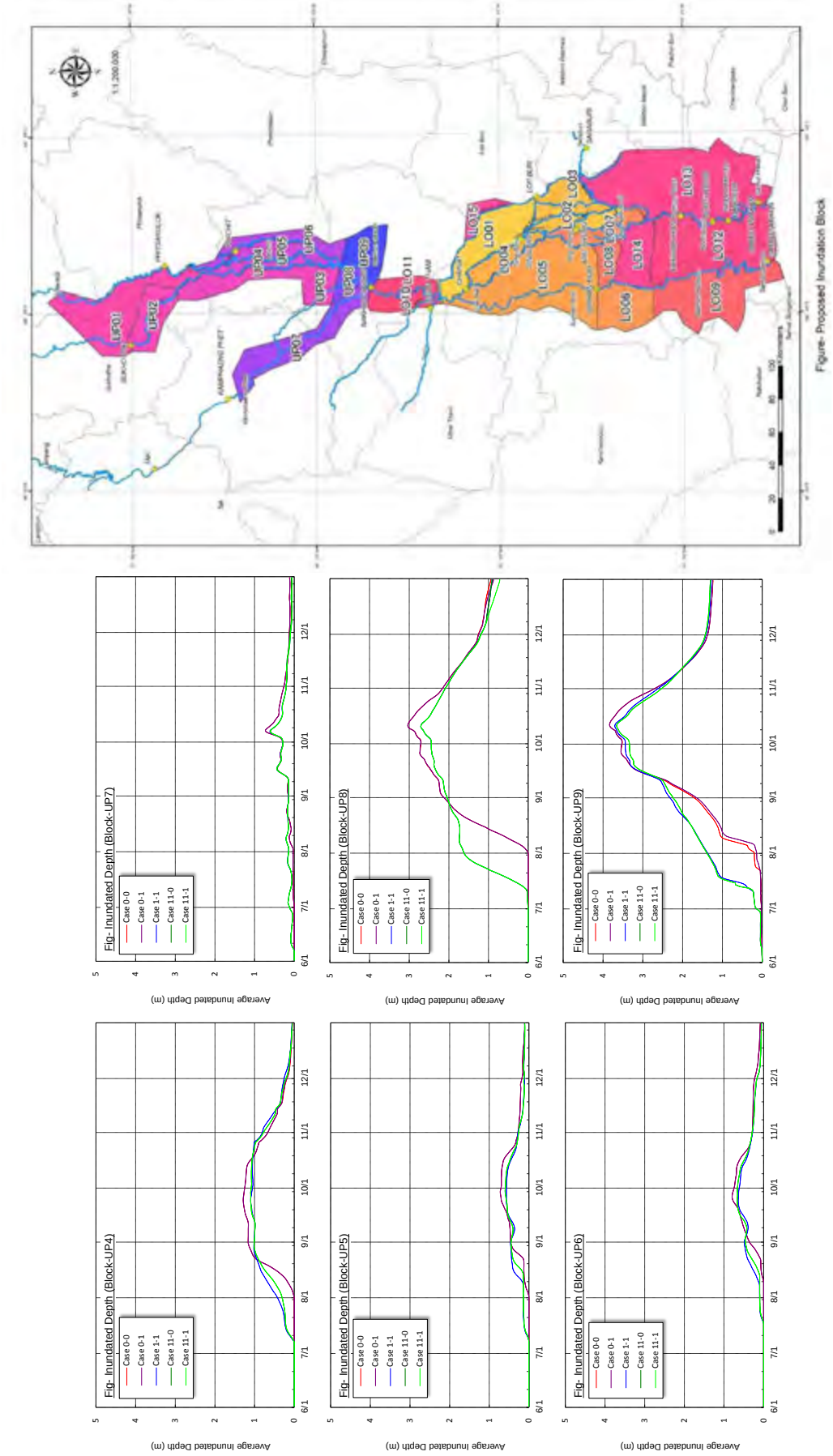


Figure K2.7.30 Inundation Depth (100-year Return Period) (3/3)

K2.7.3 Inundation Area

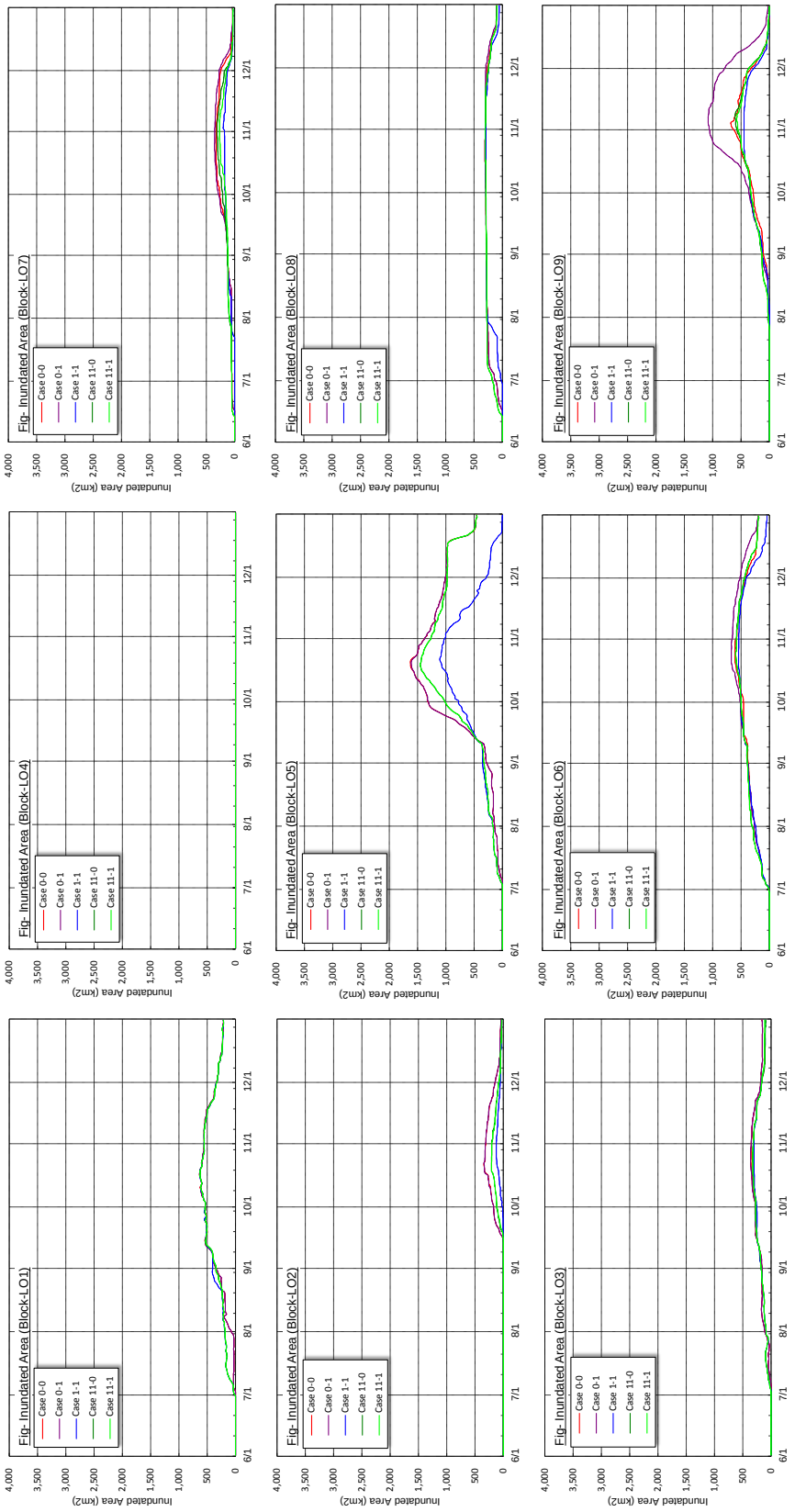


Figure K2.7.31 Inundation Area (5-year Return Period) (1/3)

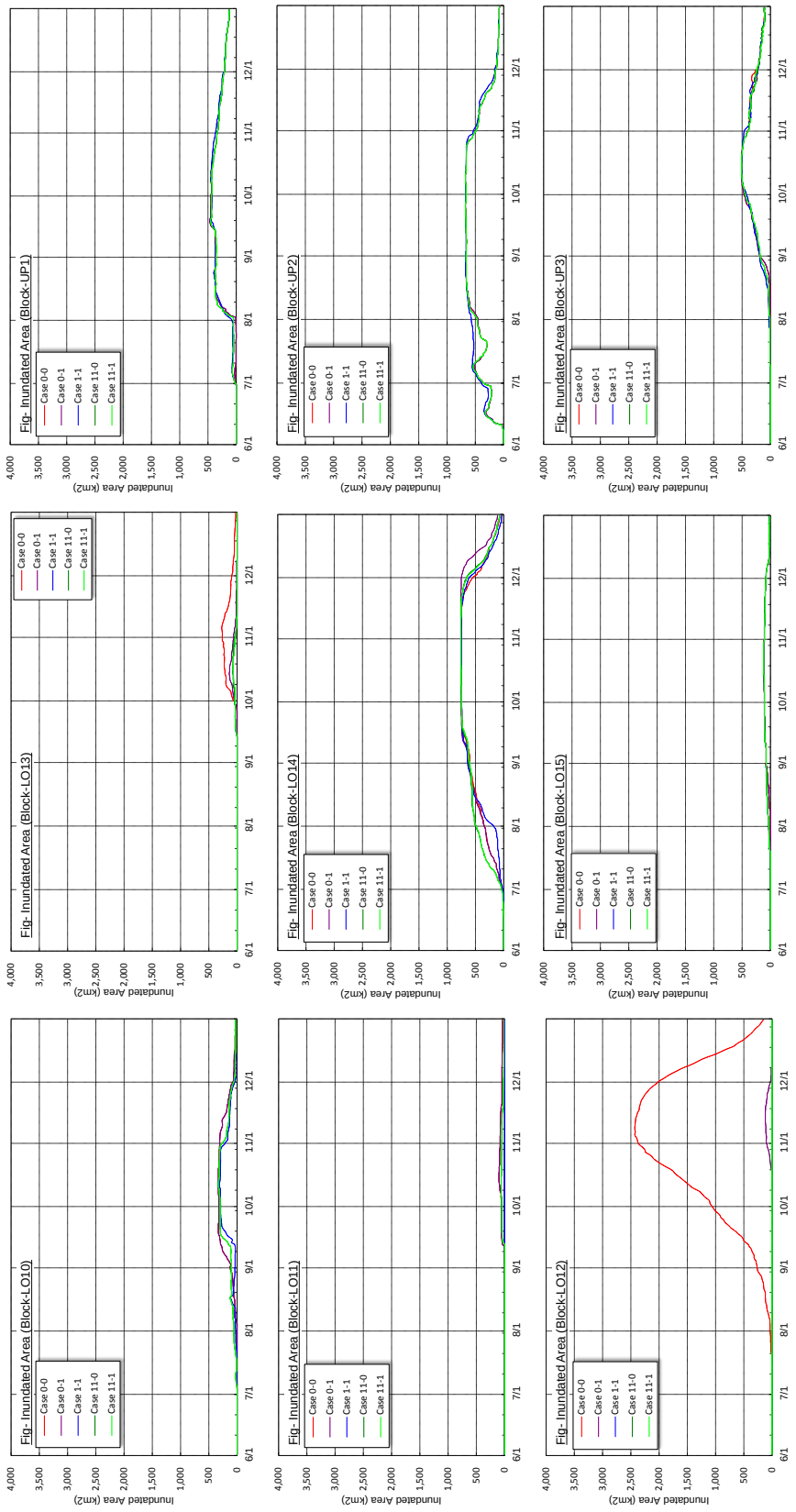


Figure K2.7.32 Inundation Area (5-year Return Period) (2/3)

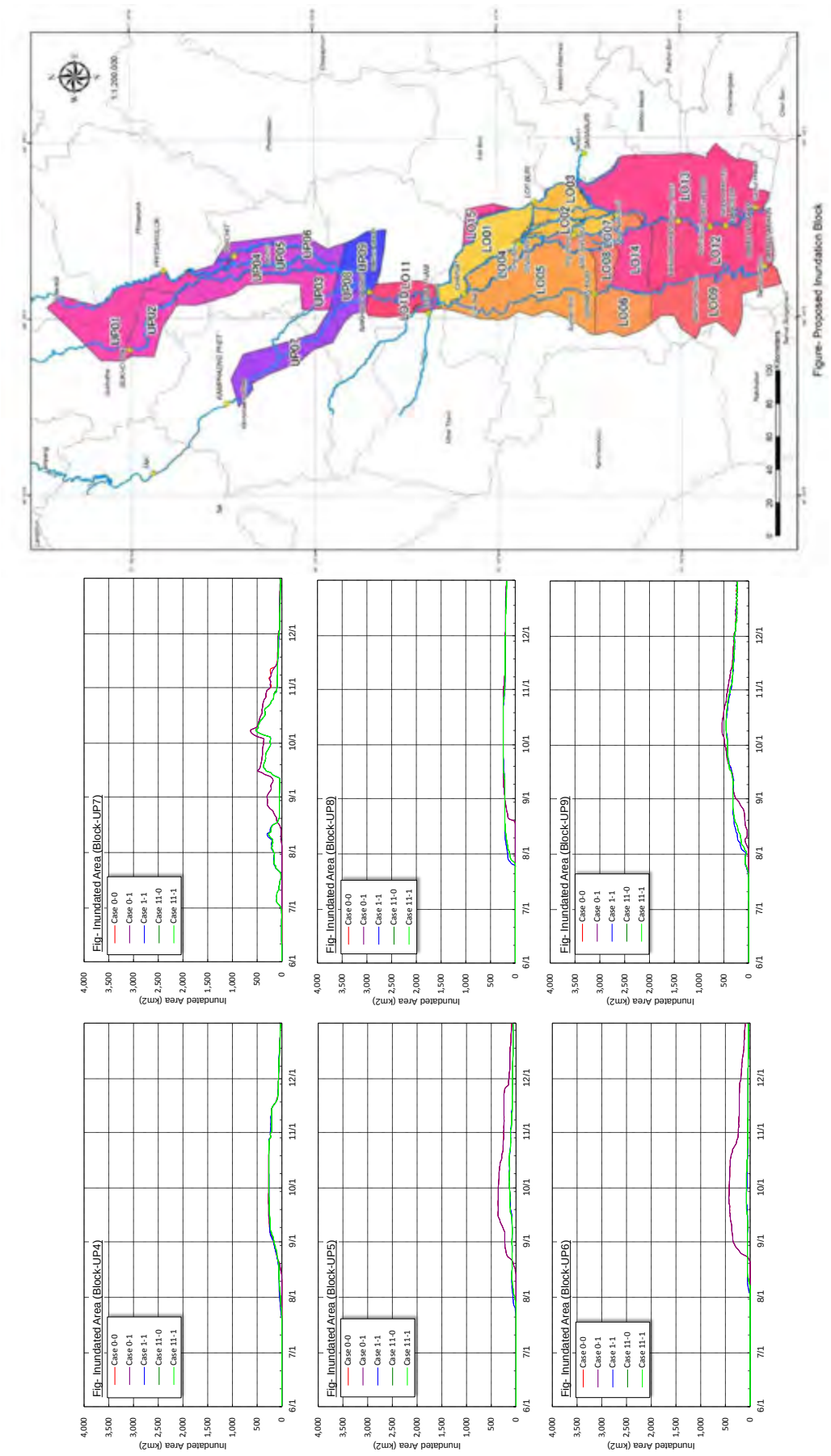


Figure K2.7.33 Inundation Area (5-year Return Period) (3/3)

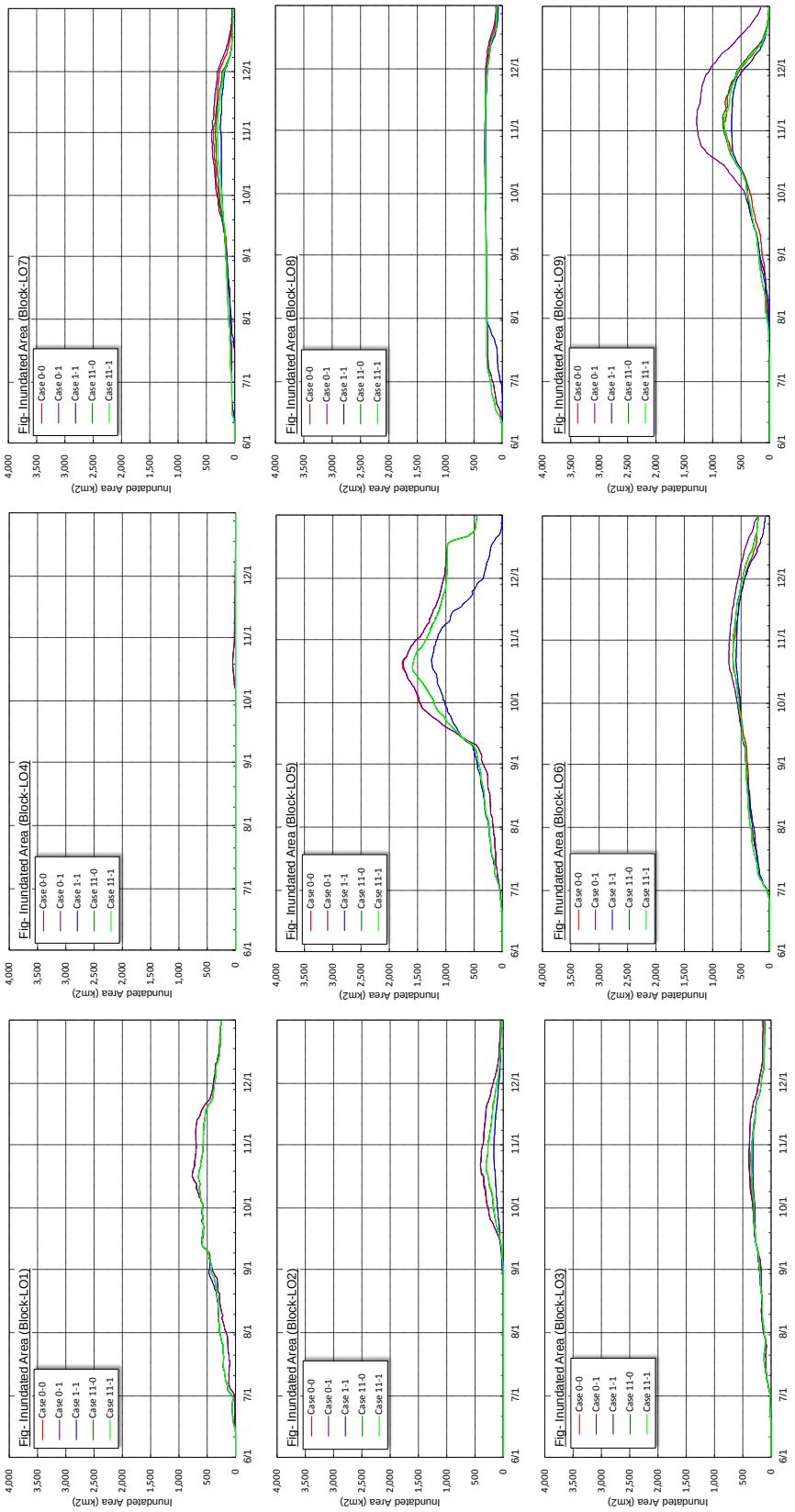


Figure K2.7.34 Inundation Area (10-year Return Period) (1/3)

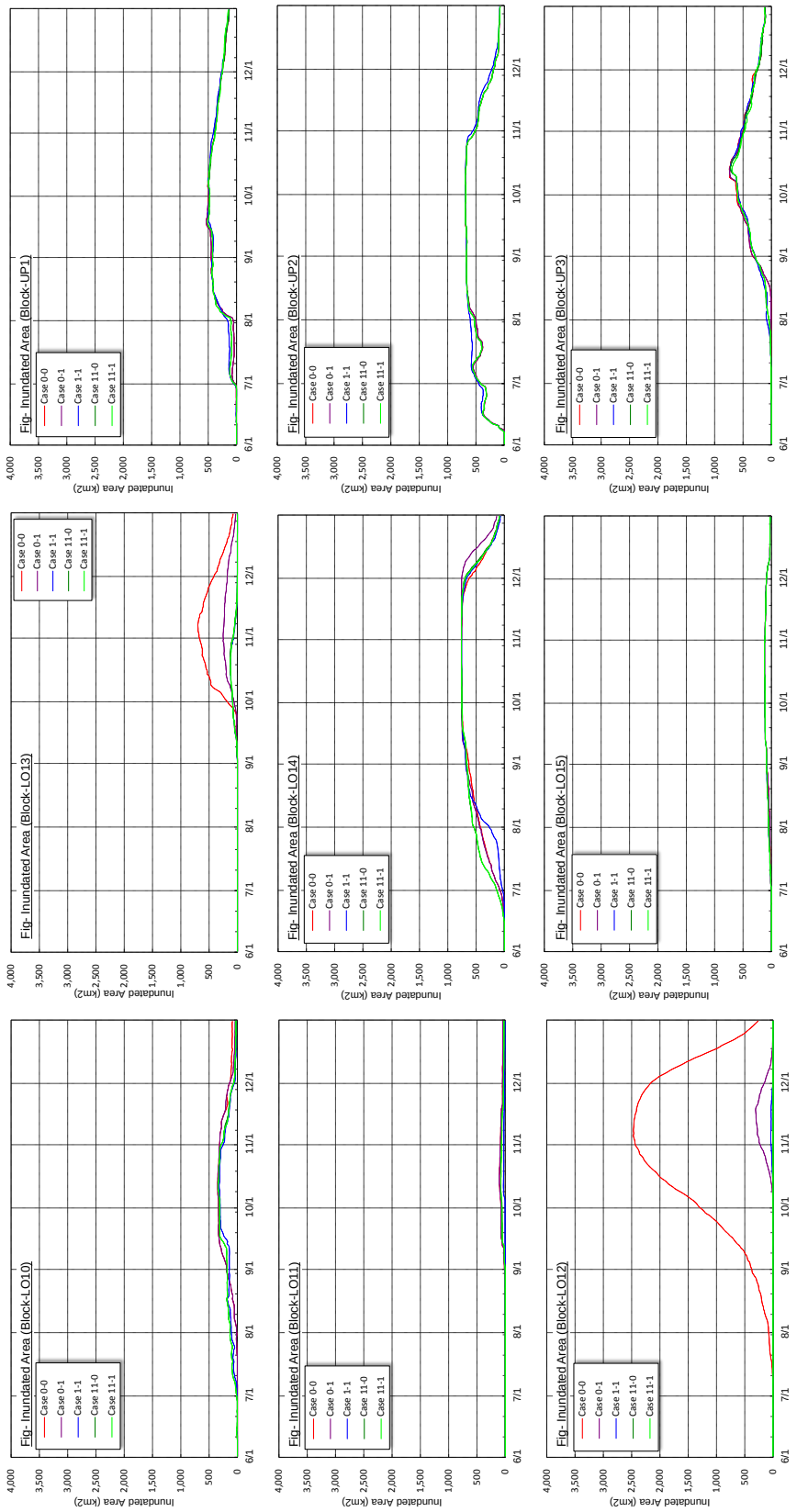


Figure K2.7.35 Inundation Area (10-year Return Period) (2/3)

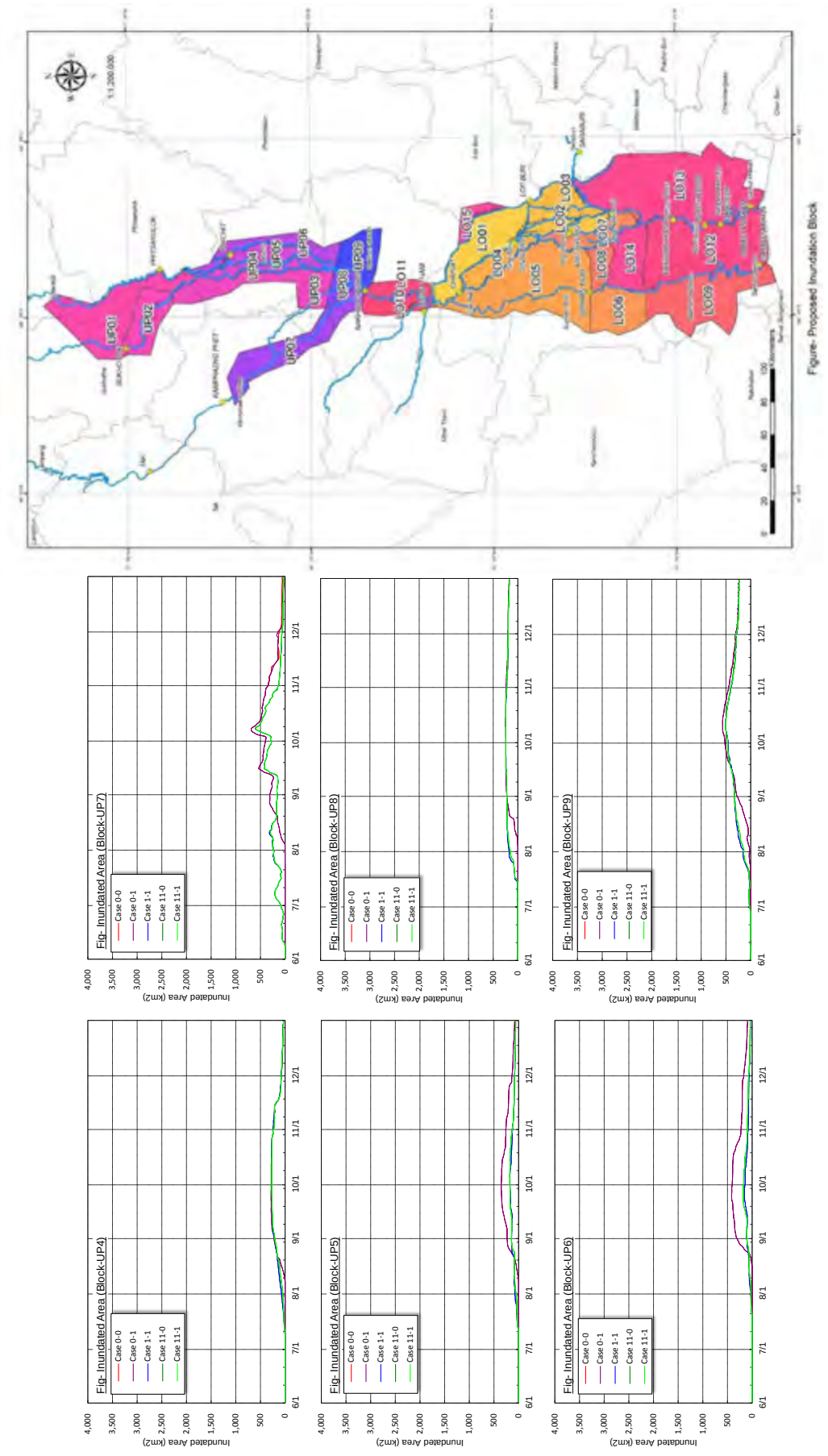


Figure K2.7.36 Inundation Area (10-year Return Period) (3/3)

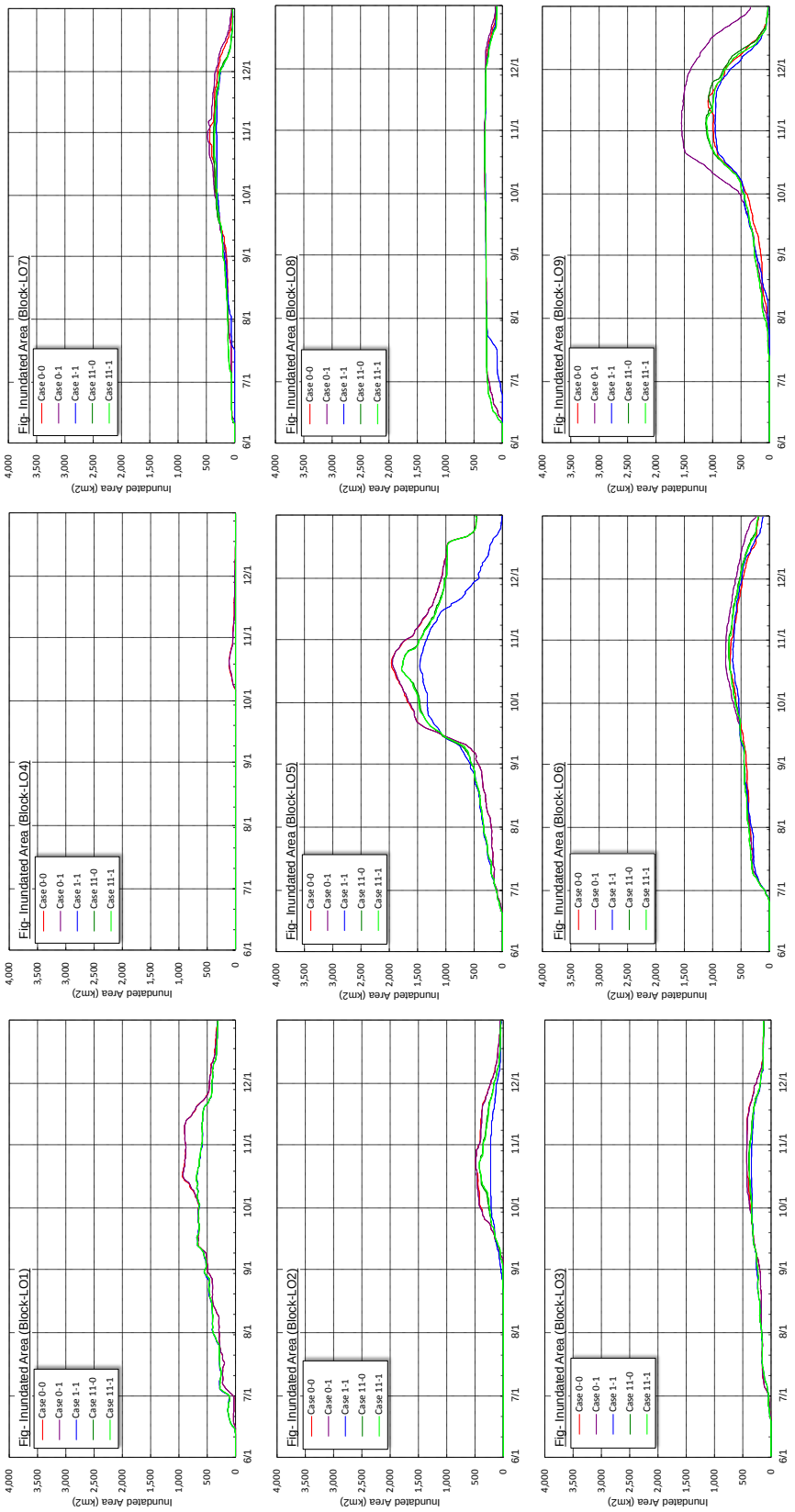


Figure K2.7.37 Inundation Area (30-year Return Period) (1/3)

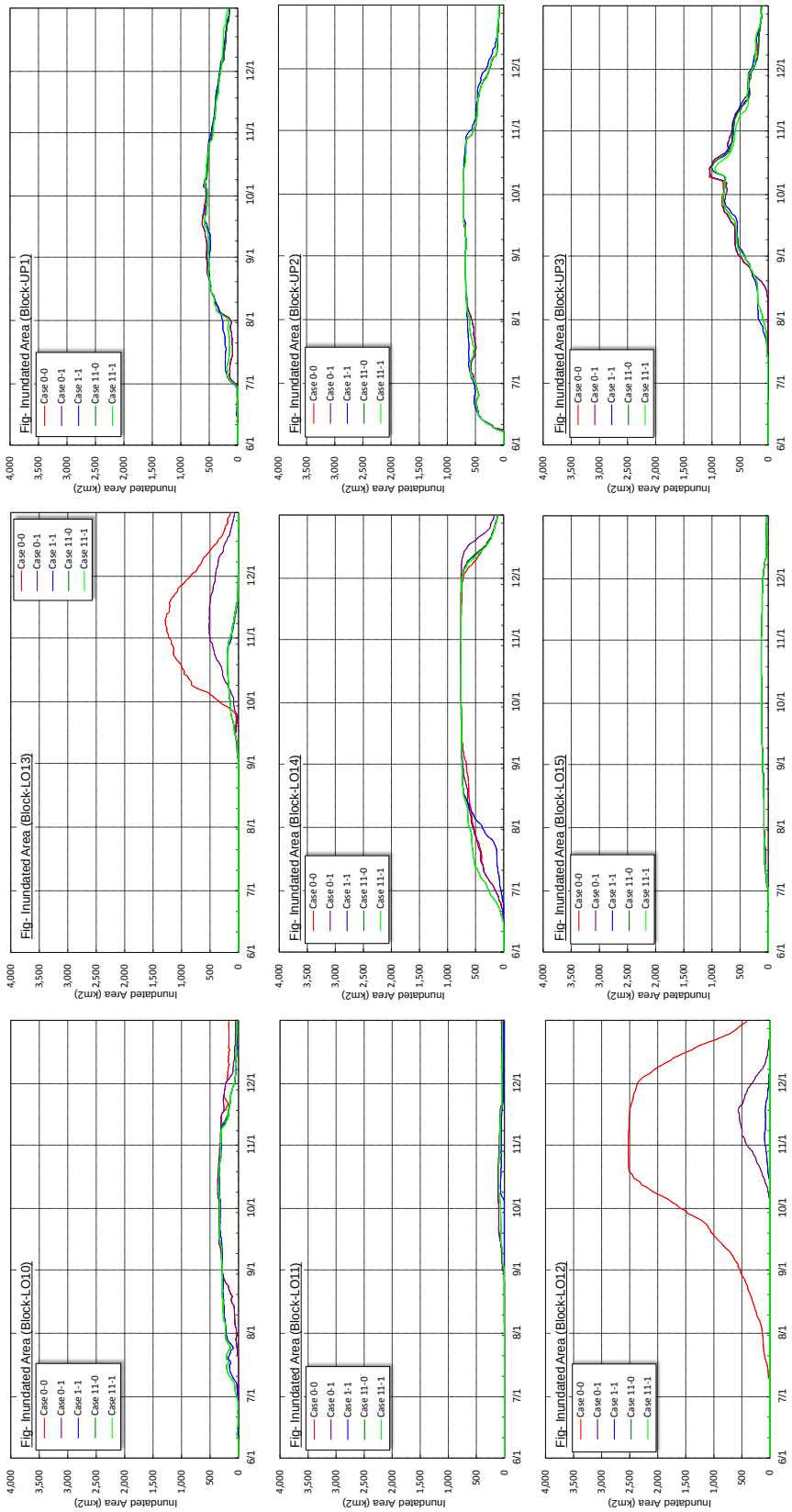


Figure K2.7.38 Inundation Area (30-year Return Period) (2/3)

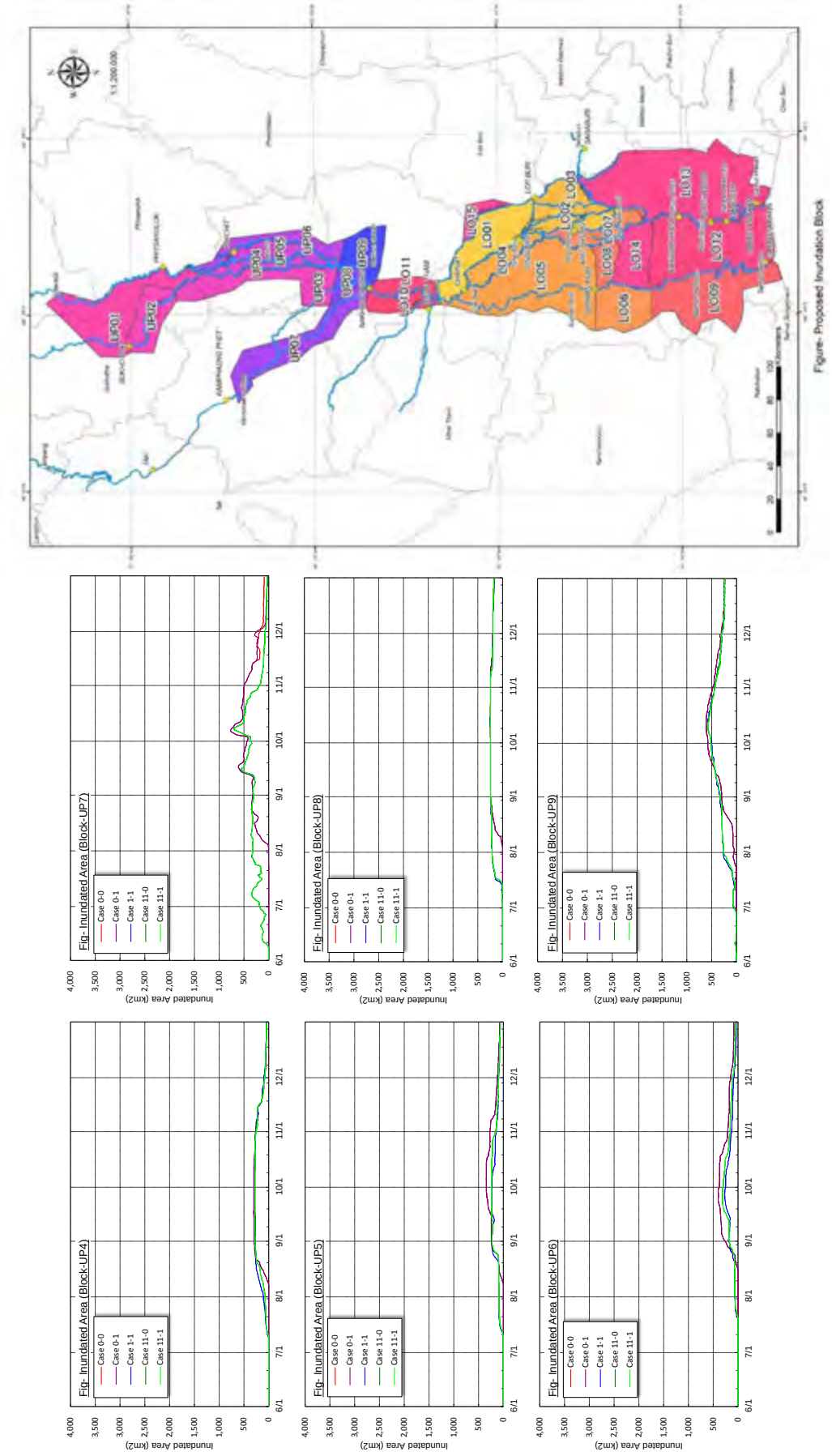


Figure K2.7.39 Inundation Area (30-year Return Period) (3/3)

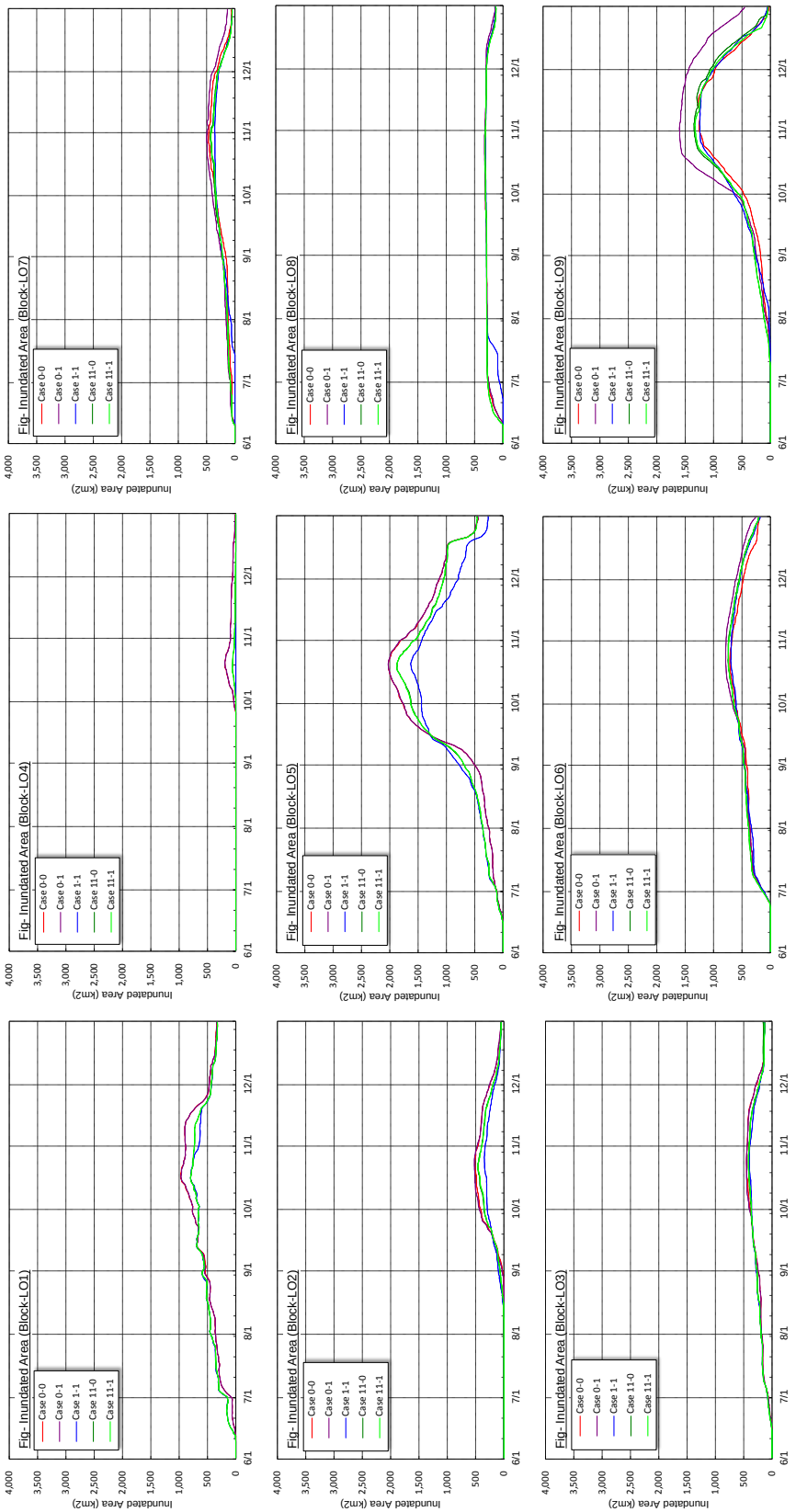


Figure K2.7.40 Inundation Area (50-year Return Period) (1/3)

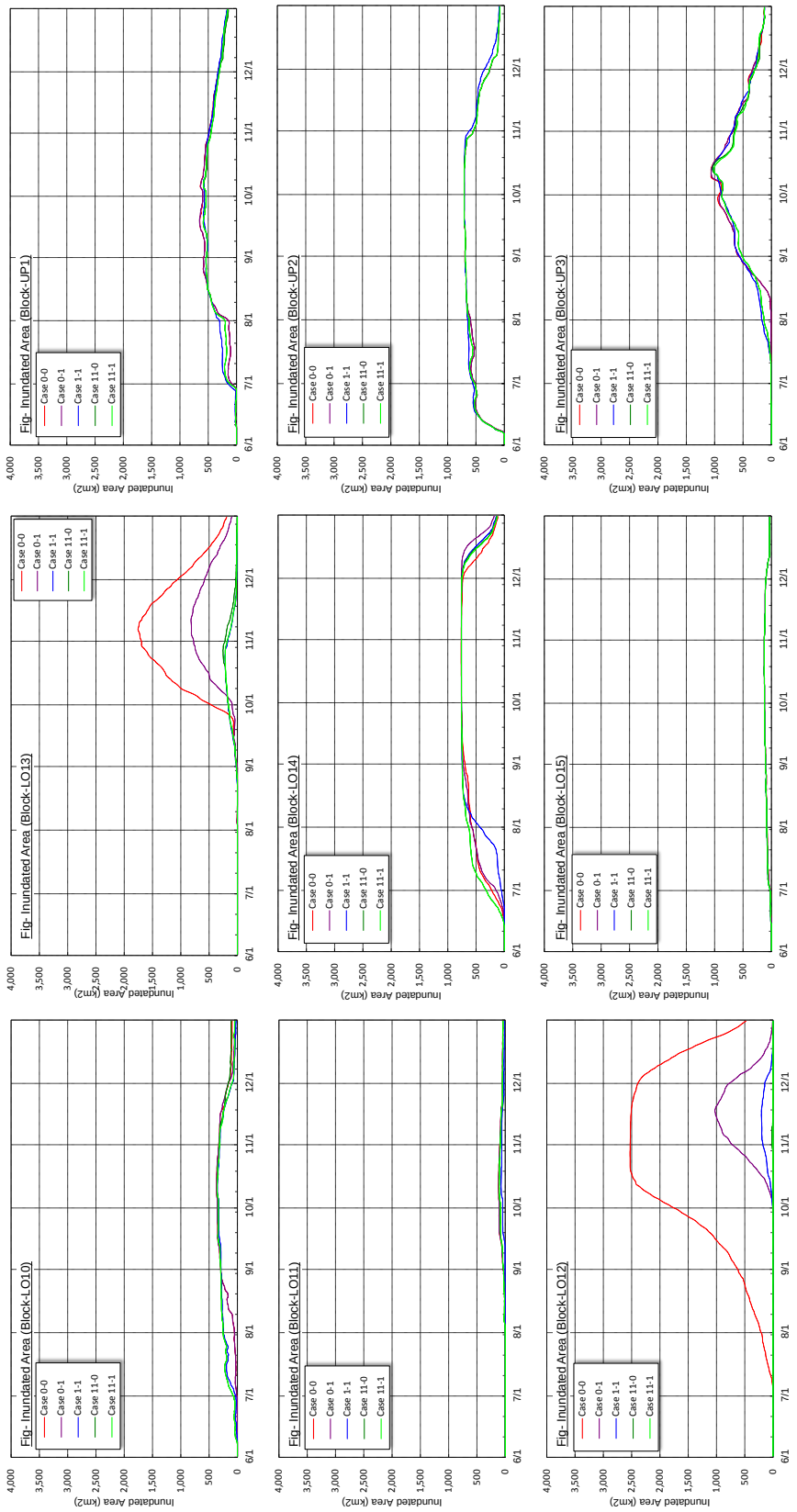


Figure K2.7.41 Inundation Area (50-year Return Period) (2/3)

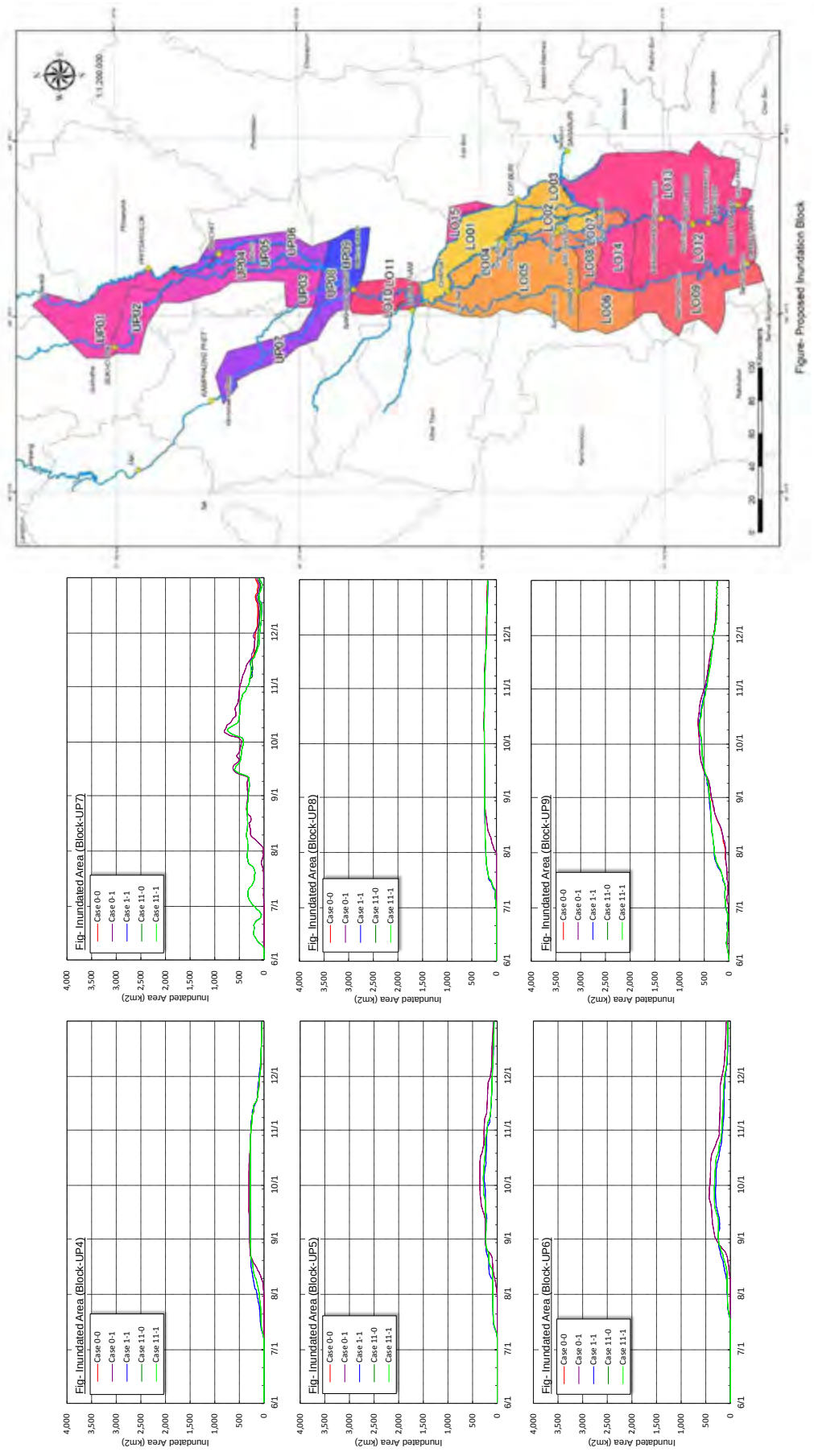


Figure K2.7.42 Inundation Area (50-year Return Period) (3/3)

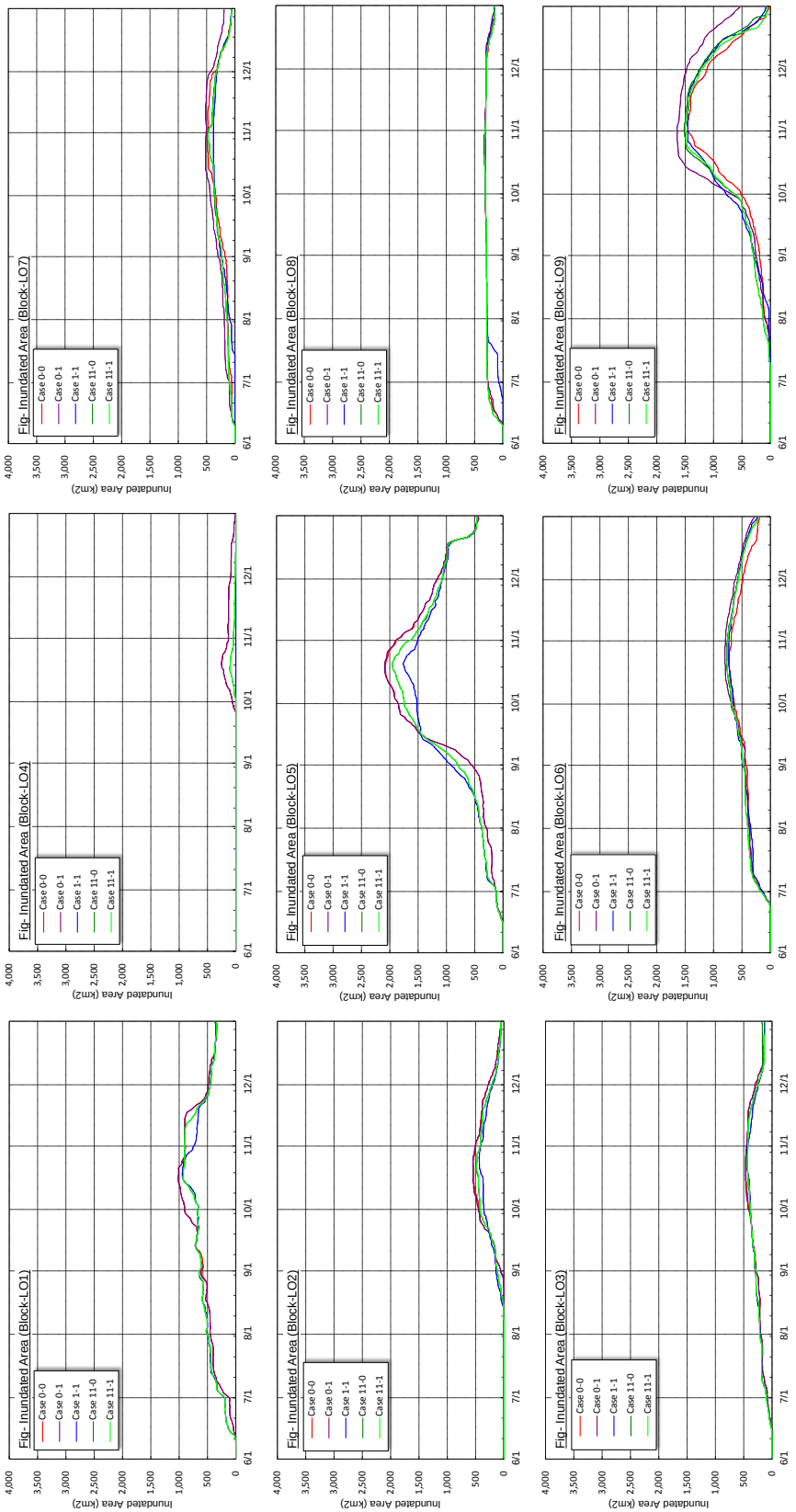


Figure K2.7.43 Inundation Area (100-year Return Period) (1/3)

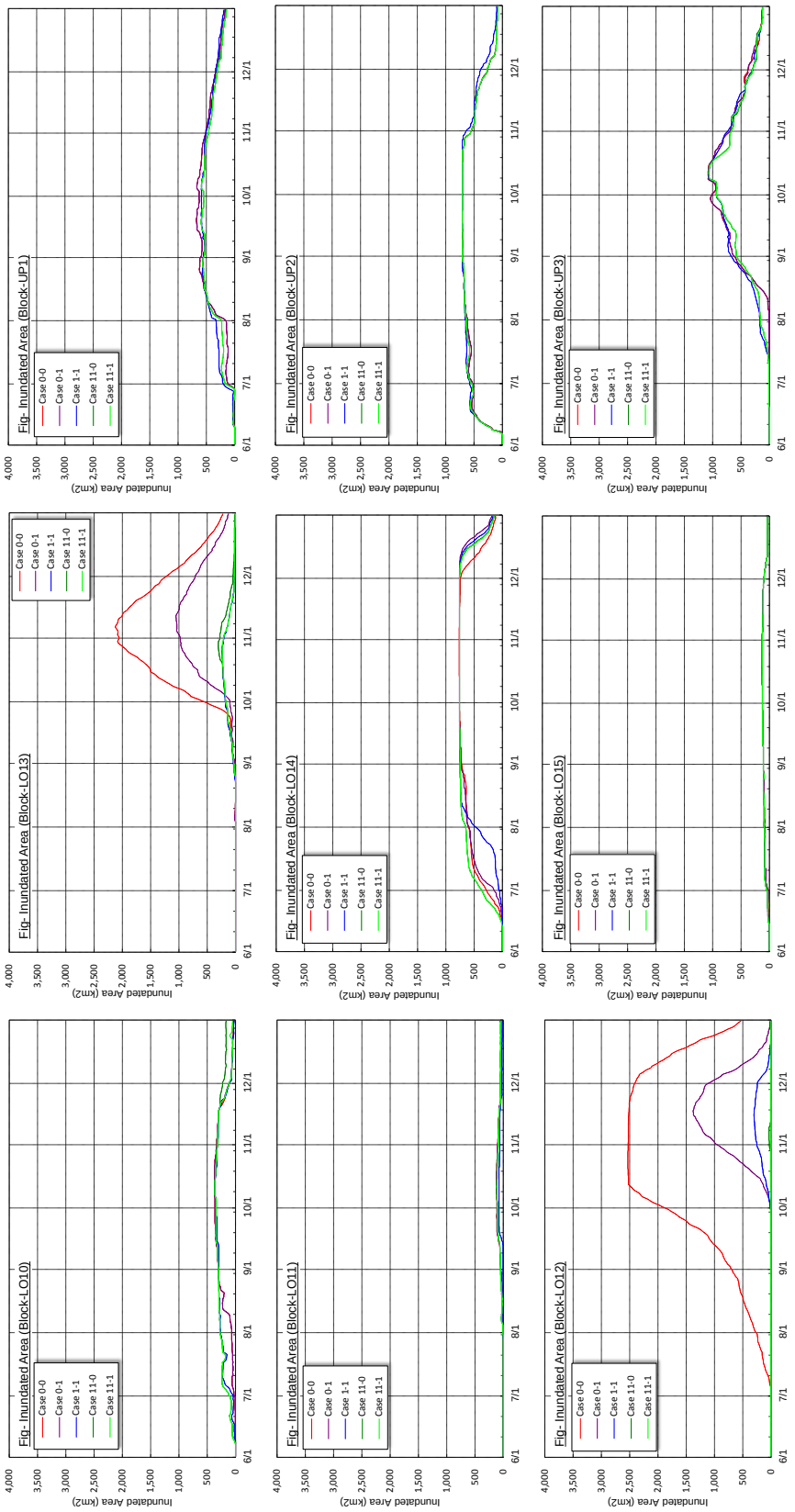


Figure K2.7.44 Inundation Area (100-year Return Period) (2/3)

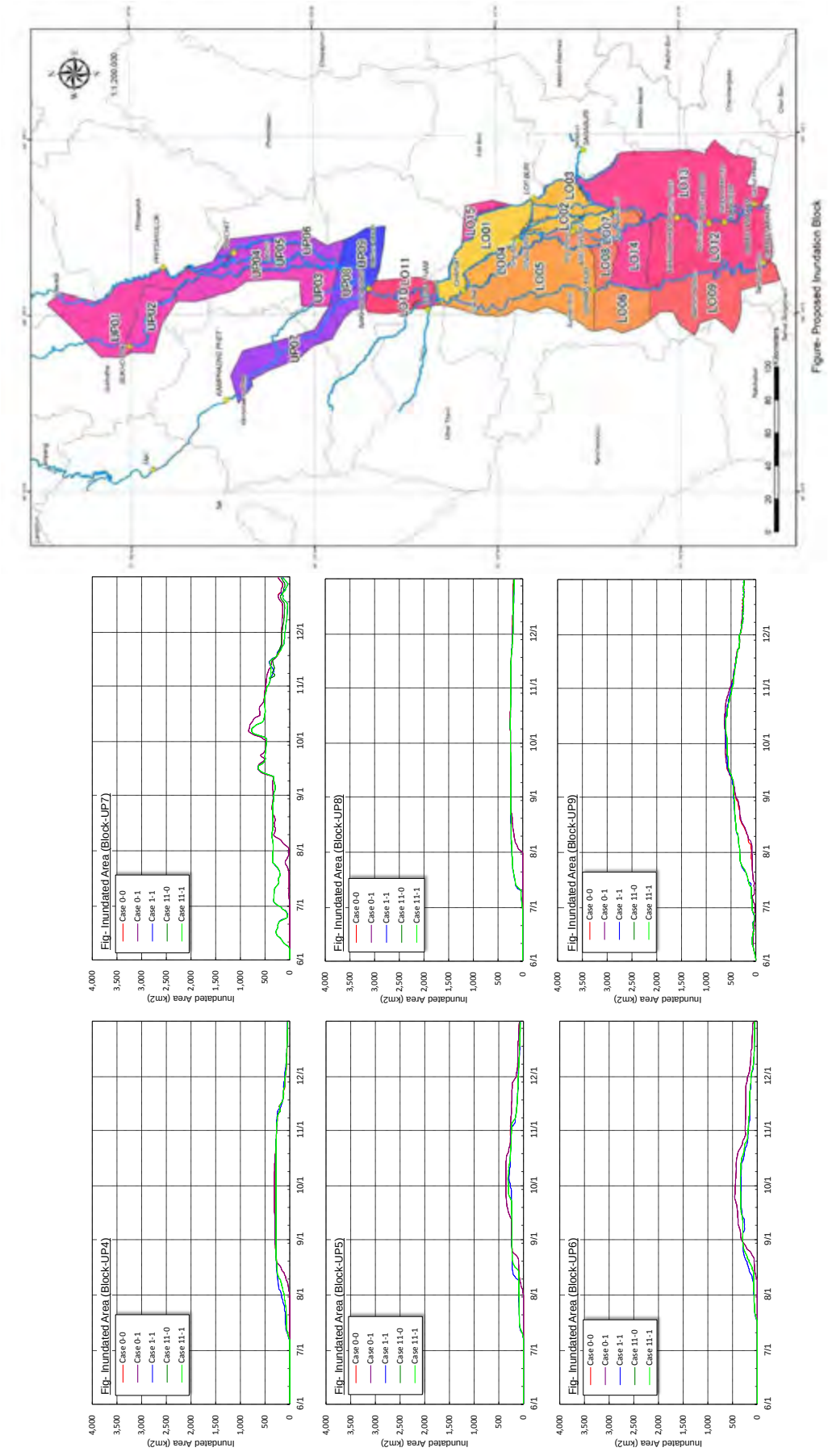


Figure K2.7.45 Inundation Area (100-year Return Period) (3/3)

SECTOR K: ANNEX-1 Retention Area Managed by Existing and Proposed

Retention Area Managed by RID (Existing and Proposed)

1. Upper Nakhon Sawan (Existing)

Retention Area	Location	Area (km²)	Remark
N1	Nan River left bank	219	Irrigation area
N2	Nan River right bank	165	Irrigation area
N3	Between Yom river and Nan River	147	Irrigation area
N4	Between Yom River and Nan River	86	Irrigation area
N5	Nan River left bank	209	Irrigation area
	Total	826	

2. Nakhon Sawan – Ayutthaya Area (Existing)

Retention Area	location	Area (km²)	Remark
C1	Between Chao Phraya and Noi River	52	Irrigation area
C2	Between Chao Phraya and Noi River	190	Irrigation area
C3	Between Noi River and Tha Chin	190	Irrigation area
C4	Between Noi River and Chao Phraya	117	Irrigation area
C5	Between Pasak and Lopburi River	152	Irrigation area
C6	Between Chao Phraya and Lopburi River	89	Irrigation area
C7	Between Chao Phraya and Lopburi River	166	Irrigation area
C8	Between Chao Phraya and Noi River	99	Irrigation area
	Total	1,055	

3. Retention Area Proposed by RID in 2012

Retention Area	Location	Area (km²)	Remark
U1	Left bank of Nan River	387	Naresuan Dam Irrigation Area and outside irrigation area
U2	Between Yom River and Nan River	671	Irrigation area
U3	Right bank of Yom River	261	Outside irrigation area
U4	Chao Phraya、Nan River	591	Outside irrigation area
L1	Left bank of Chao Phraya River	686	Irrigation area
L2	Between Chao Phraya and Lopburi River	426	Irrigation area
L4	Between Chao Phraya and Noi River	413.88	Irrigation Area
Total		3,435.9	

SECTOR K: ANNEX-2 Flood Mark Survey

ANNEX-2

1 FLOOD MARK SURVEY

1.1 Summary

The field survey was conducted from March to June 2012 and collected information of flood level, depth/duration, flow velocity and impacts in each grid (2 km x 2 km) of the inundation area in the Chao Phraya River Basin. The total survey area and survey sites are about 24,000 km^2 and 6,699 sites respectively and the questionnaires were conducted at 2,800 sites.

1.1.1 Objective of the Survey

The objective of the survey is to collect data and information from the actual inundation area of the 2011 floods in the Chao Phraya River Basin in order to utilize them as basic information for a preparation of food analysis.

1.1.2 Coverage of the Survey and Selection of Survey Sites

The survey area covered the estimated inundation area of the 2011 floods. The survey was conducted by sub-contract after training of the surveyors at the actual survey sites. Selection of survey sites were instructed as follows:

1. Appropriate wide level land.
2. Easy access by car like road, school ground, parking space of public building, precincts of temple, big garden, park, dry paddy field or wasteland with no glass near the road, etc.
3. Flood marks should exist in or near the sites.
4. Survey site should not be selected more than one site at one grid (2 km x 2 km) of the grid map provided.
5. All survey sites should be at appropriate distance from each other among the survey sites.
6. If there is not the site descried above in the grid, such grid is able to be skipped from the survey.
7. Estimated numbers of survey sites were about 6000 points.

1.1.3 Methodology

The survey was conducted due to the following methods:
1. To record the coordinates of survey positions by a handheld GPS at the center of each survey site in the record sheet prepared by the Study Team.
2. To record the height of the flood mark and the inundation survey site.
3. To take photos of surrounding conditions of interview locations.
4. To collect and compile the results of questionnaires to electric file (Microsoft Excel version 2003)
5. To send daily the coordinates of inundation survey positions to the Study Team.

1.1.4 Analysis

The survey data have been compiled as inundation maps and utilized as reference data for the flood analysis

1.1.5 Evaluation

The survey is assessed as follows:
- The survey results have provided the study with the data/information of actual conditions and situations locally in the inundation area.
- The survey data/information are base for the further surveys for the inundation area.

1.1.6 Survey Area and Survey Point

The survey area and survey point are shown as follows:

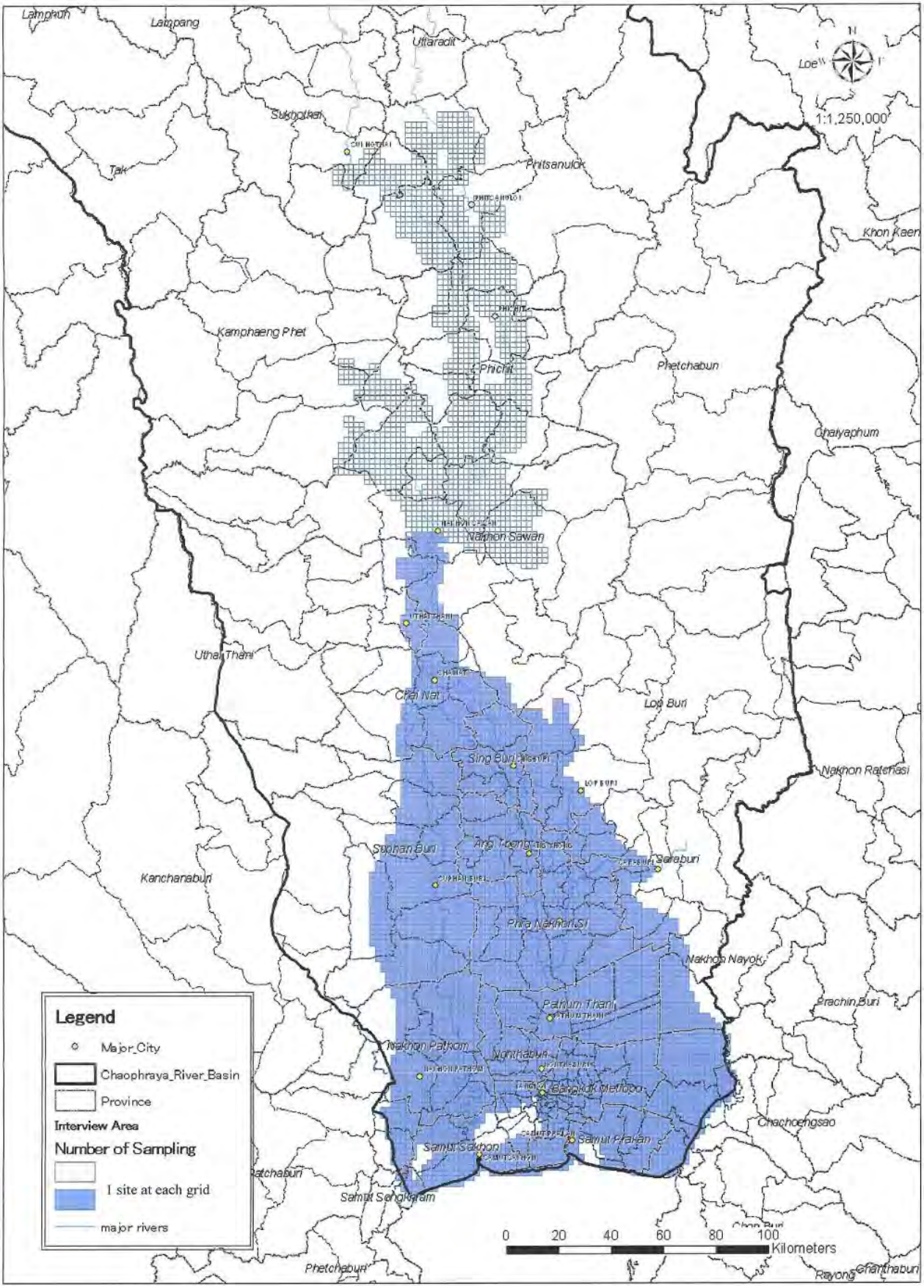


Figure1 Comparison between Flood Mark Survey and GISTDA Data during 2011 Flood

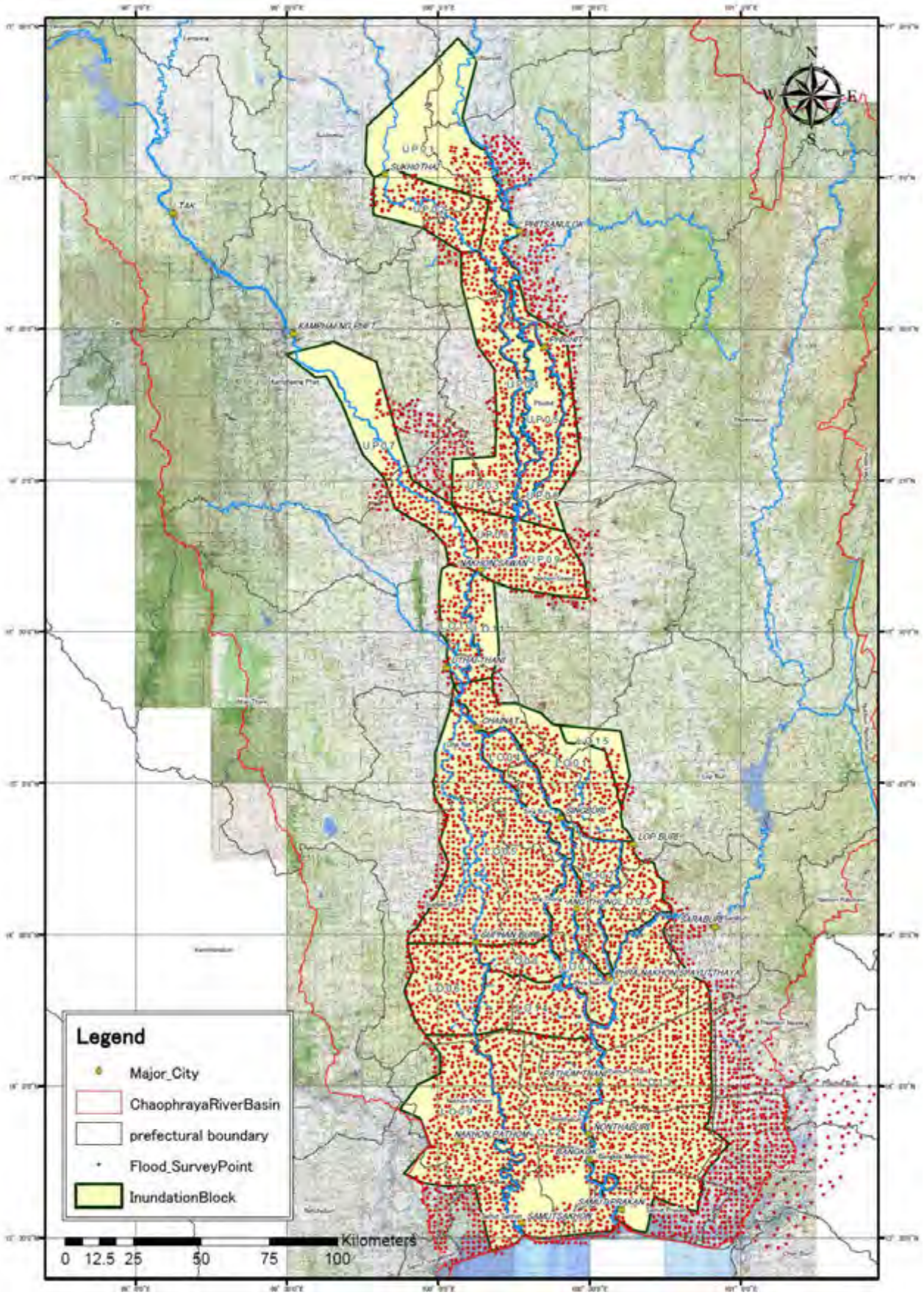


Figure2 Flood Mark Survey Point

2 RESULTS OF FLOOD MARK SURVEY

2.1 Inundation Area

Comparison between flood mark survey during 2011 flood and GISTDA Data are shown as follows:

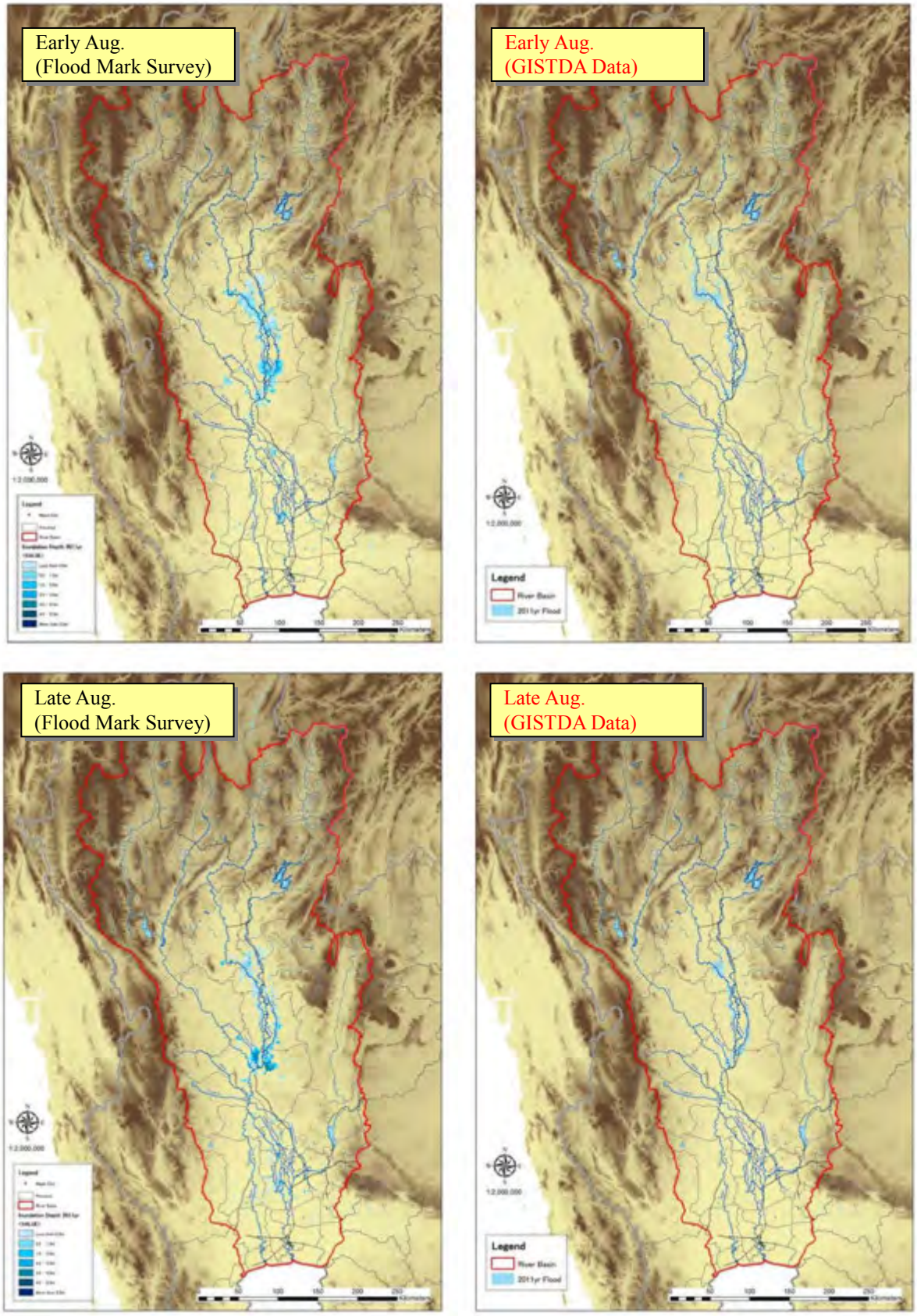


Figure3 Comparison between Flood Mark Survey and GISTDA Data during 2011 Flood (1/4)

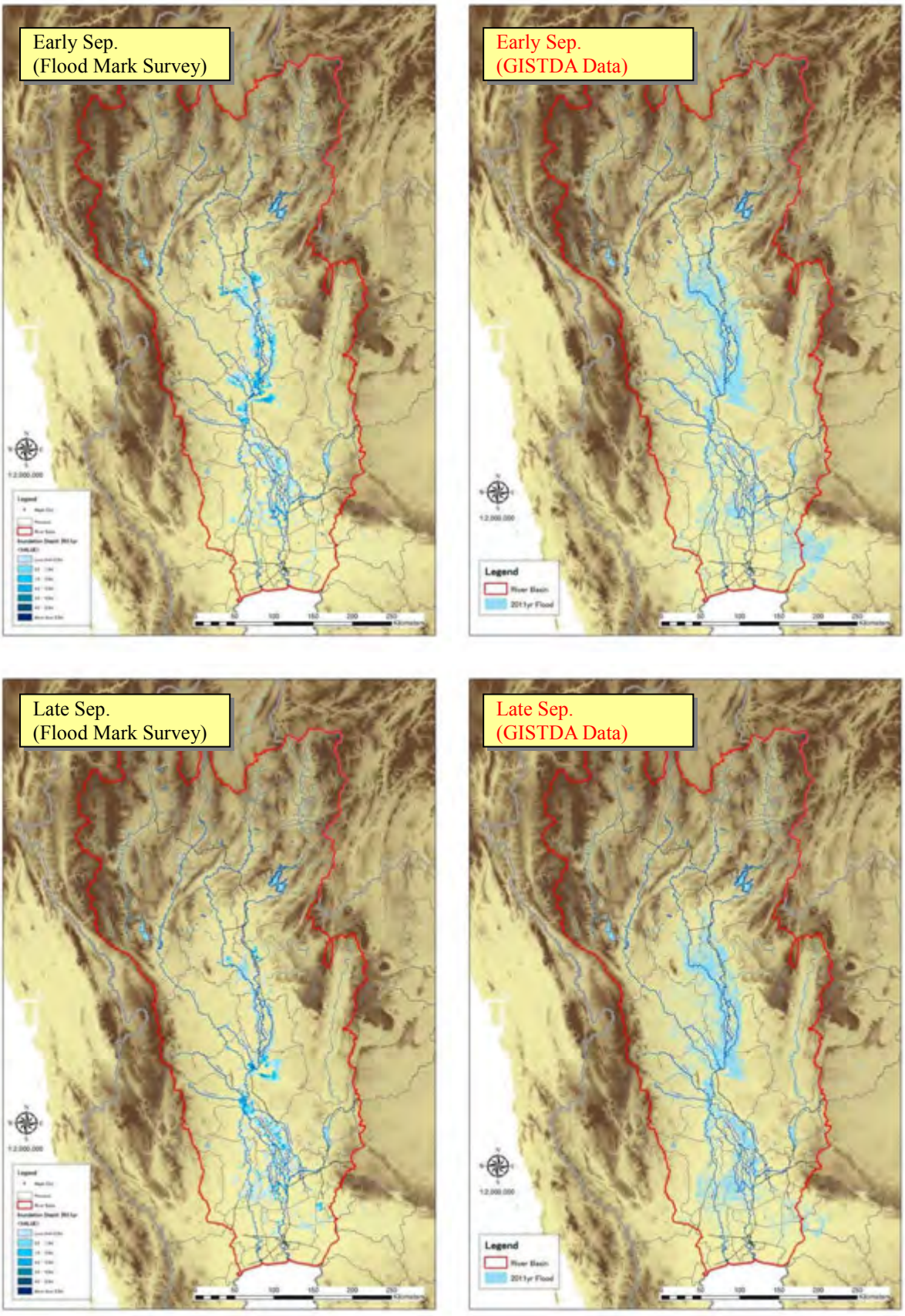


Figure4 Comparison between Flood Mark Survey and GISTDA Data during 2011 Flood (2/4)

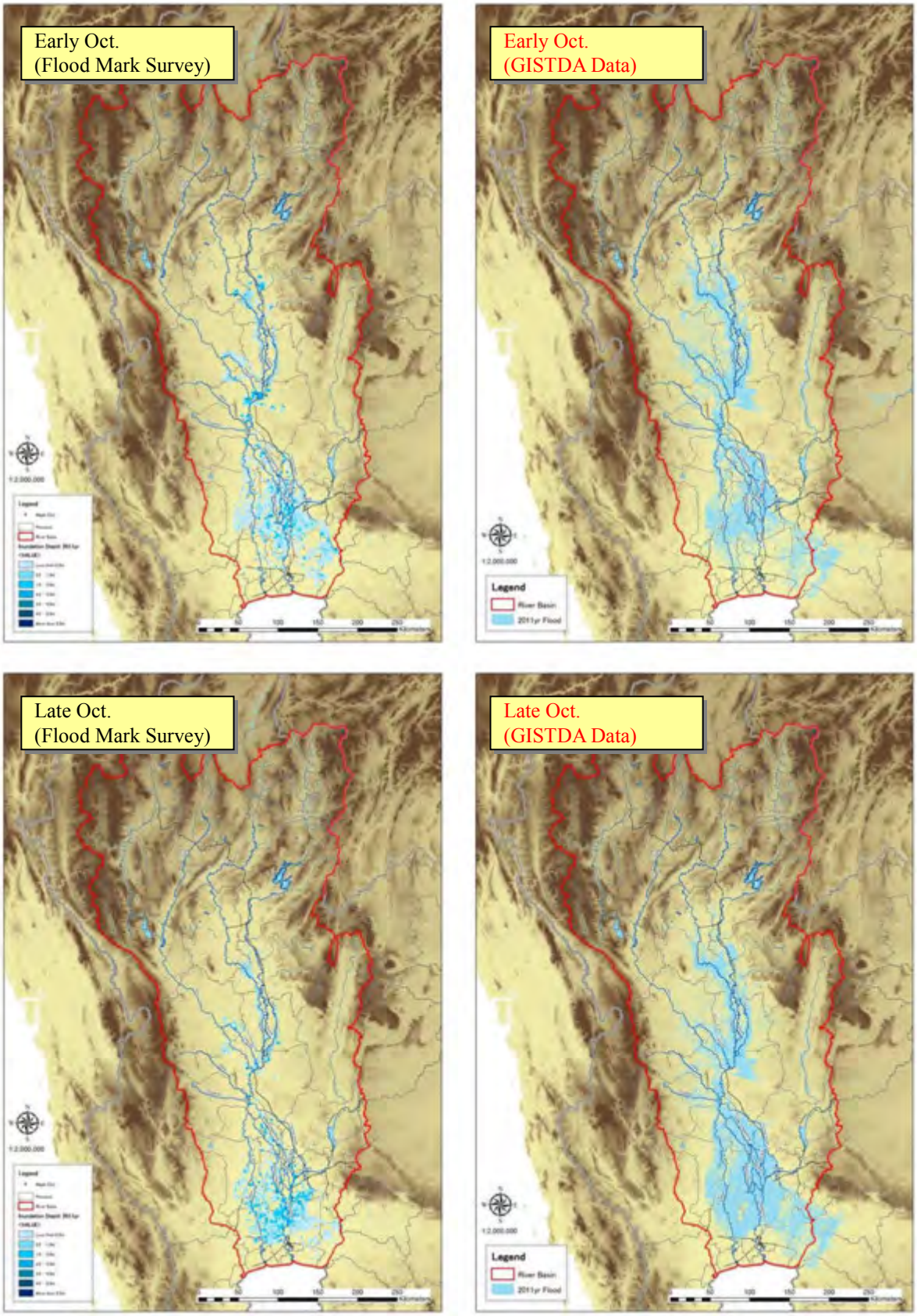


Figure5 Comparison between Flood Mark Survey and GISTDA Data during 2011 Flood (3/4)

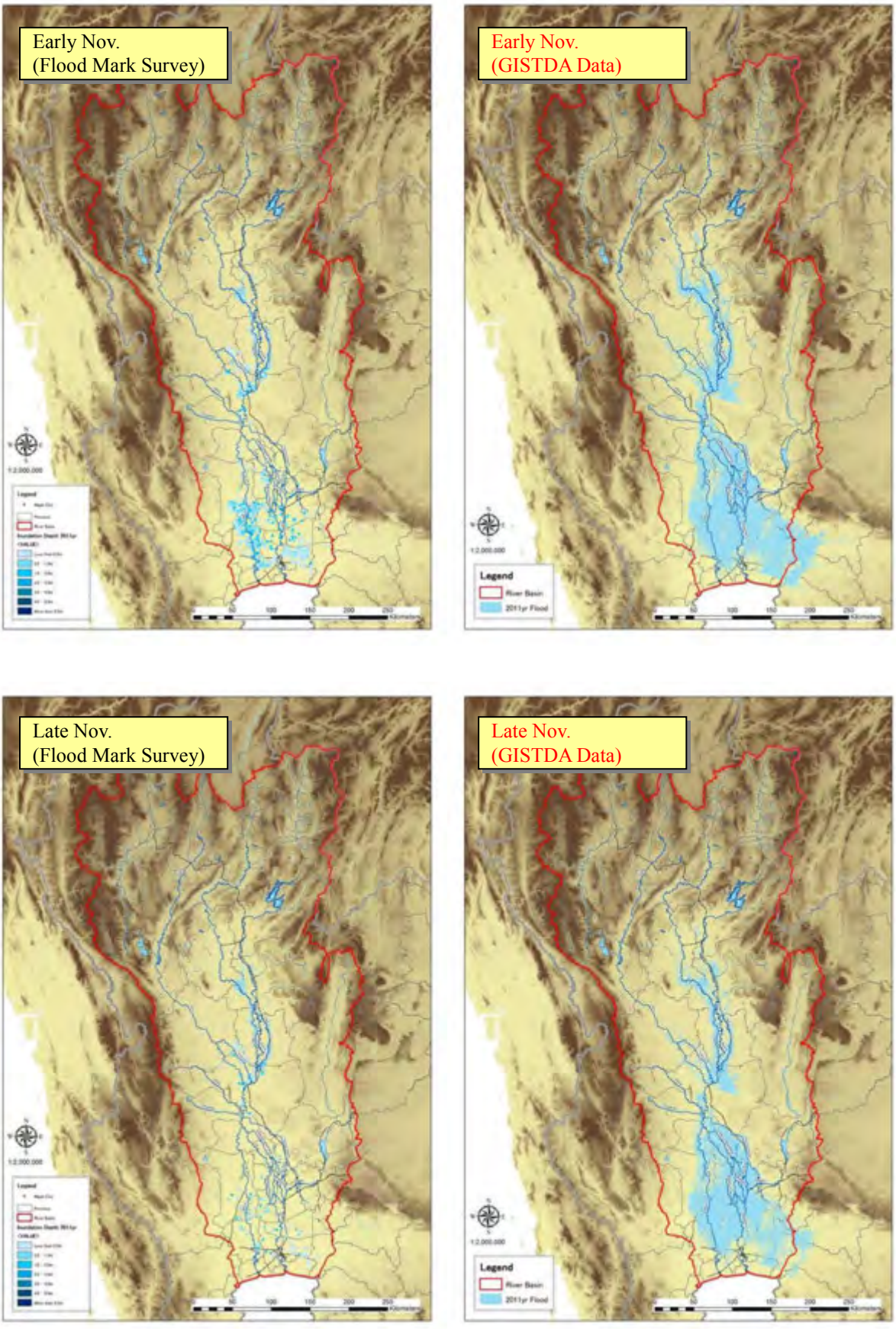


Figure6 Comparison between Flood Mark Survey and GISTDA Data during 2011 Flood (4/4)

2.2 Inundation Volume

Comparison of inundation volume between simulation (Case 0 with Rainfall, Reproduction of 2011 flood) and flood mark survey after 2011 flood are shown as follows:

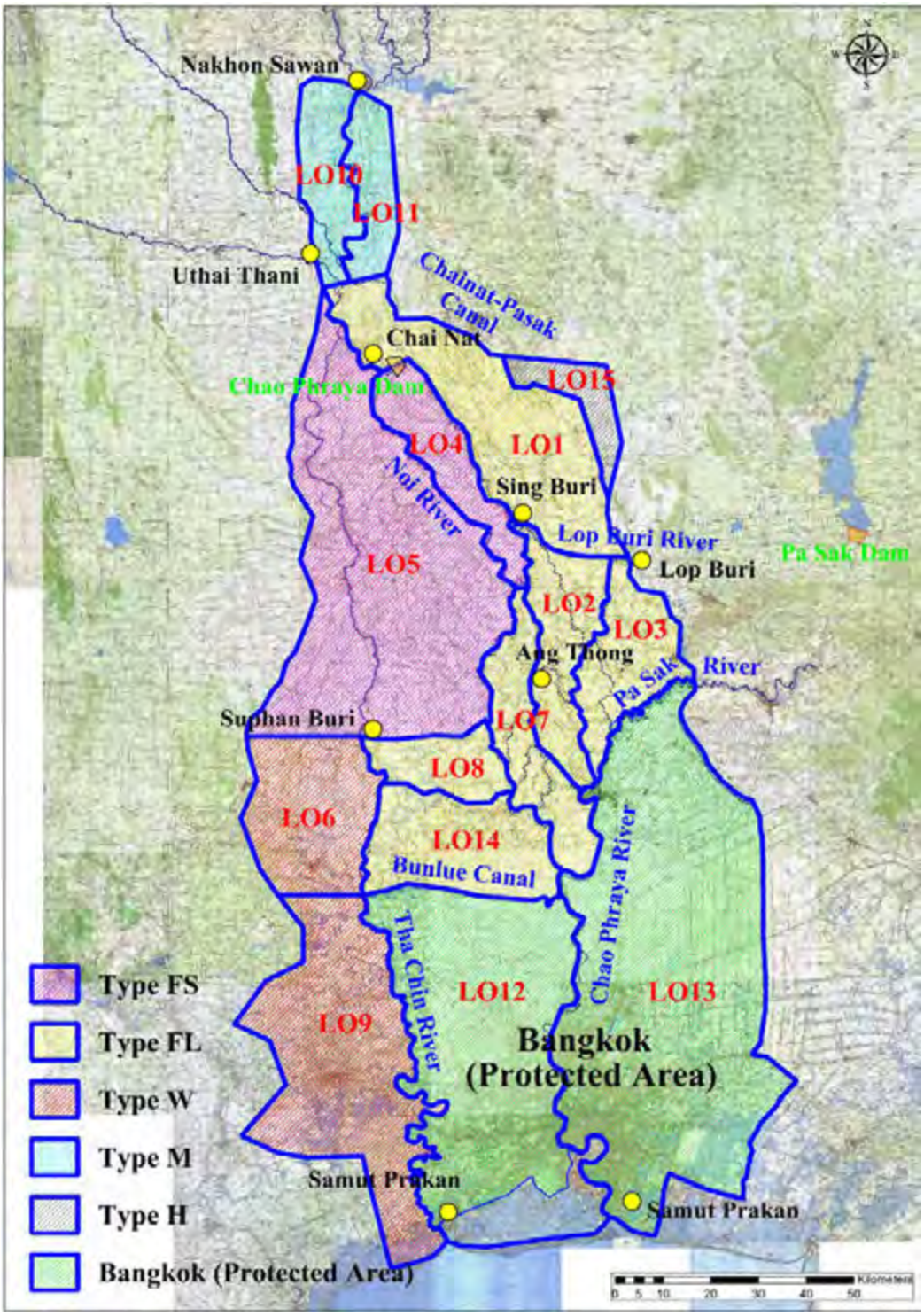


Figure7 Subdivisions of Assumed Inundation Area at Lower Nakhon Sawan

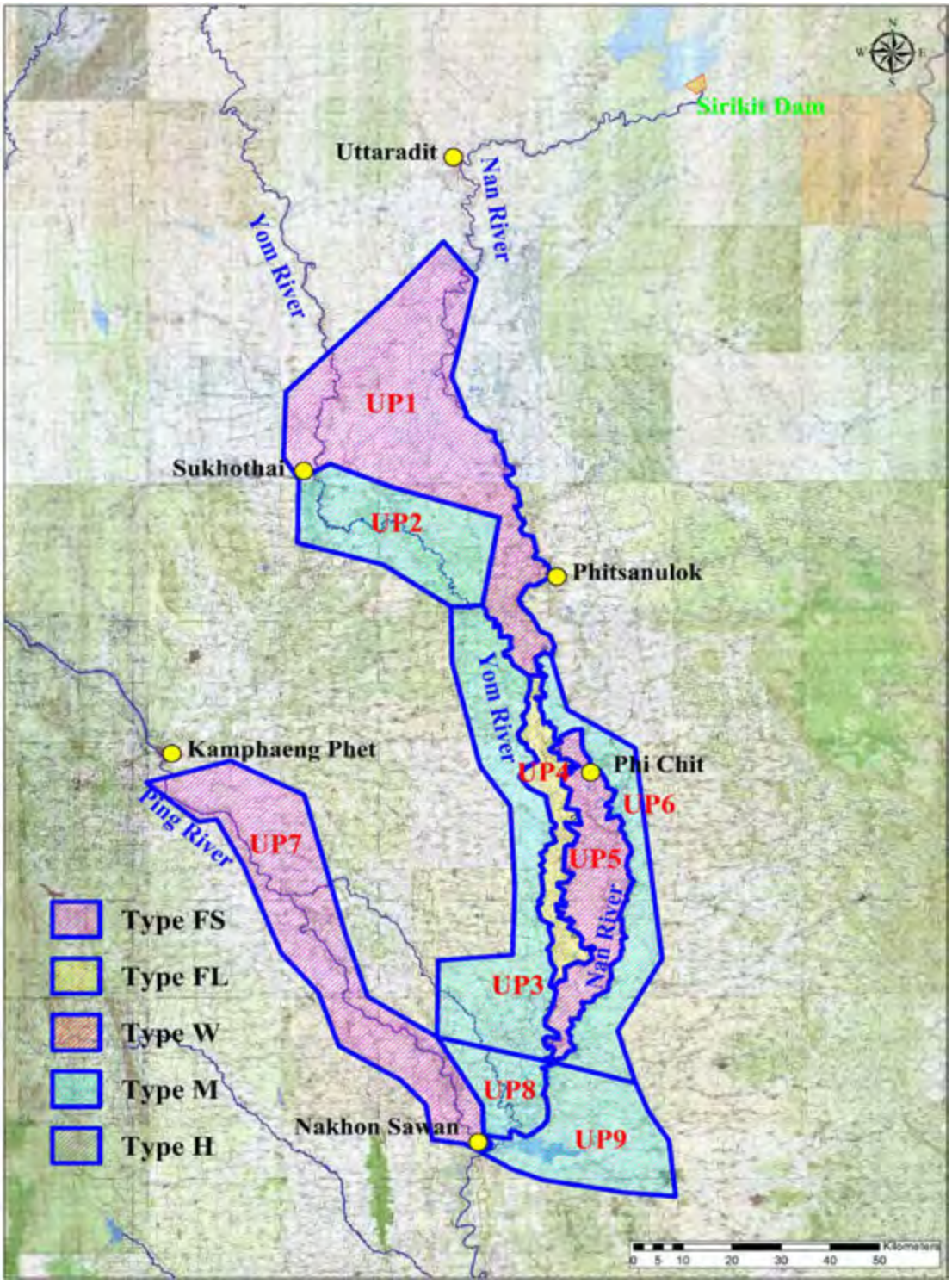
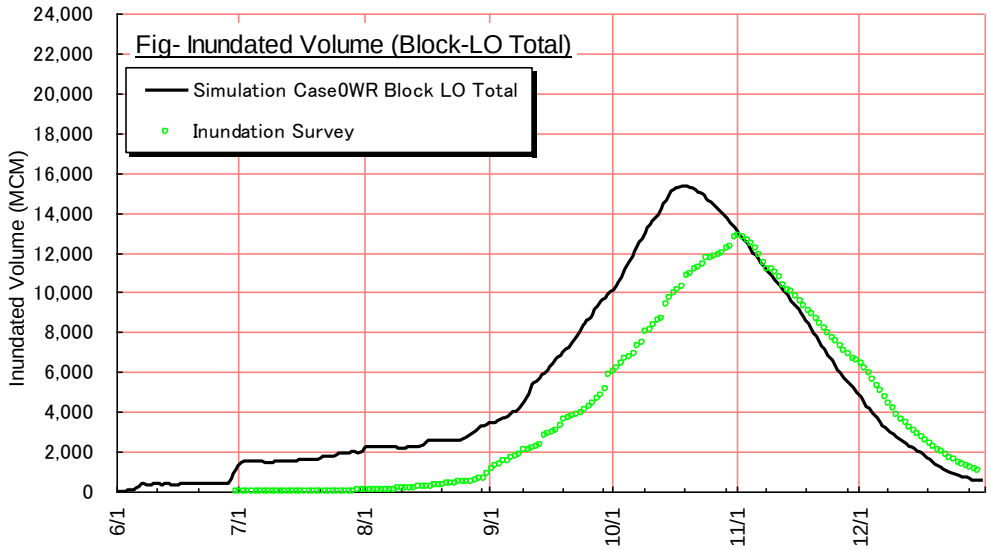
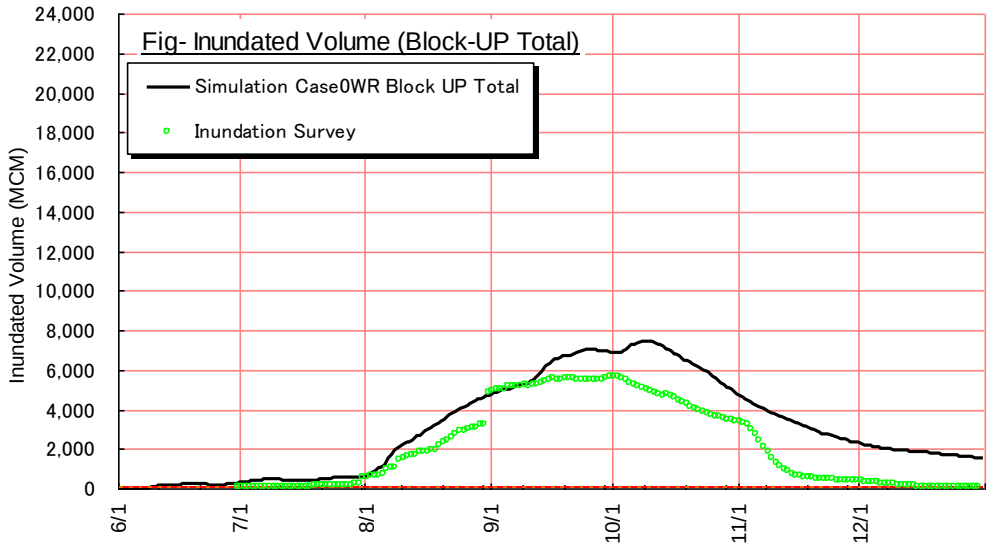


Figure8 Subdivisions of Assumed Inundation Area at Upper Nakhon Sawan





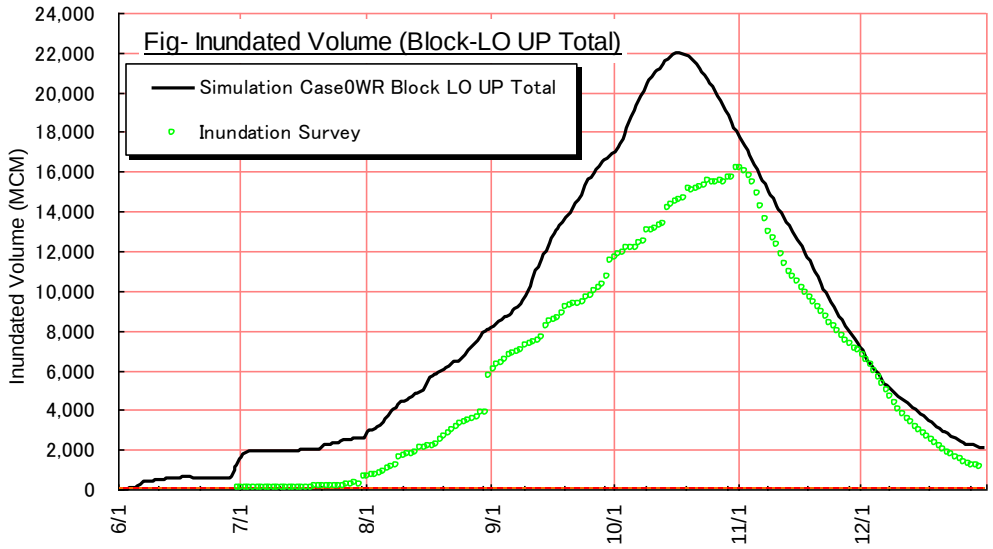


Figure9 Comparison of Total Inundation Volume between Simulation and Flood Mark Survey

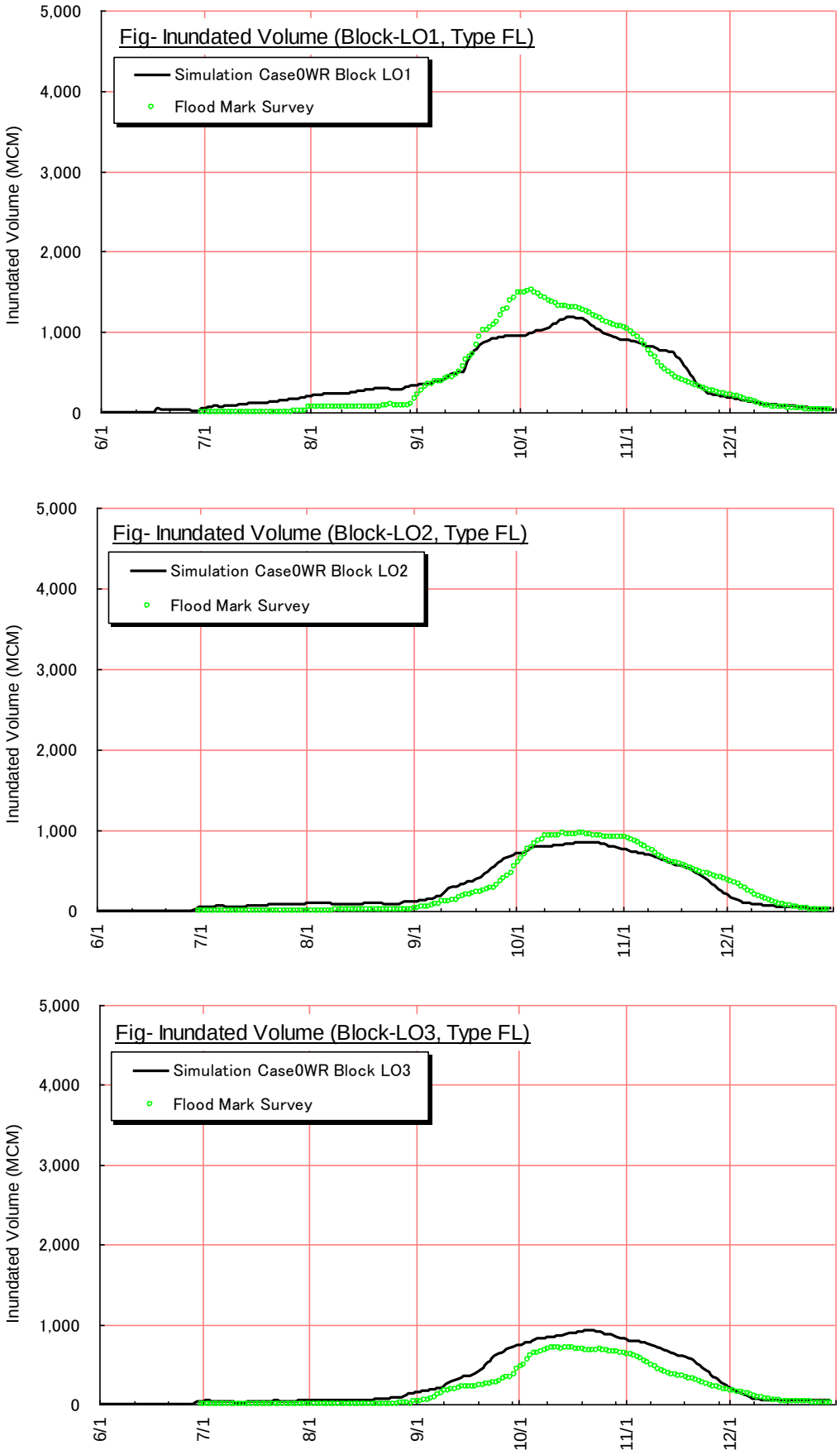


Figure10 Comparison of Inundation Volume between Simulation and Flood Mark Survey (1/8)

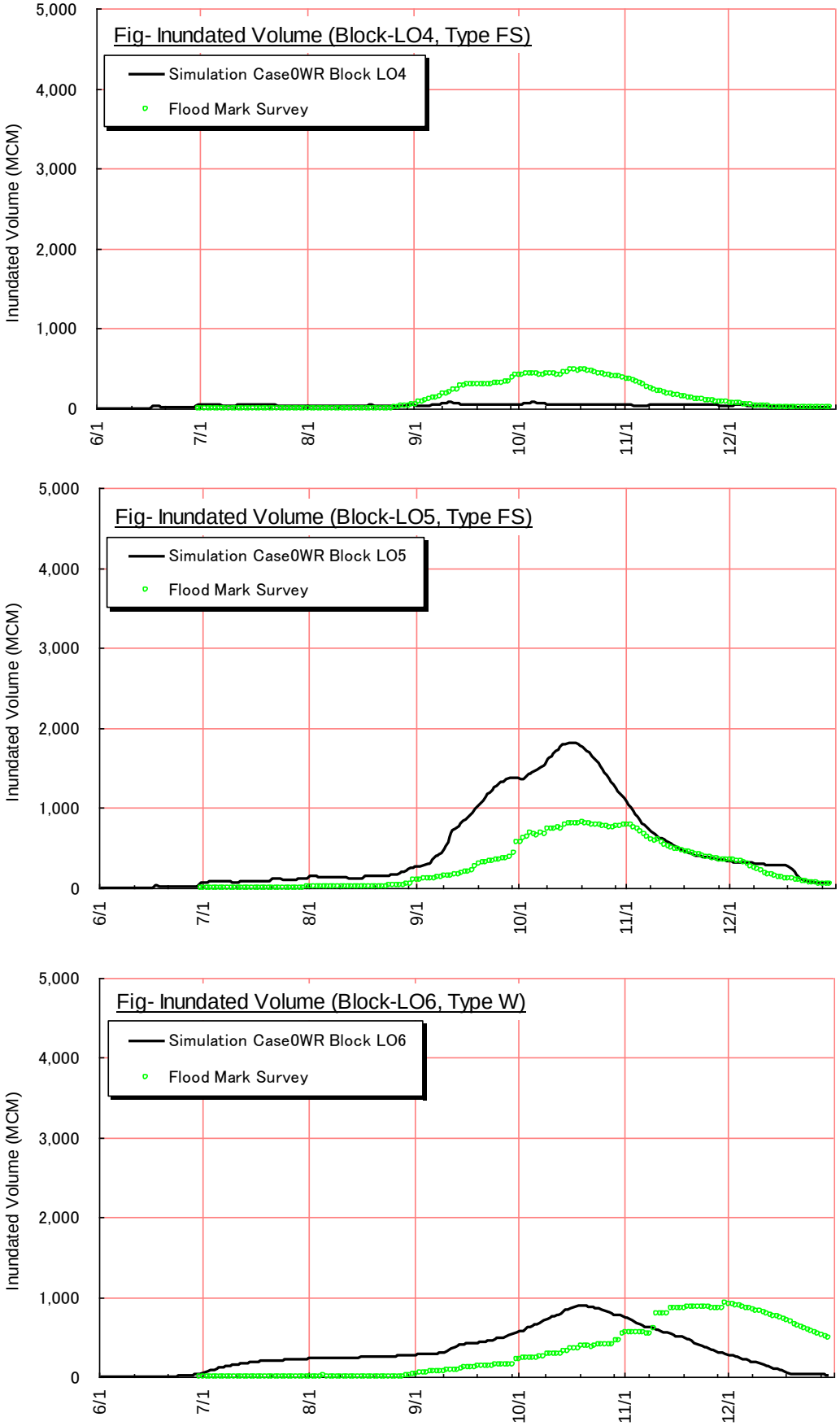


Figure11 Comparison of Inundation Volume between Simulation and Flood Mark Survey (2/8)

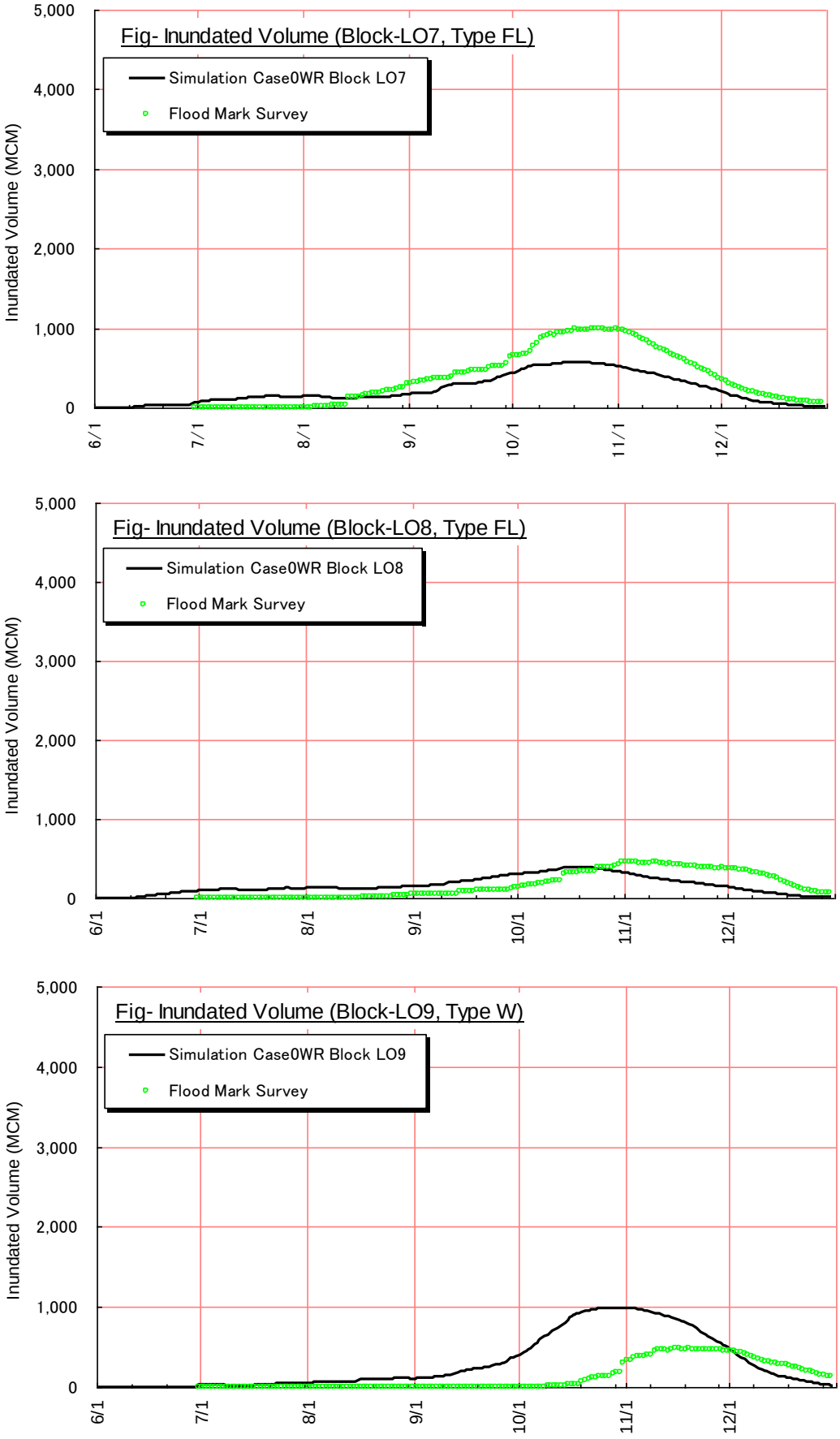
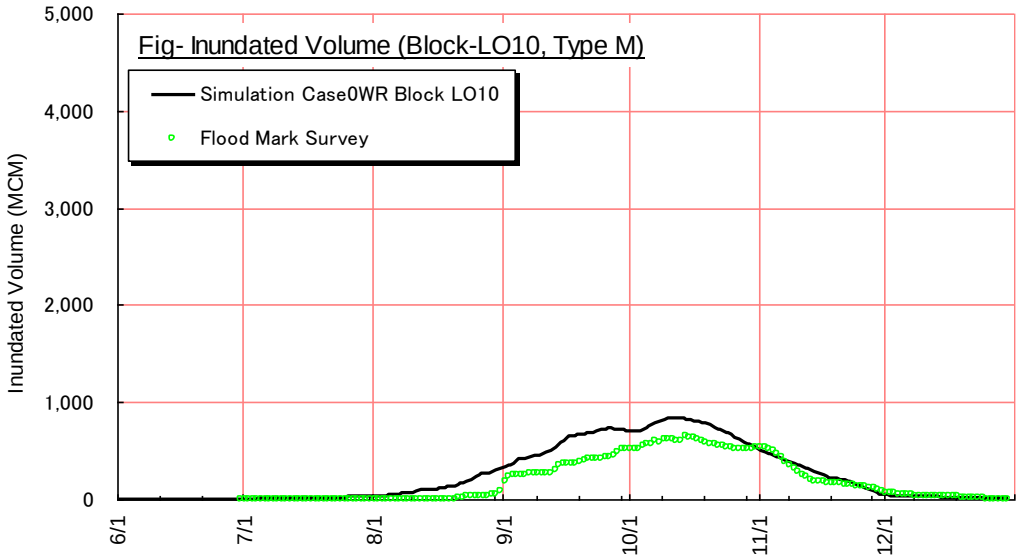
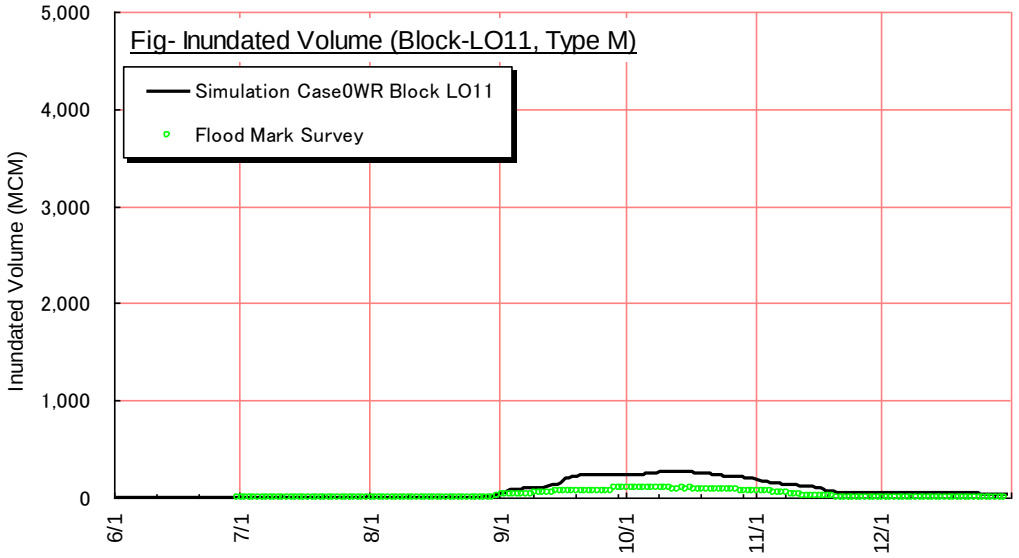


Figure12 Comparison of Inundation Volume between Simulation and Flood Mark Survey (3/8)





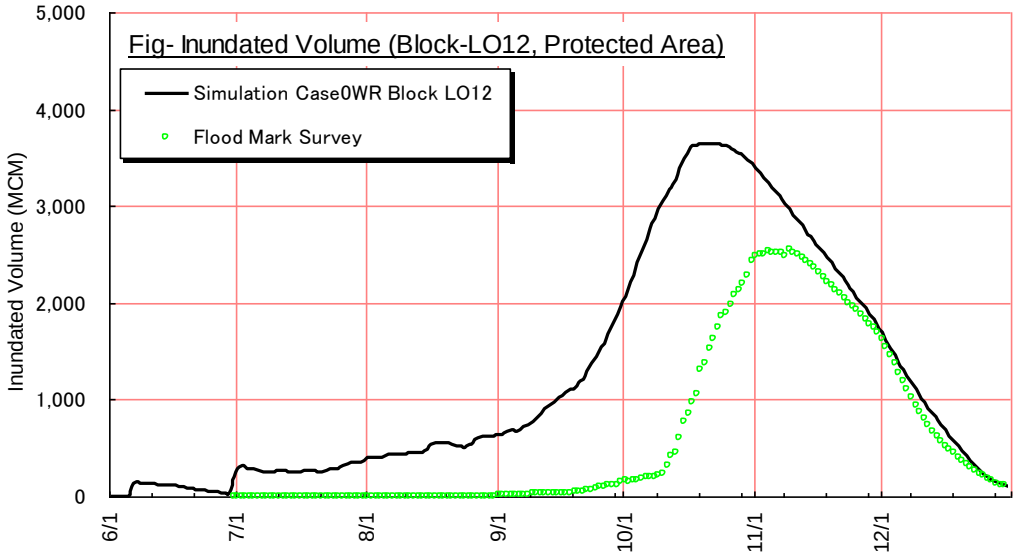


Figure13 Comparison of Inundation Volume between Simulation and Flood Mark Survey (4/8)

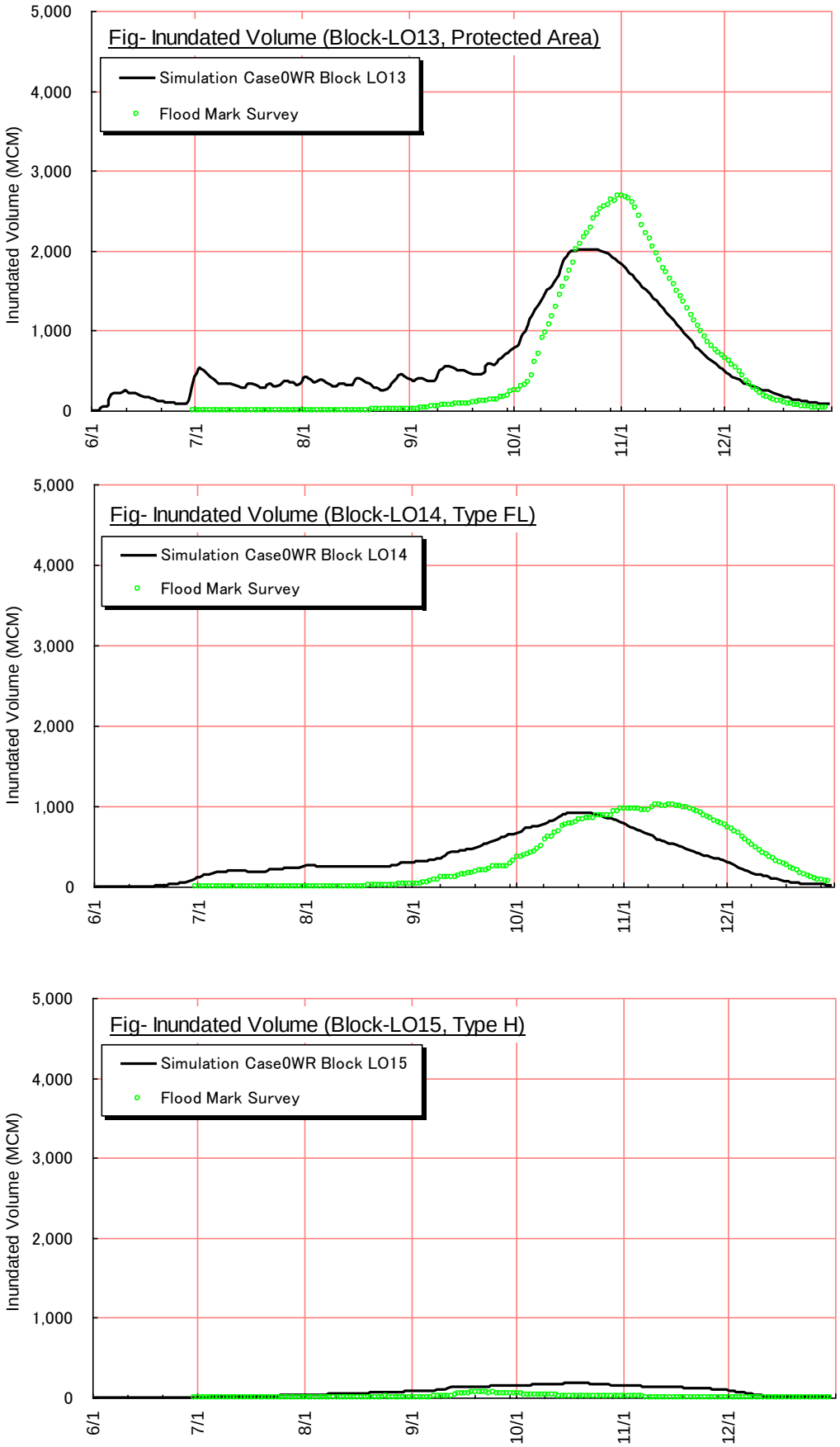


Figure14 Comparison of Inundation Volume between Simulation and Flood Mark Survey (5/8)

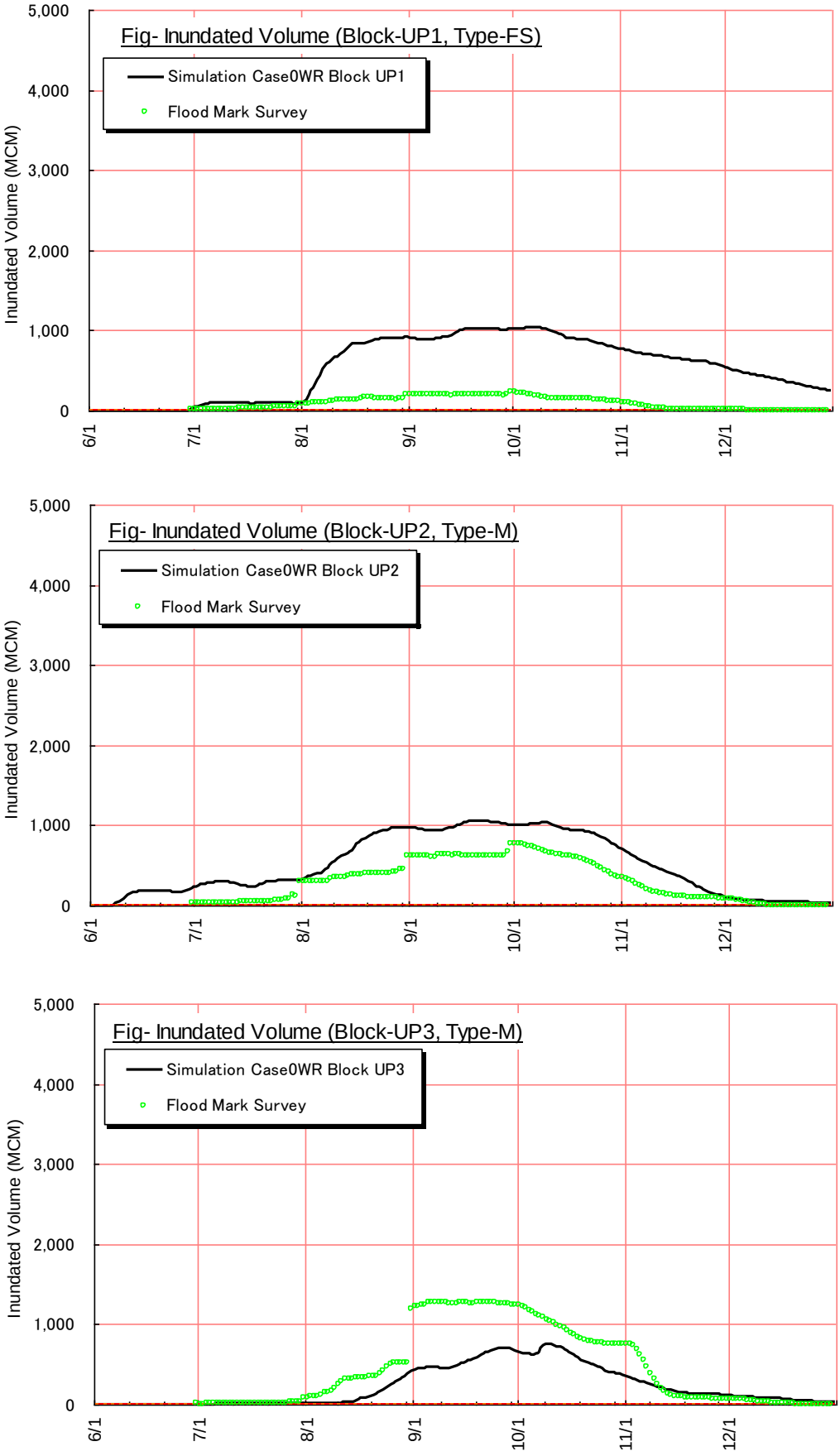


Figure15 Comparison of Inundation Volume between Simulation and Flood Mark Survey (6/8)

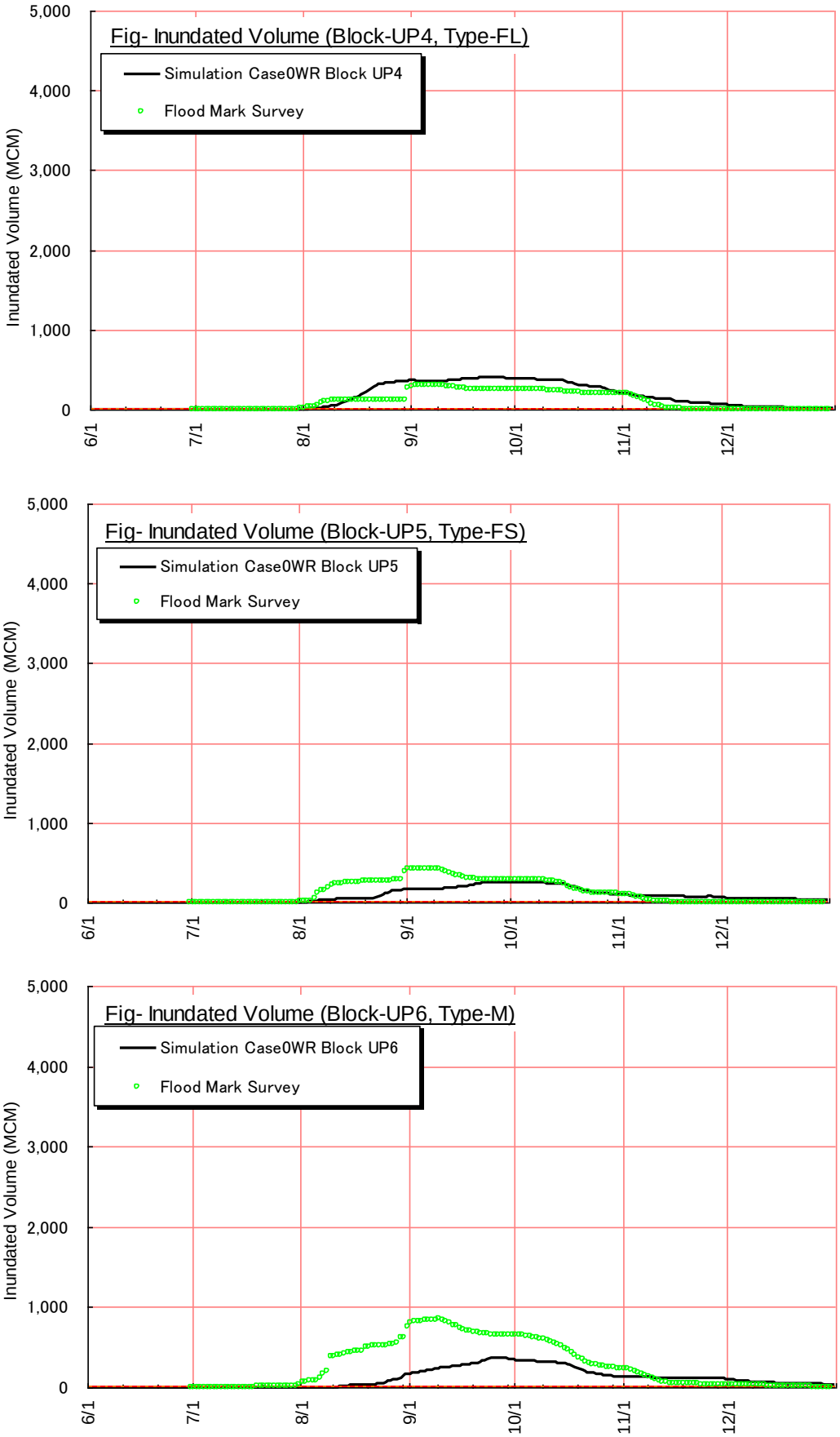


Figure16 Comparison of Inundation Volume between Simulation and Flood Mark Survey (7/8)

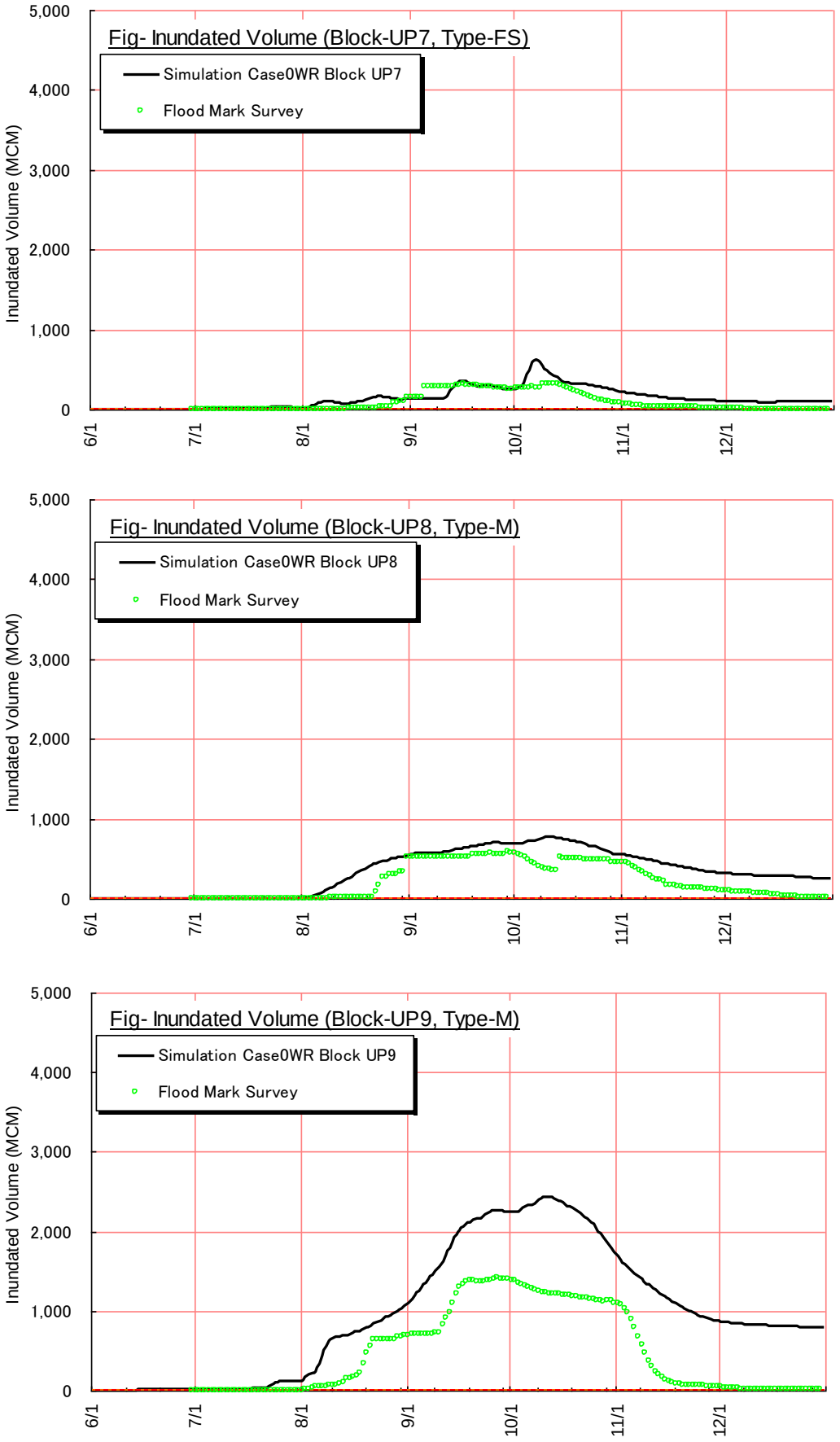


Figure17 Comparison of Inundation Volume between Simulation and Flood Mark Survey (8/8)

2.3 Inundation Depth (Reference)

Comparison of average inundation depth between simulation (Case 0 with Rainfall, Reproduction) and flood mark survey are shown as follows:

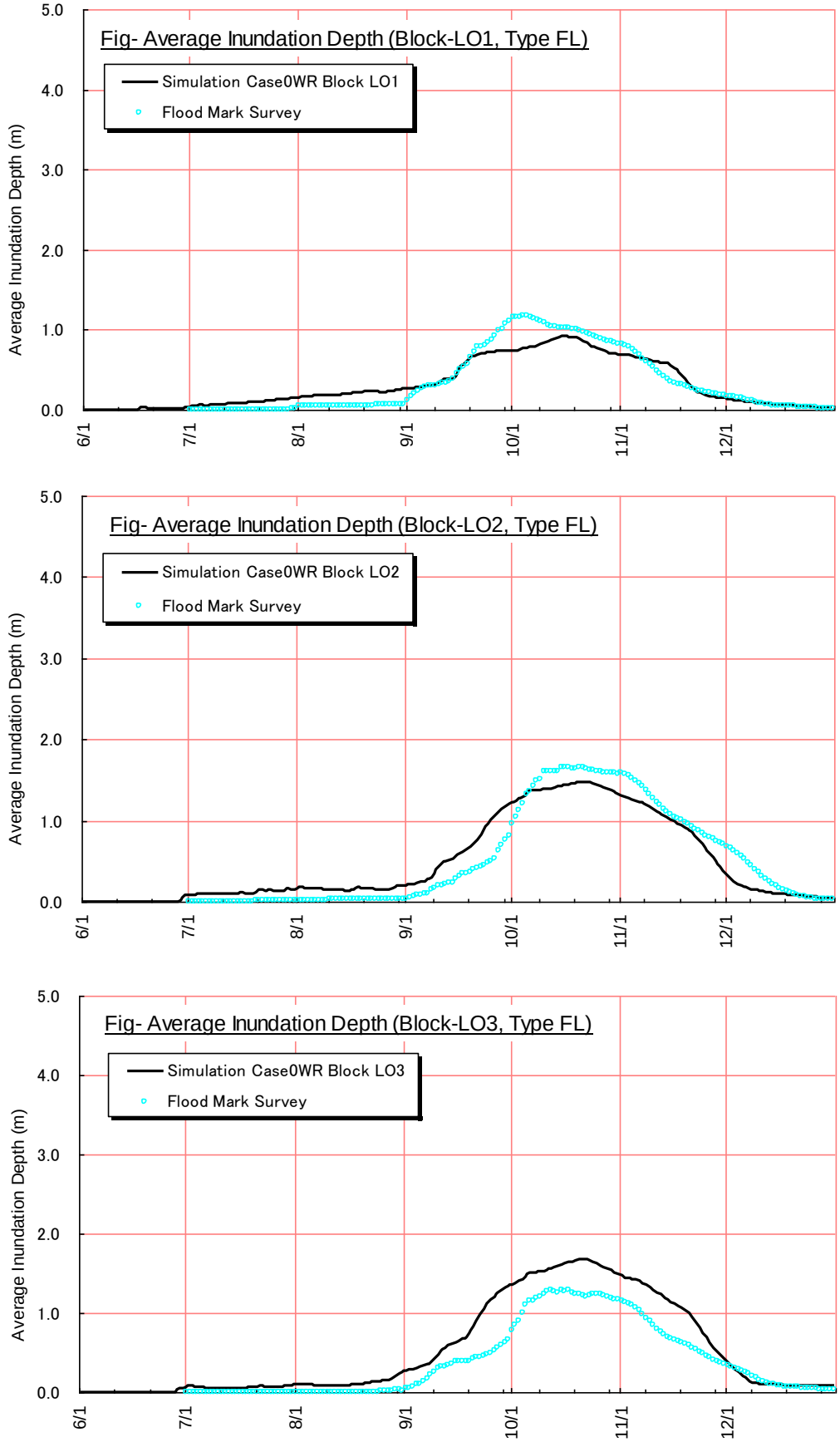


Figure18 Comparison of Inundation Depth between Simulation and Flood Mark Survey (1/8)

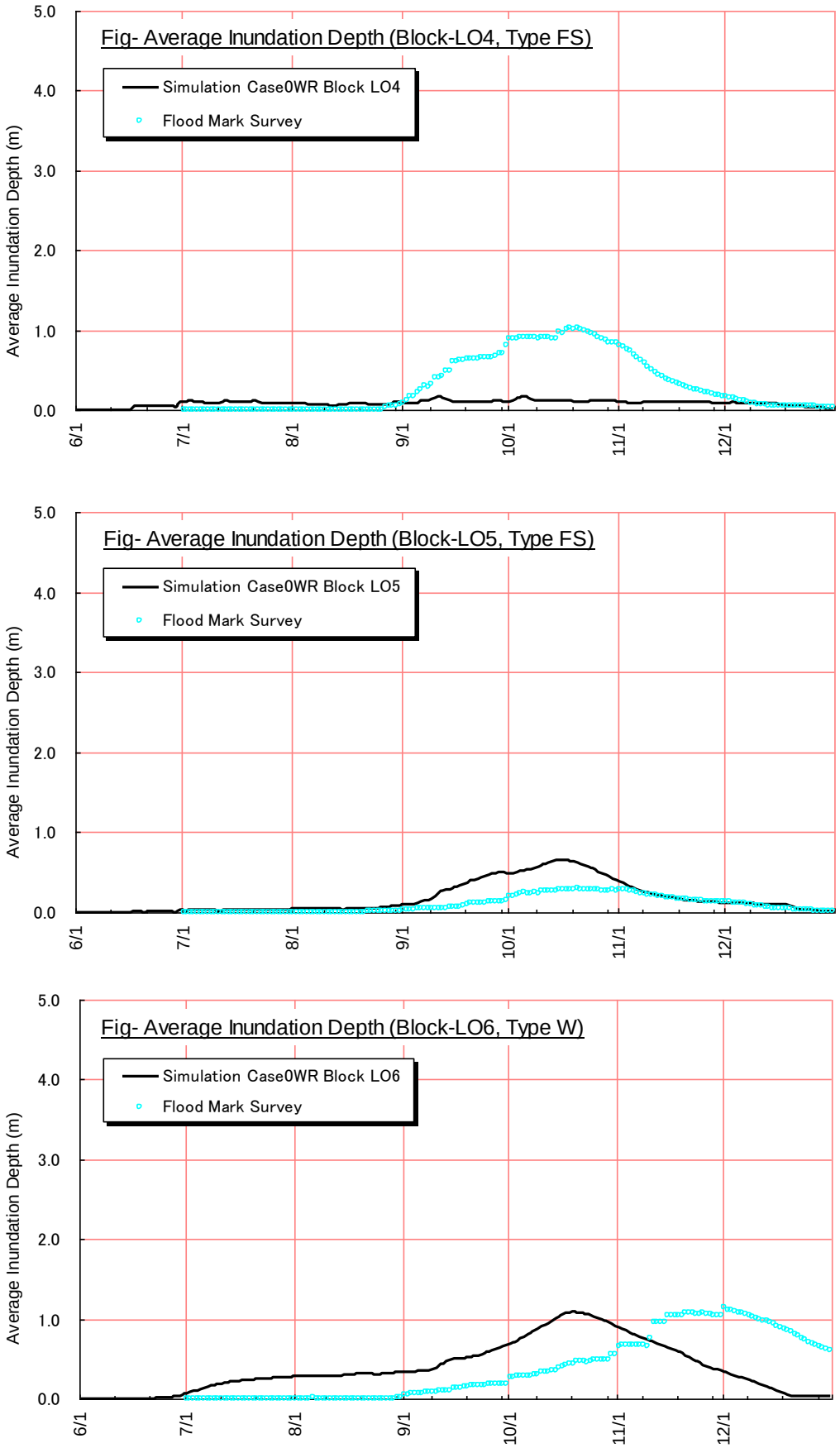


Figure19 Comparison of Inundation Depth between Simulation and Flood Mark Survey (2/8)

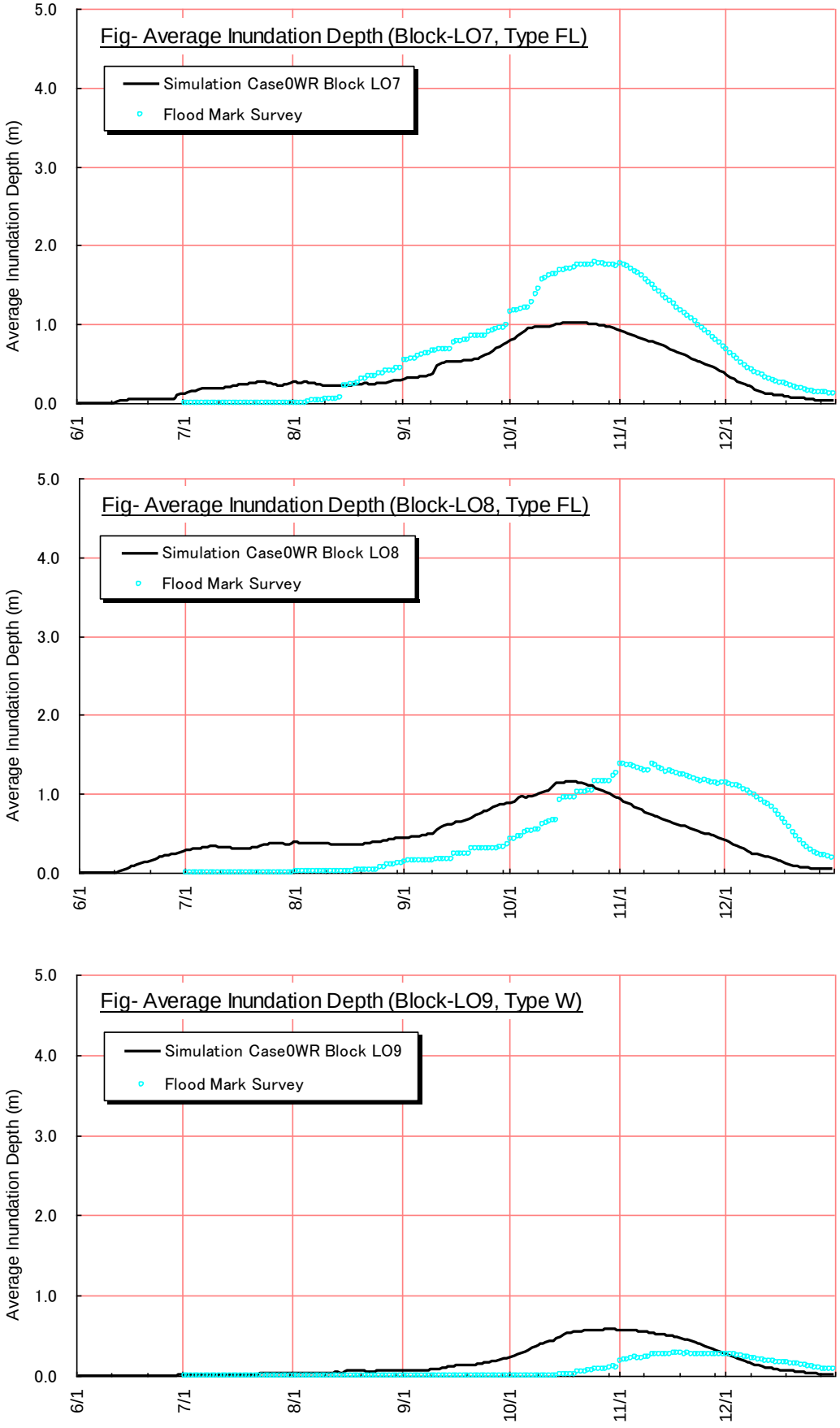
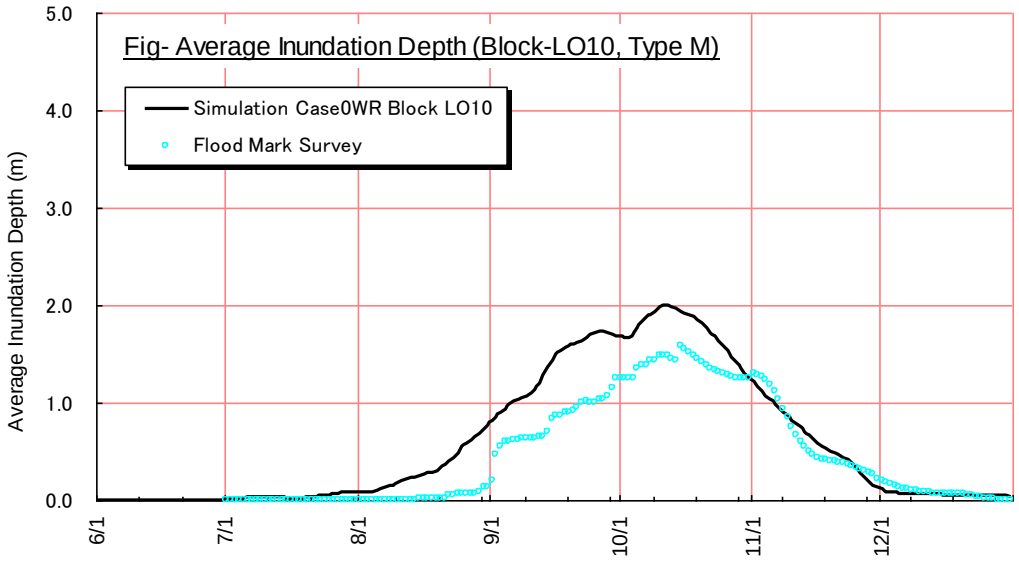
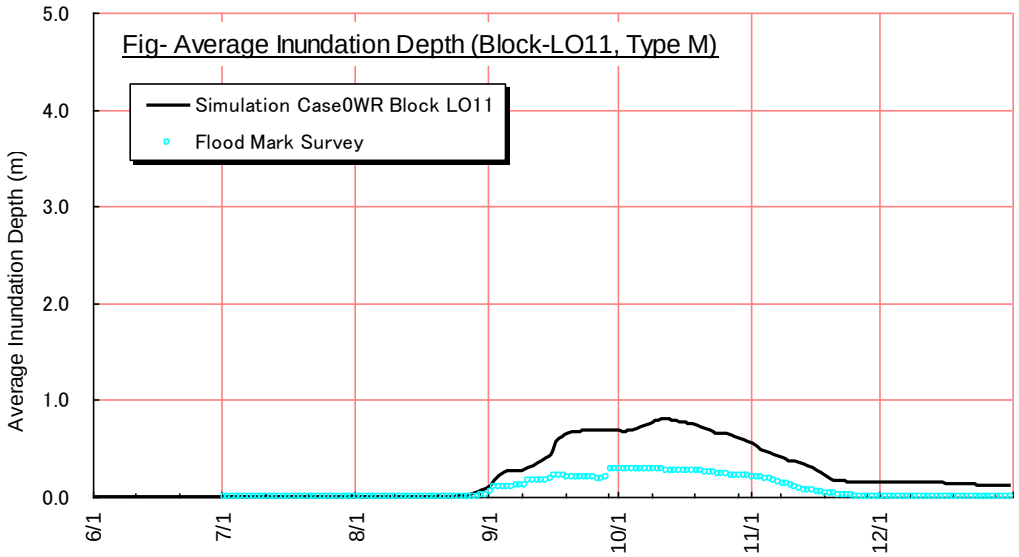


Figure20 Comparison of Inundation Depth between Simulation and Flood Mark Survey (3/8)





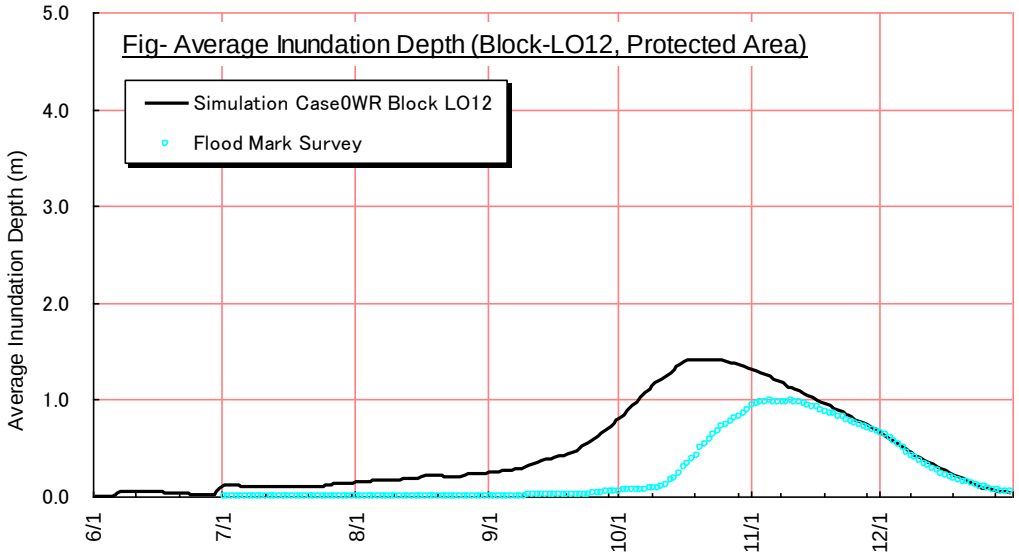


Figure21 Comparison of Inundation Depth between Simulation and Flood Mark Survey (4/8)

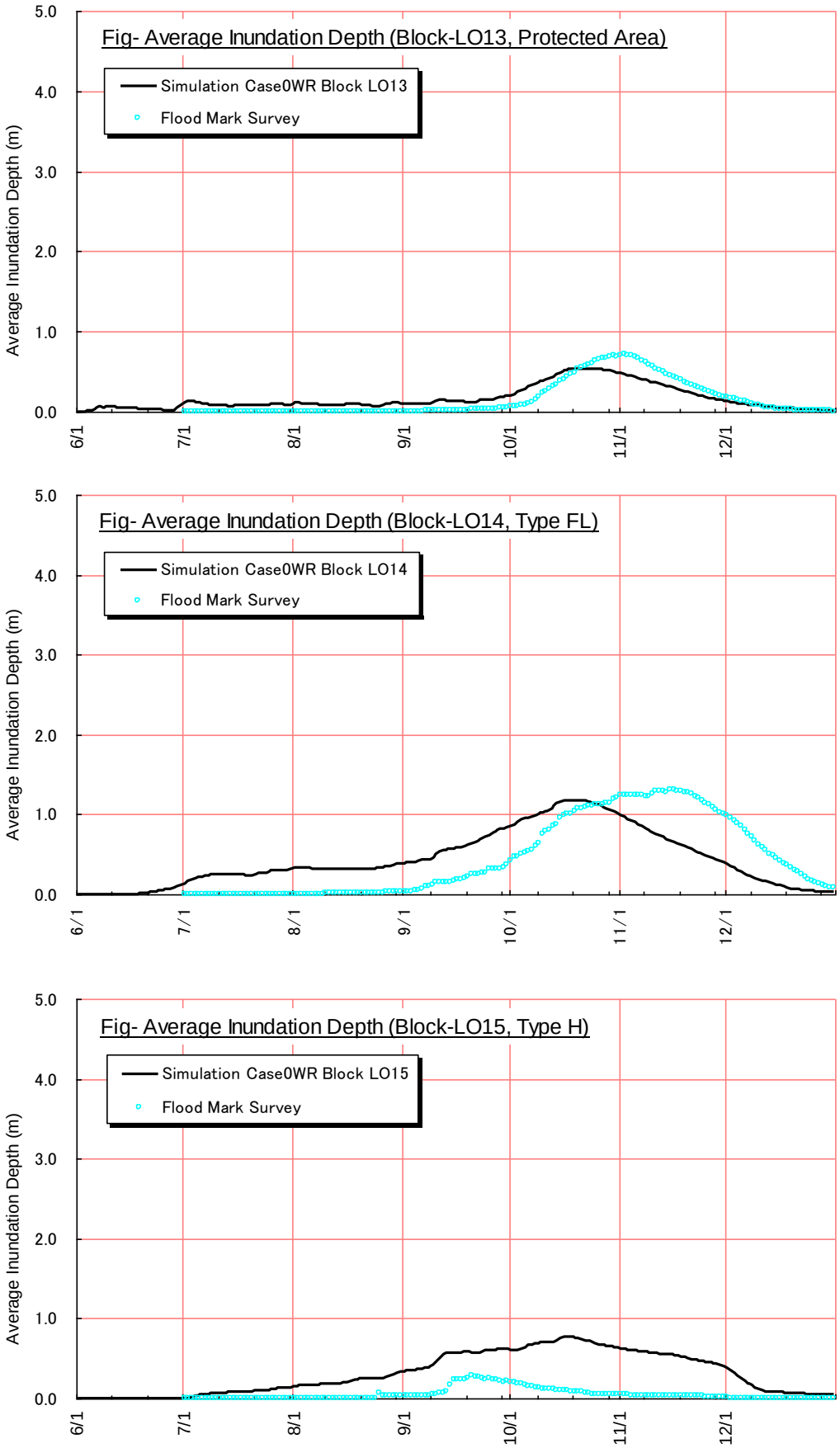


Figure22 Comparison of Inundation Depth between Simulation and Flood Mark Survey (5/8)

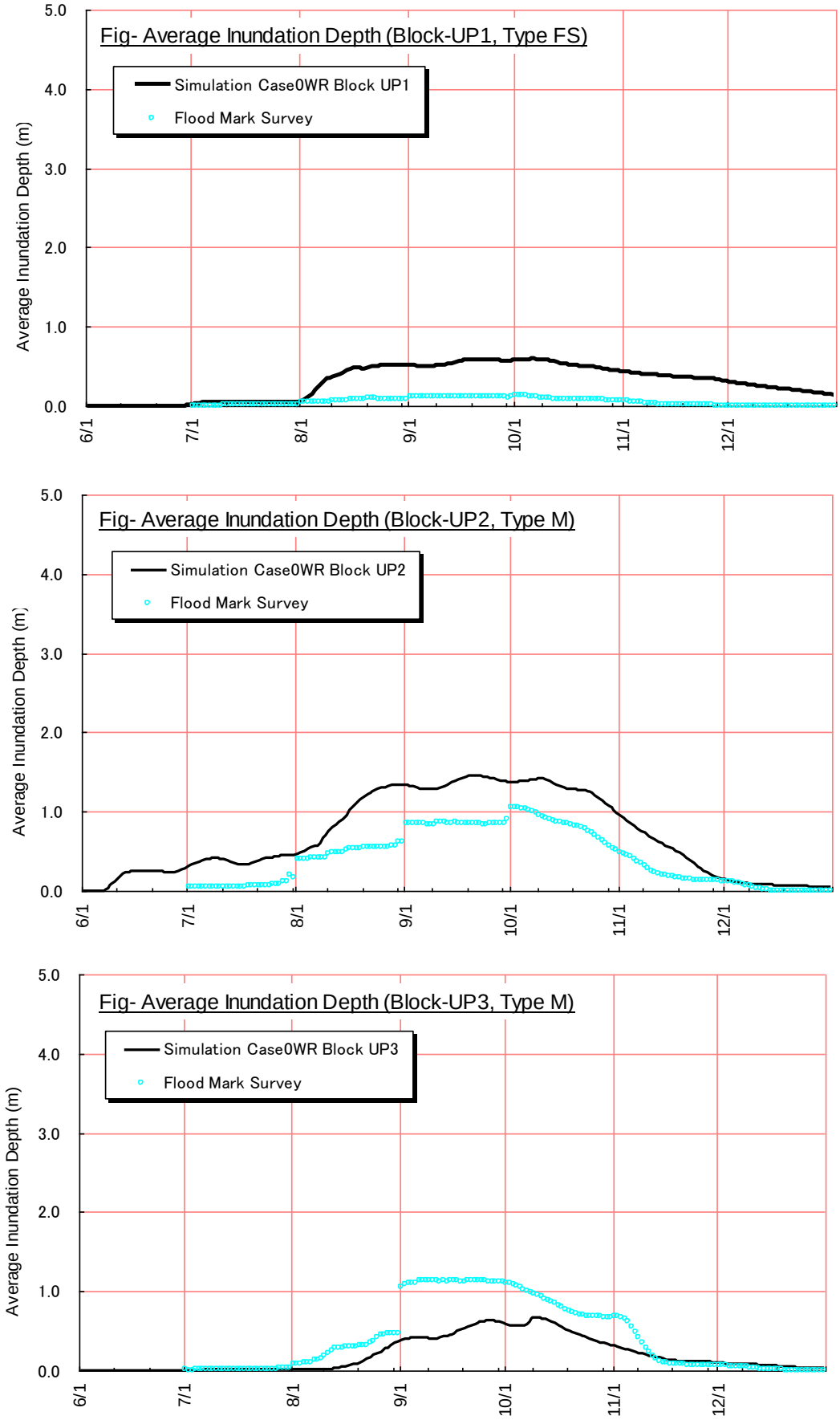
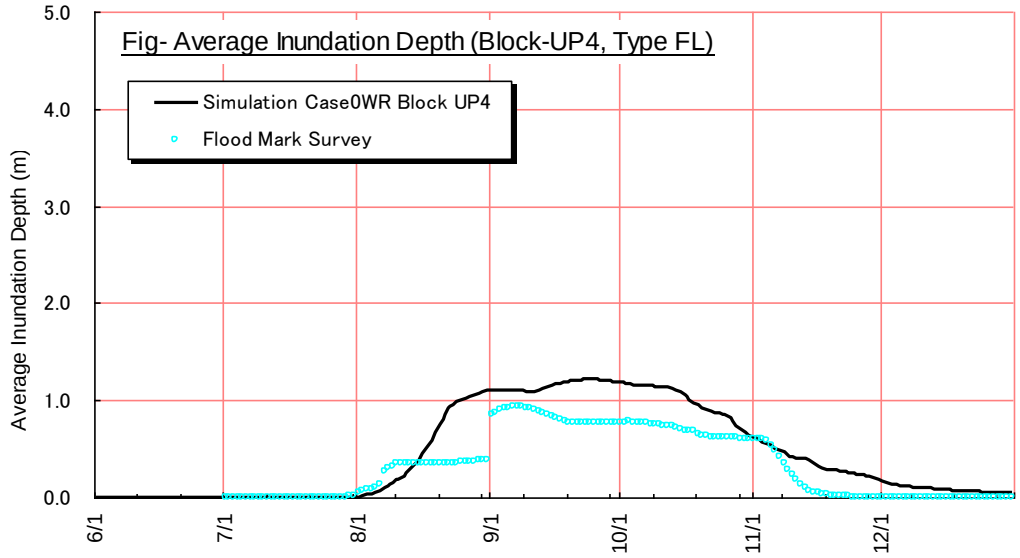
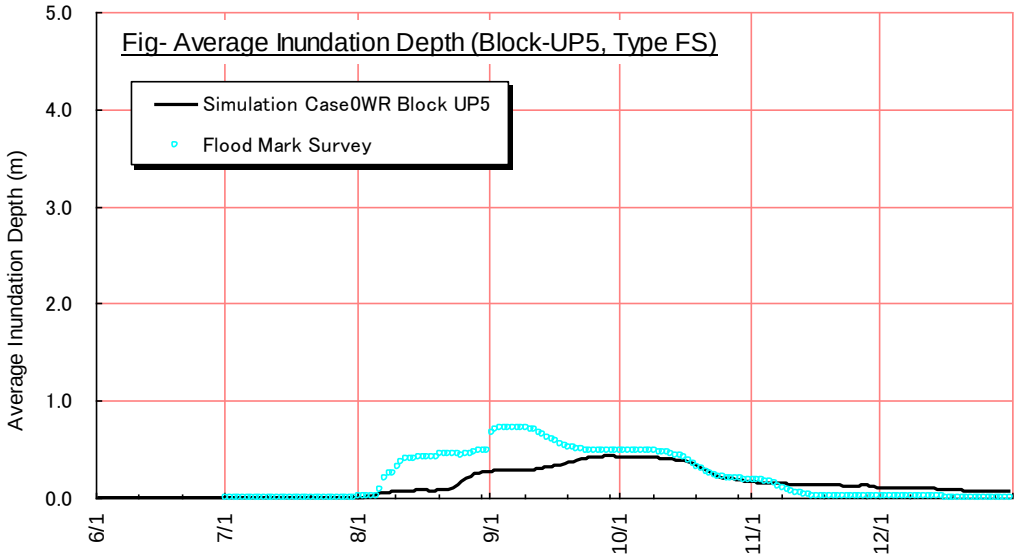


Figure23 Comparison of Inundation Depth between Simulation and Flood Mark Survey (6/8)





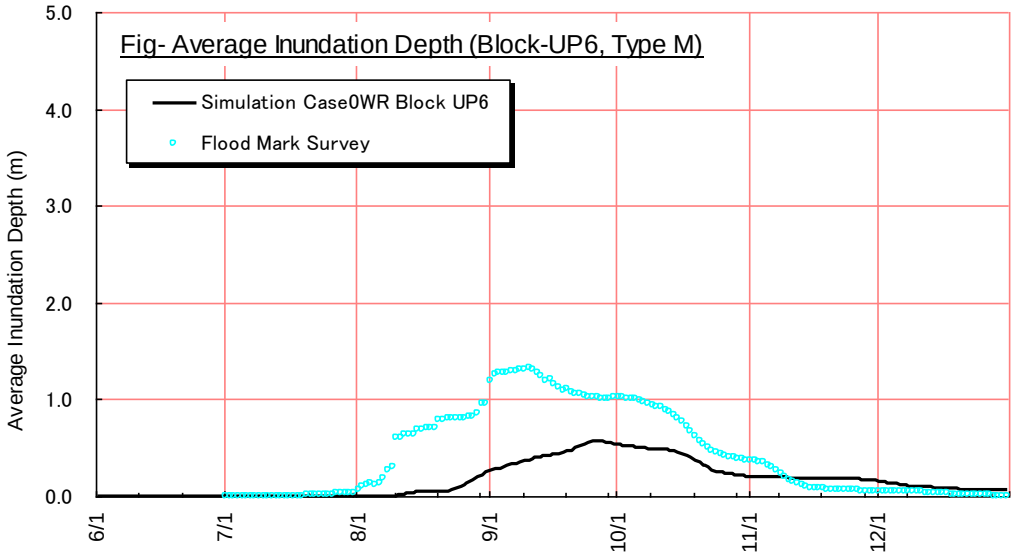


Figure24 Comparison of Inundation Depth between Simulation and Flood Mark Survey (7/8)

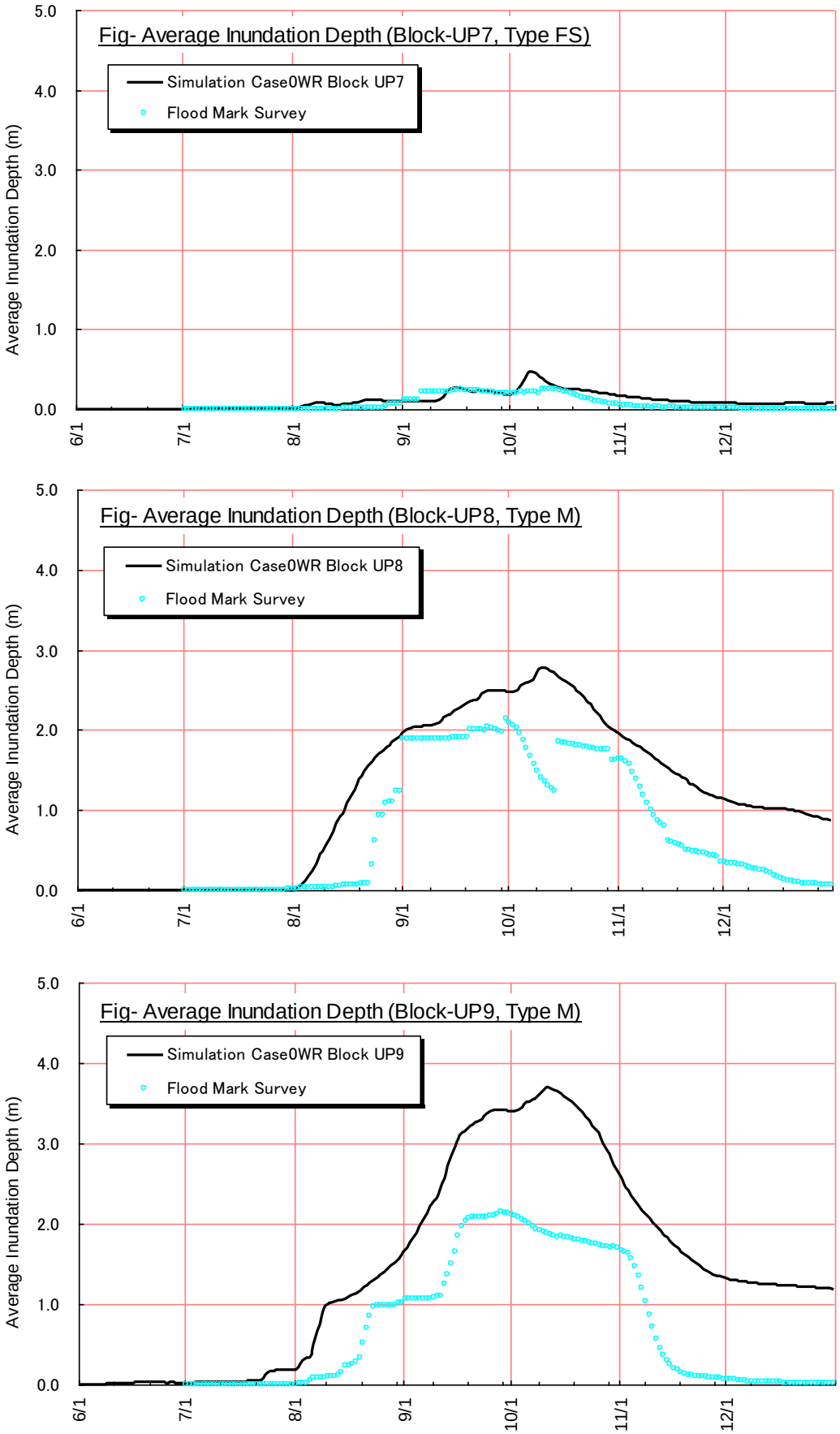


Figure25 Comparison of Inundation Volume between Simulation and Flood Mark Survey (8/8)