Centre for Computational Geostatistics (CCG)

Guidebook Series Vol. 5

User's Guide to Alluvsim Program

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Centre for Computational Geostatistics (CCG) Guidebook Series

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Volume 5. User's Guide to Alluvsim Program

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1 Introduction

This is a user's guide for the event-based fluvial simulation program, Alluvsim, which was developed by Michael J. Pyrcz and modified by Fuenglarb Zabel to condition multiple wells. The purpose of this user's guide is to give enough information for the new user to understand how Alluvsim works, how to prepare the input parameters, how to get the program to run, and how to visualize the output files. For the experienced user who wishes to understand Alluvsim program in greater details or the developer who wishes to modify the code for specific applications, please refer to Michael's thesis.

2 Overview of Alluvsim

Alluvsim was developed with the aim to provide flexible tools to construct stochastic fluvial or channelized models. Stochastic modeling of fluvial reservoirs generally requires an integration of information related to fluvial style and sequence stratigraphic framework. A variety of approaches have been applied to construct object-based stochastic models of fluvial depositional systems; however, these techniques are only suitable for certain types of reservoir - they fail to reproduce geometric features in other types of fluvial reservoirs. For example, these conventional algorithms cannot model the channel and bar bodies (CB type) and sheet (SH type) reservoirs. The Alluvsim algorithm takes a new approach by using flexible building blocks in constructing fluvial reservoir models. This approach makes it possible to construct various types of fluvial reservoirs as desired. Examples of constructing fluvial models for Paleo-Valley (PV), Channel and Bar Bodies (CB), and Sheet (SH) reservoir types will be illustrated in Section 5.

To understand this new approach, the building blocks and their operation will be explained. This will help new users understand how Alluvsim was developed and how it is applied to different types of fluvial reservoirs.

The basic building block used in Alluvsim model is a *streamline*. A streamline represents the central axis of a flow event. Streamlines will be generated and modified through streamline operations. These operations include Initialization, Avulsion, Aggradation, and Migration to mimic realistic fluvial depositional process. The probabilities of these flow events are specified by the user. Fluvial architectural elements, including channel fills (CH), lateral accretion (LA), levees (LV), crevasse channel and splay (CS), abandoned channel (FF(CH)), and overbank fines (FF) will be attached along with the streamlines and their geometries can be specified by the user. Since all of these elements are related to flow events, it is then logical to use streamline as a building block to construct fluvial model. All architectural elements will be characterized by streamlines. In addition, when certain streamlines are interrelated by certain process, they can be grouped together to form streamline associations, which possess similar characteristics. For example, a streamline association could be used to represent a braided stream or a meander migration. Architectural element interrelationships are characterized by streamline associations.

Streamlines are simulated to construct multiple reservoir models. Users will be able to custom build a wide variety of synthetic fluvial models because they can specify the desired depositional process and fluvial elements through input parameters to the Alluvsim program. These parameters include areal and vertical trends, distributions of geometric parameters for fluvial elements, and the probability of flow events and architectural elements. Because of this flexibility, many types of fluvial reservoir models can be reproduced with a limited number of input parameters.

2.1 What is Alluvsim?

Alluvsim is a FORTRAN program for event-based fluvial simulation based on the streamline building blocks. Alluvsim is tailored to fluvial and deepwater depositional systems. There were two algorithms in the original design developed by Michael Pyrcz. One is called Alluvsim which is an unconditional algorithm for the construction of training images. Another one is called AlluvsimCond which is a limited conditional algorithm with streamline updating for well conditioning. Alluvsim honors vertical and areal channel density trends, but not well data while AlluvsimCond algorithm is conditioned to honor channel (without differentiation of channel fills (CH), lateral accretion (LA), LV (levees), CS (crevasse splays) or abandoned channel (FF(CH)) elements) intercepts at wells.

A variety of methods are available for conditioning complicated geologic models. However, these techniques have limitations either in efficiency, robustness, or the ability to retain complicated geometries and interrelationships. Event-based model consists of associations of streamlines with associated geometric parameters and identified architectural elements. A prior model of streamline associations may be updated to reproduce well observations since it does not become trapped with complicated streamline associations. Nevertheless, it is difficult to condition to many well data; that is an ongoing area of research.

One attempt to condition multiple wells was done by Fuenglarb Zabel to modify the original AlluvsimCond program. It was done by combining Alluvsim and AlluvsimCond. The user has a choice to run either the unconditional one or conditional one by simply specifying the name of well data file (none will presume unconditional run). A different approach was implemented in this combined algorithm with an aim to condition up to 5 wells. It was implemented such that it will condition the well data along with the soft data rather than updating the prior constructed model that already matches the soft data to reproduce well observations. The main idea behind this new methodology to honor multiple wells is to apply Accepting/Rejecting rules during the selecting process of the drawn streamlines. These rules was implemented to select the best possible candidate streamlines to match the net intervals without unwarranted intercept before being placed according to the event schedules. The details of the implementation are described in reference 3 (Zabel, 2005). Note that examples of input parameters in this user guide are based on this algorithm.

The building blocks and the operators used in Alluvsim are briefly described as follows. The building blocks include the following architectural elements:

CH = channel fills

LA = lateral accretion

LV = levees

CS = crevasse channel and splay

FF(CH)= abandoned channel

FF = overbank fines

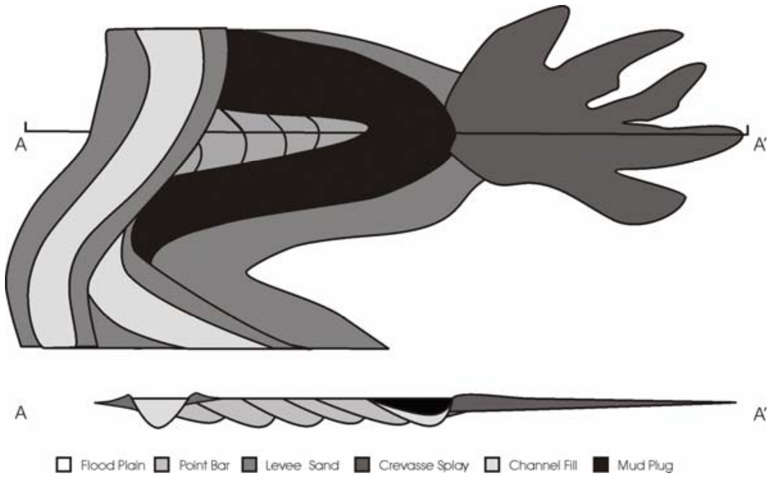


Figure 2-1: Plan and section view of conceptual model for fluvial facies: background of shales, meandering and avulsing channel with lateral accretion, levees, crevasses splays and mud plugs.

The operators used in Alluvsim include:

Initialization – generate channel streamline
This operator is applied to generate an initial streamline or to represent channel avulsion proximal of the model area. This operator generates a realistic streamline according to the source and target locations, channel sinuosity, and azimuth. Then these streamlines are modified to honor horizontal and vertical trends.

Avulsion (within and proximal) – isolated and braiding streamlines
This operator is applied to construct avulsion caused by an active channel being abandoned. A new channel is established. The user can define the probability of avulsion proximal to and within the model.

Aggradation – with simplified incision
This operator is applied to construct aggradation depending on the user defined number of aggradation levels and vertical spacing. For the current Alluvsim, only constant discrete aggradation levels are implemented.

Migration – realistic meander evolution
This operator is applied to mimic meander migration. The user can specify the maximum distance of migration.

Migration occurs when an entire meander loop migrates and may be abandoned which results in neck cut offs and chute channels (the channel cuts across the point bar). The parameters control this event include probabilities of avulsion and maximum migration distance.

Cutoff – check for chute and neck cutoffs
During migration operation, neck cut offs is checked and the facies is marked as abandoned channel. This abandoned channel may be represented by channel fill (CH) or also with the presence of fine grained abandoned channel (FF(CH)).

2.2 Applications of Alluvsim

Alluvsim can be applied to simulate fluvial models based on a specified schedule of flow events and fluvial element geometries. Many types of fluvial models can be simulated and examples of four different types of reservoir with appropriate input parameters are shown in Section 5.

2.3 Limitations of Alluvsim Implementation

Although there are many advantages of the event-based simulation including flexibility and computational efficiency, it does have certain limitations:

1. Slight artifacts in the streamline may occur with extrapolation to the model distal edge. The algorithm may become trapped if the evolving model is unable to reach the NTG in a layer of the model. For example, if there are few aggradation levels and the channels are shallow. The program will terminate when the maximum number of streamlines (ntime) are reached.
2. During the sequence of flow events to mimic the depositional process, the current implementation does not allow for the old channel to get reactivated when avulsion inside occurs.
3. The asymmetrical LV elements may have discontinuities in plan view for coarse discretization and high sinuosity.
4. Further improvements are to be considered for efficiency and robustness of the conditioning technique.

3 Preparation of Alluvsim Parameters

An input parameter file is required to run Alluvsim. It is important for the user to understand each of these input parameters well enough so that the desired fluvial model can be constructed. This section will explain the input parameter file by defining all of the parameters and providing the allowable range of variations for certain parameters. Then, the result of varied parameter settings will be illustrated to show their effect more clearly.

3.1 Description of Alluvsim Input Parameters

3.1.1.1 Definition and Allowable Range of Input Parameters

The Alluvsim program follows GSLIB conventions. A parameter file required by the program is shown below followed by a list of the definitions and allowable ranges of each parameter in Table 3-1.

```
                    Parameters for Alluvsim
                    *********************

START OF PARAMETERS:
1.  welldata.dat                - file with well data
2.  1 2 3 4 7 9                 - wcol, xcol, ycol, ztcol, zbcol, fcol
3.  50.0 50.0 1.0               - xanis, yanis, zanis
4.  100.0 10.0                  - buffer, ztol
5.  horitrend.dat               - file with the horizontal trend
6.  1                           - htcol
7.  verttrend.dat               - file with the vertical trend
8.  1                           - vtcol
9.  60 100 100                  - ntime, max_assoc, max_withinassoc
10. 3 7.0 13.0 17.0             - nlevel, level elevations
11. 0.20 50.0 5.0               - NTGtarget, mdistMigrate, stdevdistMigrate
12. 100 10 10                   - CHndraw, ndiscr, nCHcor
13. 0.1 0.1                     - probAvulOutside, probAvulInside
14. 90.0 1.0                    - CH element: mCHazi, stdevCHazi
15. 500.0 -1.0                  - mCHsource, stdevCHsource
16. 4.0 0.5 0.2                 - mCHdepth, stdevCHdepth, stdevCHdepth2
17. 15.0 2.0                    - mCHwdratio, stdevCHwdratio
18. 1.3 0.0                     - mCHsinu, stdevCHsinu
19. 0.0 0.0                     - LV Element: mLVdepth, stdevLVdepth
20. 0.0 0.0                     - mLVwidth, stdevLVwidth
21. 0.0 0.0                     - mLVheight, stdevLVheight
22. 0.0 0.0                     - mLVasym, stdevLVasym
23. 0.0 0.0                     - mLVthin, stdevLVthin
24. 0 0                         - CS Element: mCSnum, stdevCSnum
```

25. 0 0	- mCSnumlobe, stdevCSnumlobe
26. 50.0 20.0	- mCSsource, stdevCSsource
27. 200.0 50.0	- mCSLOLL, stdevCSLOLL
28. 30.0 10.0	- mCSLOWW, stdevCSLOWW
29. 100.0 20.0	- mCSLOl, stdevCSLOl
30. 20.0 10.0	- mCSLOw, stdevCSLOw
31. 0.03 0.05	- mCSLO_hwratio, stdevCSLO_hwratio
32. 0.02 0.05	- mCSLO_dwratio, stdevCSLO_dwratio
33. 0.0 0.0	- FFCH Element: mFFCHprop, stdevFFCHprop
34. 100 5.0 10.0	- nx, xmn, xsiz
35. 100 5.0 10.0	- ny, ymn, ysiz
36. 40 0.25 0.5	- nz, zmn, zsiz
37. 69569 0.05	- random number seed, color_incr
38. alluvsim.out	- file for output facies file
39. streamline.out	- file for output streamlines
40. fitness.out	-file for measure of fitness with well data

Table3-1: List of Alluvsim Input Parameter Definitions and Allowable Ranges

Line No.	Parameter Name (unit) or Example	Definition and Allowable Range
1	none Welldata.dat	Input file with well channel intercepts: *It contains the net channel fill element intervals from well data. The standard GSLIB/GEOEAS format is expected and the well is assumed to be vertical.*
2	wcol xcol ycol ztcol zbcol fcol	Column in well data file for well number (used to identify different well intersections) Column in well data file for X coordinate Column in well data file for Y coordinate Column in well data file for Z top coordinate Column in well data file for Z base coordinate Element code
3	 xanis yanis zanis	Anisotropy ratios for nearest neighbour search: in X direction in Y direction in Z direction
4	buffer ztol (m)	Buffer in number of control nodes. *This prevents artifacts due to adjacent control nodes being set to honor different wells.* Tolerance of net element interval thickness
5	none horitrend.dat	Input file with relative horizontal trend in channel density. The file should be in GEOEAS format and GSLIB grid convention.
6	htcol	Column number for the horizontal trend.
7	none	Input file with relative vertical trend in channel density.

Line No.	Parameter Name (unit) or Example	Definition and Allowable Range
	verttrend.dat	The file should be in GEOEAS format and GSLIB grid convention.
8	vtcol	Column number for the vertical trend.
9	ntime	Maximum number of streamlines: *The algorithm terminates when this number of streamlines is generated or when NTG is met.*
	max_assoc	Maximum number of streamline associations
	max_withinassoc	Maximum number of streamlines within a streamline association. *Applied to set up static arrays. Use a relatively large number.*
10	nlevel	The number of elevation levels
	level elevations (m)	A list of associated levels: *This is applied to define the vertical spacing of channels relative to Z = 0, where Zmax = (nz)(zsize).*
11	NTGtarget	The target net-to-gross ratio: *The algorithm terminates when this NTG ratio is exceeded.*
	 mdistMigrate (m) stdevdistMigrate (m)	The maximum meander migration distance Mean Standard deviation of a Gaussian distribution
12	CHndraw	The number of candidate streamlines calculated prior to model construction *Set this number several times larger than the maximum number of streamlines.*
	ndiscr	The number of discretizations for spline interpolation between control nodes
	nCHcor (m)	The correlation length of the CH width Random Function (RF)
13	probAvulOutside	The probability of avulsion proximal to the model (new streamline initialization) [Range: 0-1]
	probAvulInside	The probability of avulsion within the model [Range: 0-1] *Probability of meander migration = 1 – (probAvulOutside + probAvulInside)*
14-18	**CH element:**	**The geometric parameters for channel fill (CH) element:**
14	 mCHazi (degree) stdevCHazi (degree)	Primary azimuth of channel streamlines: *Current model assumes model proximal edge is at X=0 and distal edge is at X=Xmax, where Xmax=(nx)(xsize).* Mean (zero degree for North-South direction) [Range: 0-180 degree] Standard deviation of a Gaussian distribution
15		Source location in Y coordinate: *Source is located along the proximal edge of the model (X = 0).*

Line No.	Parameter Name (unit) or Example	Definition and Allowable Range
	mCHsource (m) stdevCHsource (m)	Mean [Range: 0-Zmax], where Zmax = (nz)(zsize) Standard deviation of a Gaussian distribution
16	 mCHdepth (m) stdevCHdepth (m) stdevCHdepth2 (m)	Channel depth Mean [Range: 1-40 m for high sinuosity channels] [Range: 1-18 m for low sinuosity channels] Standard deviation of a Gaussian distribution Standard deviation of a Gaussian distribution 2
17	 mCHwdratio stdevCHwdratio	Width to depth ratio Mean [Range: 0.2-1000 for high sinuosity channels] [Range: 0.6-10,000 for low sinuosity channels] Standard deviation of a Gaussian distribution
18	 mCHsinu stdevCHsinu	Sinuosity Mean [Range: 0-<2, where mCHsinu<1.5 is low sinuosity and mCHsinu>1.5 is high sinuosity] Standard deviation of a Gaussian distribution
19-23	**LV element:**	**The geometric parameters for levee (LV) element:**
19	 mLVdepth (m) stdevLVdepth (m)	Levee depth below the top of channel fill Mean [Range: depth + height up to 10 m] Standard deviation of a Gaussian distribution
20	 mLVwidth (m) stdevLVwidth (m)	Levee width from the edge of channel fill Mean [Range: up to 100 m for small river and 3 km for large river] Standard deviation of a Gaussian distribution
21	 mLVheight (m) stdevLVheight (m)	Levee height above the top of channel fill Mean [Range: depth + height up to 10 m] Standard deviation of a Gaussian distribution
22	 mLVasym stdevLVasym	Factor for levee asymmetry on point bar and cut bank Mean [Range: 0-1] For a value of 0, levees are symmetric. For a value of 1, levees are twice as wide on the cut bank side at the location of maximum curvature. Standard deviation of a Gaussian distribution
23	 mLVthin stdevLVthin	Factor for proximal to distal thinning along the stream-line Mean [Range: 0-1] For a value of 0, there is no thinning. For a value of 1, levee widths are doubled at the proxi-mal edge and halved at the distal edge of the model. Standard deviation of a Gaussian distribution
24-32	**CS element:**	**The geometric parameters for crevasse splay (CS) element**

Line No.	Parameter Name (unit) or Example	Definition and Allowable Range
24	 mCSnum stdevCSnum	Number of crevasse splays along a single channel streamline Mean Standard deviation of a Gaussian distribution
25	 mCSnumlobe stdevCSnumlobe	Number of lobes within a single crevasse splay Mean Standard deviation of a Gaussian distribution
26	 mCSsource (m) stdevCSsource (m)	Source location for CS in X coordinate Mean Standard deviation of a Gaussian distribution
27	 mCSLOLL (m) stdevCSLOLL (m)	Lobe length along streamline Mean [Range: up to 10 km] Standard deviation of a Gaussian distribution
28	 mCSLOWW (m) stdevCSLOWW (m)	Lobe maximum width Mean [Range: up to 5 km] Standard deviation of a Gaussian distribution
29	 mCSLOl (m) stdevCSLOl (m)	Lobe length along streamline to the position of maximum width Mean Standard deviation of a Gaussian distribution
30	 mCSLOw (m) stdevCSLOw (m)	Lobe width at proximal edge Mean Standard deviation of a Gaussian distribution
31	 mCSLO_hwratio stdevCSLO_hwratio	Lobe height to width ratio Mean Standard deviation of a Gaussian distribution
32	 mCSLO_dwratio stdevCSLO_dwratio	Lobe depth to width ratio Mean Standard deviation of a Gaussian distribution
33	**FF(CH) element:**	**The geometric parameters for fine grained abandoned channel fill (FF(CH)) element**
	mFFCHprop stdevFFCHprop	The fraction of abandoned channel fill assigned as fine grained Mean [Range: 0-1] For a value of 0, the abandoned channel is coded as CH. For a value of 1, the entire abandoned channel is coded as FF(CH). For a value between 0 and 1, the contact between FF(CH) and CH elements are apparent. Standard deviation of a Gaussian distribution
34-36		**The regular grid parameters:**
34	 nx xmn (m)	The size of the model in X direction: number of blocks/grid nodes in X direction X coordinate at the centre of the first block

Line No.	Parameter Name (unit) or Example	Definition and Allowable Range
	xsize (m)	size or spacing of the blocks/nodes in X direction
35	 ny ymn (m) ysize (m)	The size of the model in Y direction: number of blocks/grid nodes in Y direction Y coordinate at the centre of the first block size or spacing of the blocks/nodes in Y direction
36	 nz zmn (m) zsize (m)	The size of the model in Z direction: number of blocks/grid nodes in Z direction Z coordinate at the centre of the first block size or spacing of the blocks/nodes in Z direction
37	Random number seed color_incr	The random number seed for stochastic processing: streamline morphology, geometric parameter drawing, stochastic avulsion events etc. (using 5-7 digit odd or even integer) The element code or category increment for differentiation of individual architectural elements.
38	alluvsim.out	The output file with the architectural elements: *It contains the output gridded architectural element realization. The realizations are written from the lower left corner and then realization-by-realization (X cycles fastest, then Y, Z, and realization number).*
39	streamline.out	The output file with the streamlines: index, x, y, and z: *It contains the streamlines applied to construct the architectural element model.*
40	fitness.out	The output file for measure of fitness with well data

These parameters can generally be grouped into six categories as follows:

1. **Horizontal and Vertical Distribution Parameters**

   These parameters include the input files to specify the horizontal and vertical trends (Line 5-8).

2. **Geometric Parameters**

   These parameters include all of the geometric parameters for the following architectural elements:

   CH element (Line 14-18)

   LV element (Line 19-23)

   CS element (Line 24-32)

   FFCH element (Line 33)

3. **Event Schedule Parameters**

   These parameters include those controlling the schedule of events during streamline operations:

Initialization (Line 12: CHndraw)

Aggradation (Line 10: nlevel and a list of level elevations)

Avulsion (Line 13: probAvulOutside and probAvulInside)

Meander migration
(Line 13: probAvulOutside and probAvulInside due to Probability of meander migration = 1 – (probAvulOutside + probAvulInside)
Line 11: mdistMigrate and stdevdistMigrate)

4. **Conditioning Parameters**

   These parameters include the well data and other data used in well conditioning (Line 1-4, 9).

5. **Grid Parameters**

   These parameters include the regular grid size of the model in X, Y, and Z directions (Line 34-36)

6. **File Parameters**

   Input files (Line 1, 5, and 7)

   Output files (Line 38-40)

It is important for the user to understand how these parameters affect the object-based model constructed so that they can be varied within the reasonable range to obtain the expected results. The effect of the first four groups including Horizontal and Vertical Distribution, Geometric Distribution, Event Schedule, and Conditioning Data will be discussed in further detail in the following sections.

3.1.2 Examples to Show Effect of Input Parameters

This section provides some examples to illustrate how horizontal and vertical distribution, net-to-gross ratio, geometric distribution, event schedule, and conditioning data can affect the constructed model.

3.1.2.1 Horizontal and Vertical Distribution Parameters

As mentioned earlier, Alluvsim can be used to construct fluvial model to honor horizontal and vertical trends. These trends are relative measure of local reservoir quality without units.

Analogue, well test and seismic information may indicate areal trends while well data and analogue information may provide information on vertical trends in reservoir quality. Figure 3-1 and Figure 3-2 demonstrate the control of areal trend on the drawn streamlines. It can be seen that the drawn streamlines correspond to the supplied areal trends. Note that there is no vertical trend supplied and the mean of channel source is at Y equals to 500 m with standard deviation of 500 m for both cases.

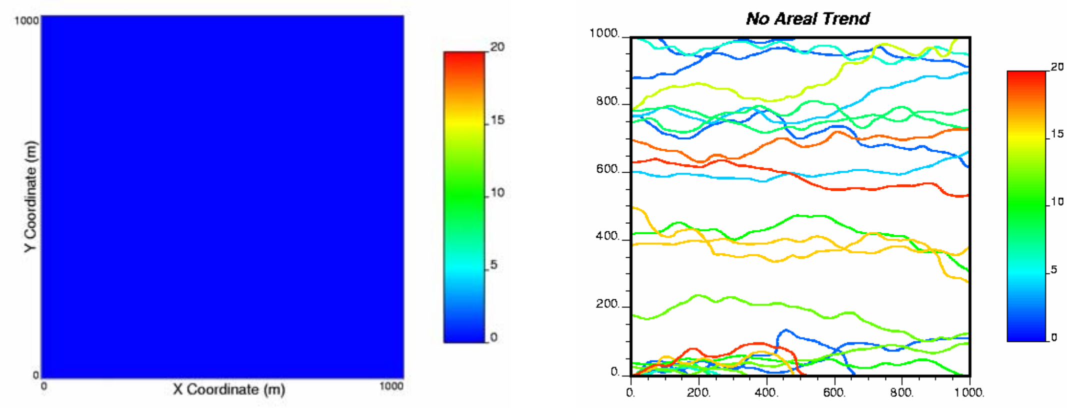


Figure 3-1: No areal trend and the resulting streamlines.

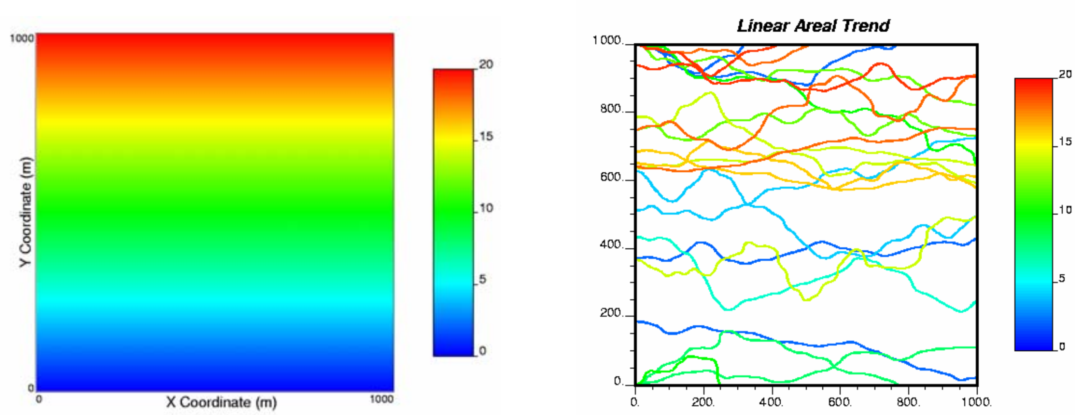


Figure 3-2: Linear areal trend increasing in the Y positive direction and the resulting streamlines.

Vertical trends may be honored by constraining the aggradation schedule. The current implementation is to apply the trend within a user defined number of constant elevation levels (nlevel). Note that the number of aggradation levels impacts the vertical trend reproduction. Too few levels results in coarse reproduction of the vertical trend while many levels allow for more precise reproduction of the vertical trends as illustrated in Figure 3-4. Note that the current implementation only considers discrete aggradation levels. It is recommended that the number of aggradation levels (nlevel) be chosen based on the observed vertical stacking in the fluvial reservoir. Three examples of different vertical trends with YZ cross sections from the resulting models at X coordinate of 500 m are shown in Figure 3-3. Note that these models were constructed with no horizontal trend and probAvulOutside was set to 1.

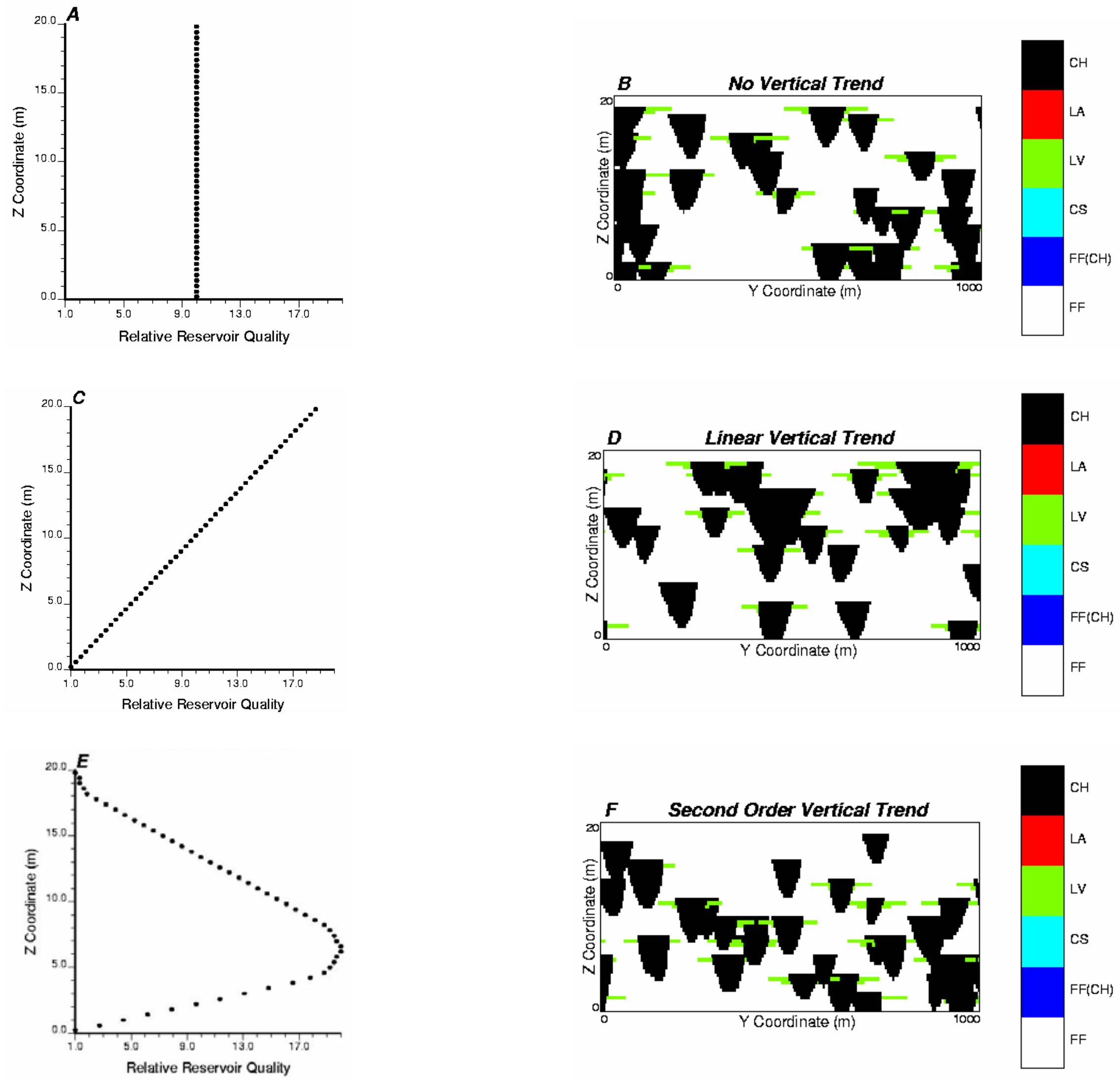


Figure 3-3: Example vertical trends and the resulting architectural element models of YZ cross section at X equals to 500 m. A and B – no vertical trend supplied, C and D – a linear trend increasing in the Y positive direction, and E and F – a second order trend increasing in the Y positive direction.

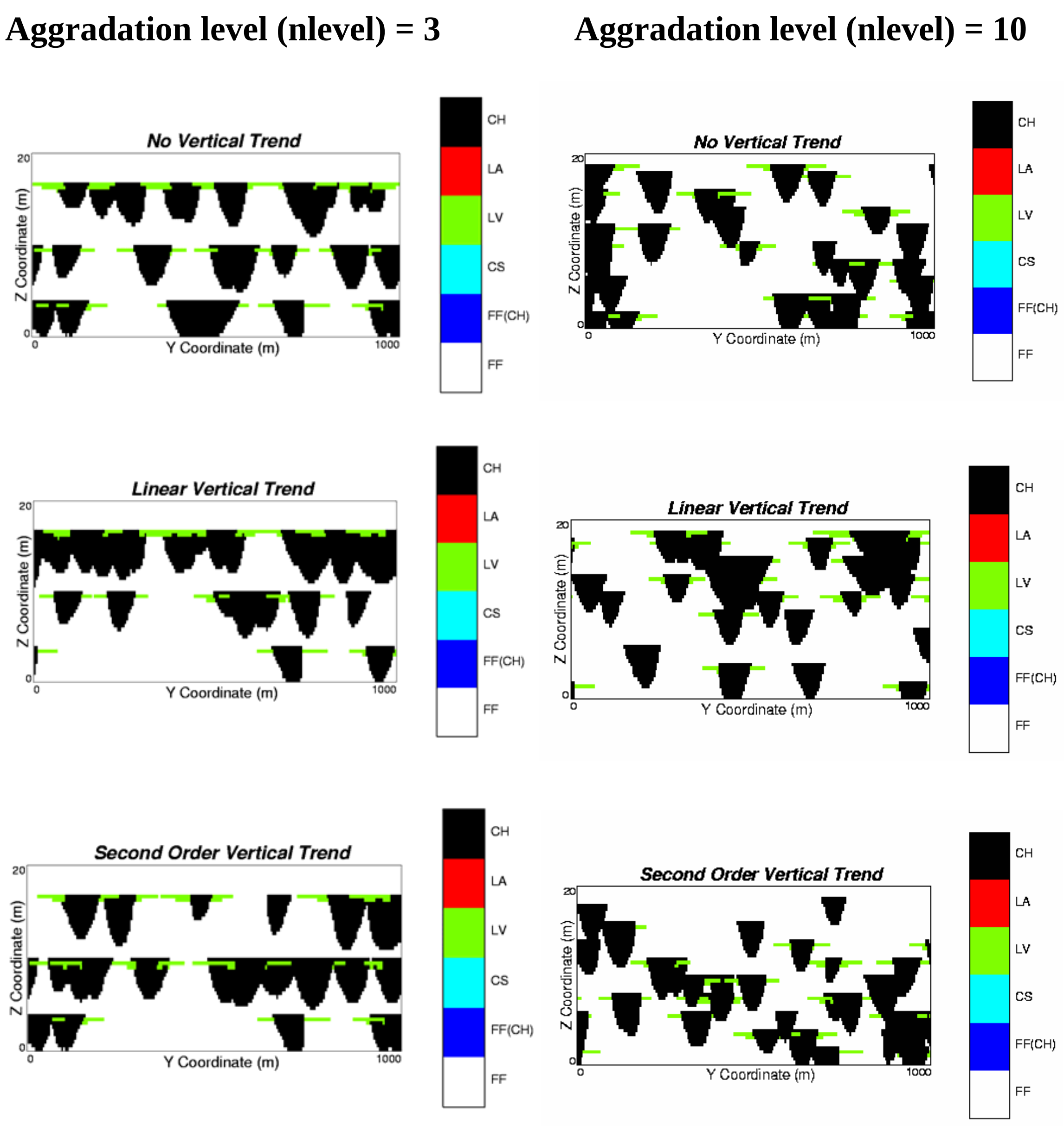


Figure 3-4: Comparison of vertical trend distribution for elevation level of 3 on the left and 10 on the right.

The resulting streamlines and architectural element models for various combinations of vertical and horizontal trends are shown in the following figures (Figure 3-5 and 3-6).

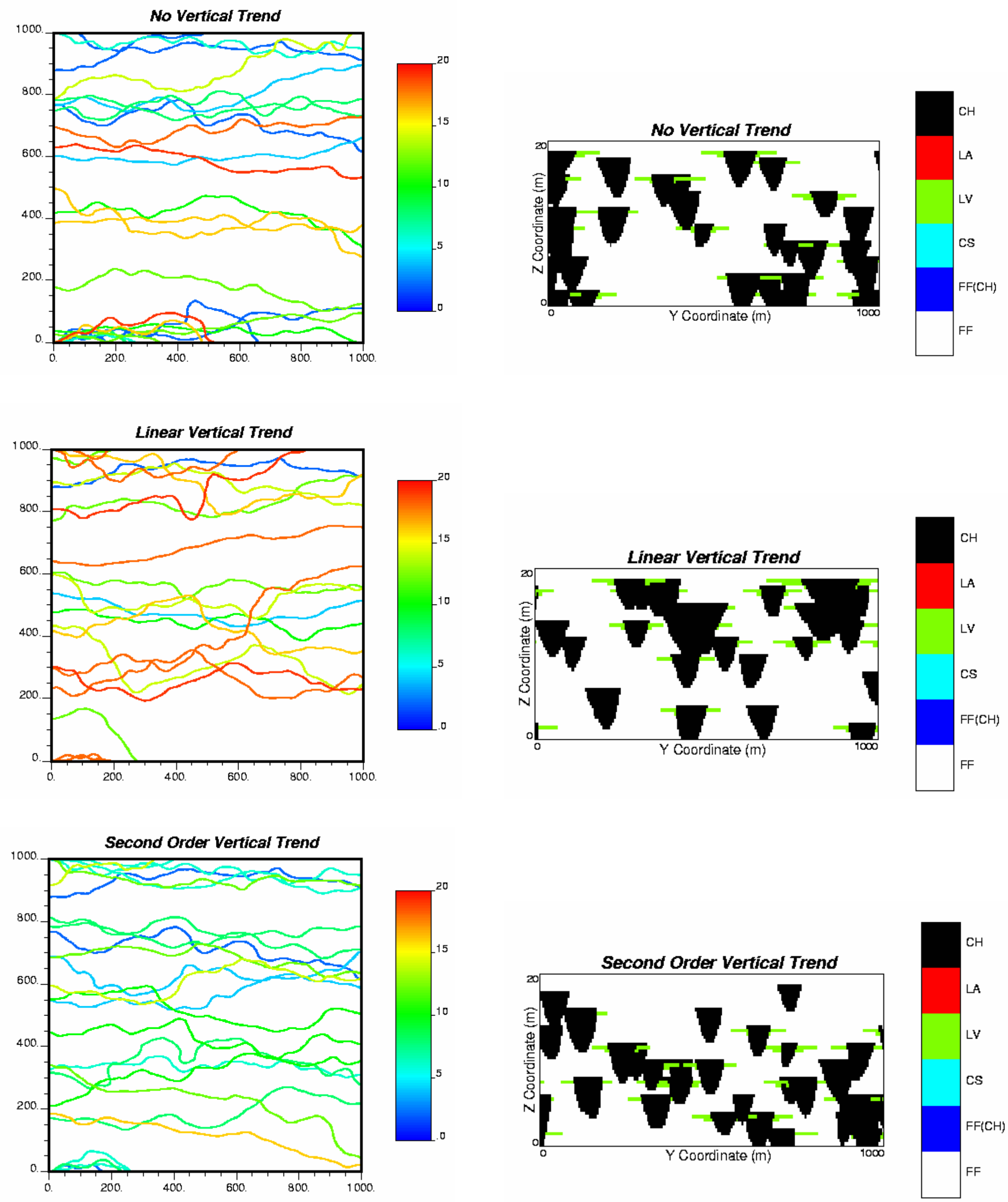


Figure 3-5: Resulting streamlines and architectural element models for different vertical trends with no horizontal trend.

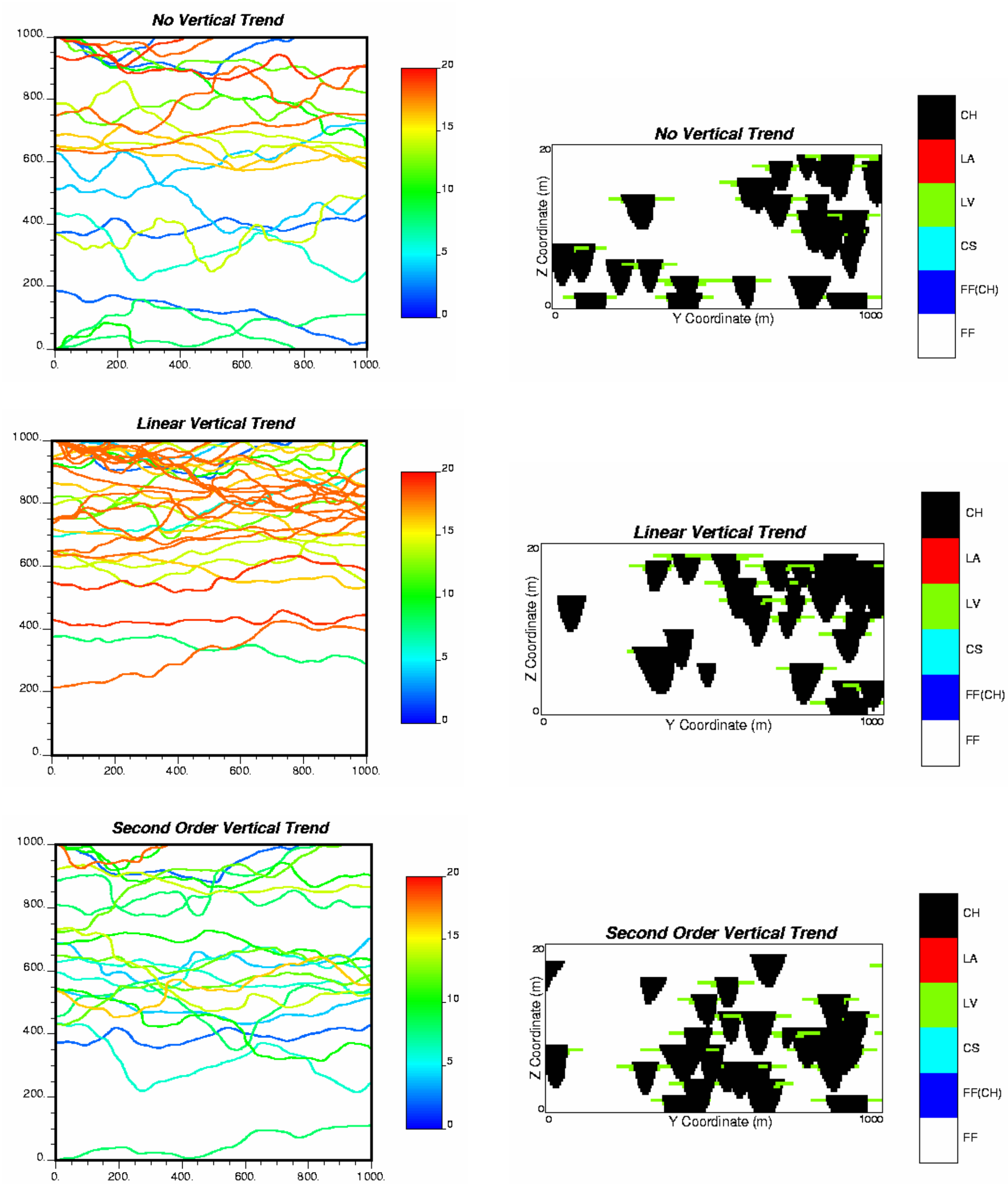


Figure 3-6: Resulting streamlines and architectural element models for different vertical trends with linear horizontal trend.

3.1.2.2 Net-to-Gross Ratio

High net-to-gross ratio results in amalgamated channel deposits while low net-to-gross ratio results in more isolated channel bodies encased within thicker floodplain fines. Lower net-to-gross ratio results in greater vertical separation of channel bodies. This effect can be seen on facies YZ cross section at X equals to 500 m in Figure 3-7.

Net-to-gross ratio = 0.2 Net-to-gross ratio = 0.4 Net-to-gross ratio = 0.6

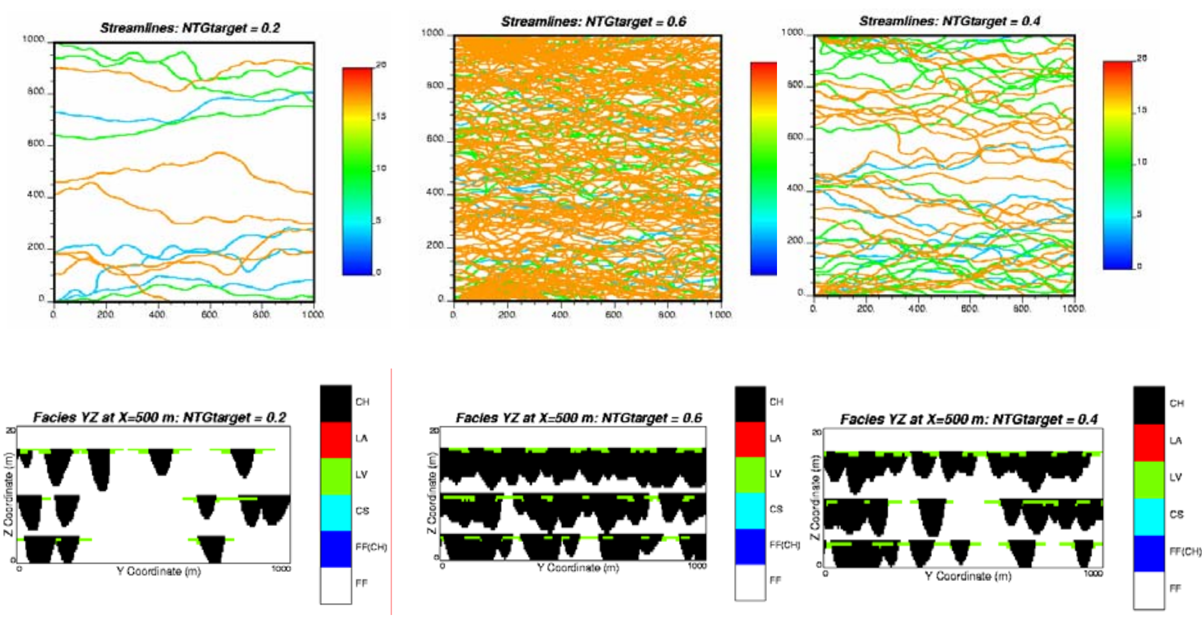


Figure 3-7: Effect of net-to-gross ratio on architectural element models.

3.1.2.3 Geometric Parameters

Geometric parameters are those for geometric distribution of each architectural element including CH, LA, LV, CS, FF(CH), and FF. The effect of related geometric parameters for each architectural element will be discussed as follows.

Channel Fill (CH) Elements

CH element in Alluvsim represents channel fill in abandoned channels with or without the presence of FF(CH) elements and channel fill of active channel. As an active channel, CH element geometry constrains the geometries of other architectural elements. Therefore, LV, CS and FF(CH) elements are anchored to CH elements and LA elements are assigned as abandoned CH element after meander migration. Figure 3-8 illustrates the channel element cross section and associated geometric parameters.

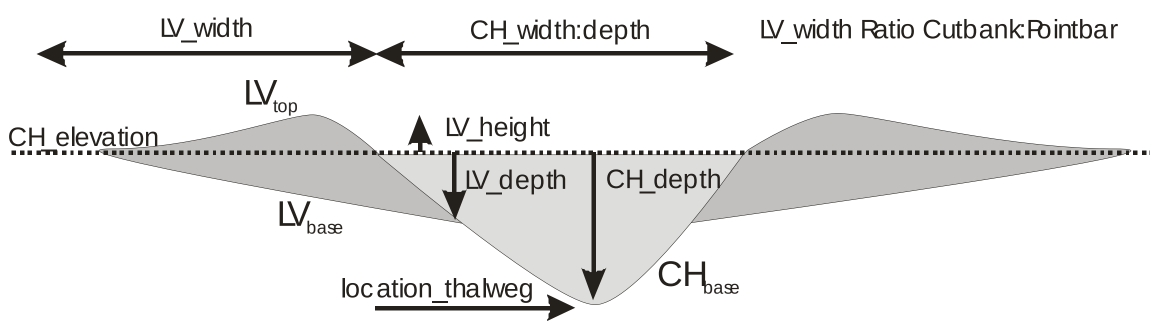


Figure 3-8: Channel and levee elements cross section and associated geometric parameters. Note the LV geometry is eclipsed by the channel geometry.

The following parameters control the geometry of the CH elements:

Primary azimuth of channel streamlines: mCHazi and stdevCHazi
Three different angles of primary azimuth mean were applied and the resulting streamlines and XY cross sections are shown in Figure3-9. Two different standard deviations of azimuth were applied for each azimuth mean with the resulting streamlines and XY cross sections shown in Figure 3-9 as well. It can be seen that small azimuth standard deviations result in parallel to sub parallel channels while large azimuth standard deviations result in a more dispersive pattern.

Source location in Y direction along the proximal edge of the model: mCHsource and stdevCHsource
Effect of applying different source location mean is apparent in Figure 3-10 and Figure 3-11. Three different standard deviations of CH source were applied for each source location mean setting. It shows that a small source standard deviation (stdevCHsource=10.0 m for mCHsource=500.0 m and stdevCHsource=1.0 m for mCHsource=900.0 m) results in a point source system on the proximal edge while a large standard deviation (stdevCH-

source=500.0 m for mCHsource=500.0 m and stdevCHsource=100.0 m for mCHsource=900.0 m) results in an apron or linear source system (see this effect in Figure 3.10 and Figure 3.11).

The alluvial fan channel pattern may be reproduced with a small source standard deviation and a large azimuth deviation (see Figure3-11).

Sinuosity: mCHsinu, stdevCHsinu

Channel width to depth ratio: mCHwdratio, stdevCHwdratio
Note that previous algorithms could not provide a realistic model of channel sinuosity. The Alluvsim algorithm provides direct control over sinuosity and results in realistic sinuosity patterns for low to high sinuosities.

Figure 3-12 and Figure 3-13 show the effect of sinuosity and channel width to depth ratio for different avulsions. This results in different fluvial channel styles which can be summarized in the following table.

Width to Depth Ratio	**Sinuosity**	**Single-channel**	**Multi-channel**
Low width to depth ratio (< 10)	low sinuosity (<1.2)	Straight	Braided
	Intermediate sinuosity (1.2-1.5)	Straight	Wandering*
	High sinuosity (>1.5)	Meandering	Anastomosing
Medium width to depth ratio (10-40)	low sinuosity (<1.2)	Straight	Braided
	Intermediate sinuosity (1.2-1.5)	Straight	Wandering*
	High sinuosity (>1.5)	Meandering	Anastomosing
High width to depth ratio (>40)	low sinuosity (<1.2)	Straight	Braided
	Intermediate sinuosity (1.2-1.5)	Straight	Wandering*
	High sinuosity (>1.5)	Meandering	Anastomosing

* wandering style is intermediate between braided and meandering

Lateral Accretion (LA) Elements

The lateral accretion deposits are represented as the volume of channel abandoned during channel migration. LA elements are characterized by wedge channel fills distributed along the inside of meander bends. These elements are formed during channel migration towards the cut bank. The combination of a realistic model of channel migration and a realistic channel cross section results in realistic LA geometries (see Figure 3-23). The related parameters contributed to the resulting LA geometries are CH geometries, probability of avulsion (probAvulOutside and probAvulInside), and maximum migration distance (mdistmigrate and stdevdistMigrate) (see Figure 3-23 to Figure 3-25).

Levee (LV) Elements

The LV geometry and associated parameterization are shown in Figure 3-8. The distribution of LV elements may not be uniform along the channel axis. Typically LV elements are more pronounced on the cut bank.

The following parameters control the geometry of the LV elements:

Levee depth below the top of channel fill: mLVdepth and stdevLVdepth

Levee width from the edge of channel fill: mLVwidth and stdevLVwidth

Levee height above the top of channel fill: mLVheight and stdevLVheight
Figure 3-14 shows the effect of levee depth, width, and height for no levee, thin with small width levee, and thick with large width levee.

Factor for levee asymmetry on point bar and cut bank: mLVasym and stdevLVasym
LV asymmetry is a value between 0 and 1 that parameterizes the strength of the levee asymmetry. A LV asymmetry value of 0 results in symmetric LV elements and a LV asymmetry value of 1 results in no LV element on the point bar side and double width of LV element on the cut bank side at the location along the streamline with greatest curvature.

Figure 3-15 illustrates the above mentioned effect as symmetric levees are obtained when the value of mLVasym was set to 0.0. In addition, levees with the width one time and twice larger on the cut bank side at the location of maximum curvature are obtained when the values of mLVasym were set to 0.5 and 1.0, respectively.

Factor for proximal to distal thinning along the streamline: mLVthin and stdevLVthin
Thinning factor is a value between 0 and 1. For a value of 0, there is no thinning. For a value of 1, levee widths are doubled at the proximal edge and halved at the distal edge of the model.

Figure 3-16 illustrates the effect of levee proximal to distal thinning factor. It can be seen that no thinning is shown for levee thinning factor of 0.0. Half of levee width is shown at the distal edge of the model for thinning factor of 0.5 and double of levee width at the proximal edge is shown for thinning factor of 1.0.

Crevasse Splay (CS)

For each streamline, the number of CS elements is drawn from a Gaussian distribution with mean (mCSnum) and standard deviation (stdevCSnum) supplied by the user. Therefore, to have CS element shown in the facies model, these parameters must be set with values greater than 0. Similarly, the number of lobes and the lobe geometric parameters (see Figure 3-17) are drawn from Gaussian distributions with user supplied mean and standard deviation. The location of each CS element along the streamline is drawn from a distribution of streamline locations (mCSsource and stdevCSsource), weighted by the curvature. Crevasse splays more likely occur at locations with high curvature since high near bank velocities erode the confining LV elements. The CS elements are modeled as a series of lobes fit to low sinuosity streamlines initiated from the crevasse location with initial azimuth normal to the channel streamline toward the cut bank.

The following parameters control the geometry of the CS elements:

Number of crevasse splays along a single channel streamline: mCSnum, stdevCSnum

Number of lobes within a single crevasse splay: mCSnumlobe, stdevCSnumlobe
Figure 3-18 and Figure 3-19 show the effect of number of crevasse splays and number of lobes within a single crevasse splay for small lobes (inter fingering) and large lobes (sheet), respectively. Note that to be able to obtain the number of setting crevasse splays and number of lobes, very high number of candidate streamlines (CHndraw) may be required.

Source location for CS in X coordinate: mCSsource, stdevCSsource
Figure 3-20 shows effect of source location for crevasse splay. It can be seen that the variation of source location setting has no effect on the actual location of CS drawn since it is weighted by curvature and CS more likely occurs at locations with high curvature.

Lobe length along streamline: mCSLOLL, stdevCSLOLL

Lobe maximum width: mCSLOWW, stdevCSLOWW

Lobe length along streamline to the position of maximum width: mCSLOl, stdevCSLOl

Lobe width at proximal edge: mCSLOw, stdevCSLOw

Lobe height to width ratio: mCSLO_hwratio, stdevCSLO_hwratio

Lobe depth to width ratio: mCSLO_dwratio, stdevCSLO_dwratio
The lobe geometric parameters used for small lobes in Figure 3-18 are as follows.

mCSLOLL=300.0,	stdevCSLOLL=50.0
mCSLOWW=50.0,	stdevCSLOWW=10.0
mCSLOl=100.0,	stdevCSLOl=30.0
mCSLOw=50.0,	stdevCSLOw=10.0
mCSLO_hwratio=0.000,	stdevCSLO_hwratio=0.000
mCSLO_dwratio=0.010,	stdevCSLO_dwratio=0.005

The lobe geometric parameters used for large lobes in Figure 3-19 are as follows.

mCSLOLL=200.0,	stdevCSLOLL=50.0
mCSLOWW=150.0,	stdevCSLOWW=30.0
mCSLOl=50.0,	stdevCSLOl=20.0
mCSLOw=150.0,	stdevCSLOw=30.0
mCSLO_hwratio=0.000,	stdevCSLO_hwratio=0.000
mCSLO_dwratio=0.010,	stdevCSLO_dwratio=0.005

Abandoned Channel (FF(CH)) Elements

Channels, particularly in high-sinuosity streams, may be abandoned by chute or neck cut-off, in which case they will be filled by fine-grained deposits showing a channelized, concave base.

In the current implementation, FF(CH) elements form as follows:

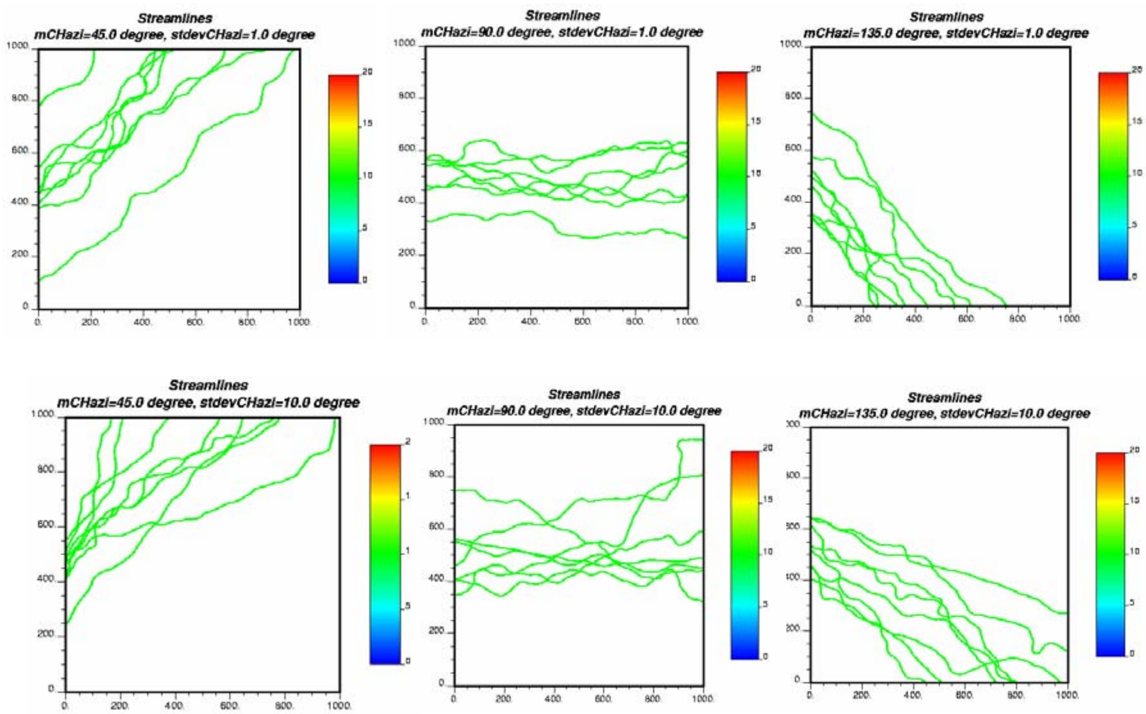
1. in oxbow lakes when meander migration has cut off a reach,
2. in the channel reaches distal of avulsion locations, and
3. in the last channel placed for a level or within a level.

The user supplies the distribution of the proportion of abandoned channels fill with FF(CH) elements (mFFCHprop). For a proportion of 0, the abandoned channel is coded as CH element and for a proportion of 1, the entire abandoned channel is coded as FF(CH) element. For a proportion between 0 and 1, the contact between the FF(CH) and CH elements will be shown. Figure 3-22 shows fine grained abandoned channel element when its fraction is specified in the parameter mFFCHprop (mFFCHprop=0.7, stdevFFCHprop=0.05) otherwise abandoned channel remains as channel fill (CH).

Overbank Fines (FF) Elements

Note that the model space is initialized as FF element, then other architectural elements displace FF elements during model construction.

Azimuth mean = 45 degree **Azimuth mean = 90 degree** **Azimuth mean = 135 degree**



Azimuth mean = 45 degree **Azimuth mean = 90 degree** **Azimuth mean = 135 degree**

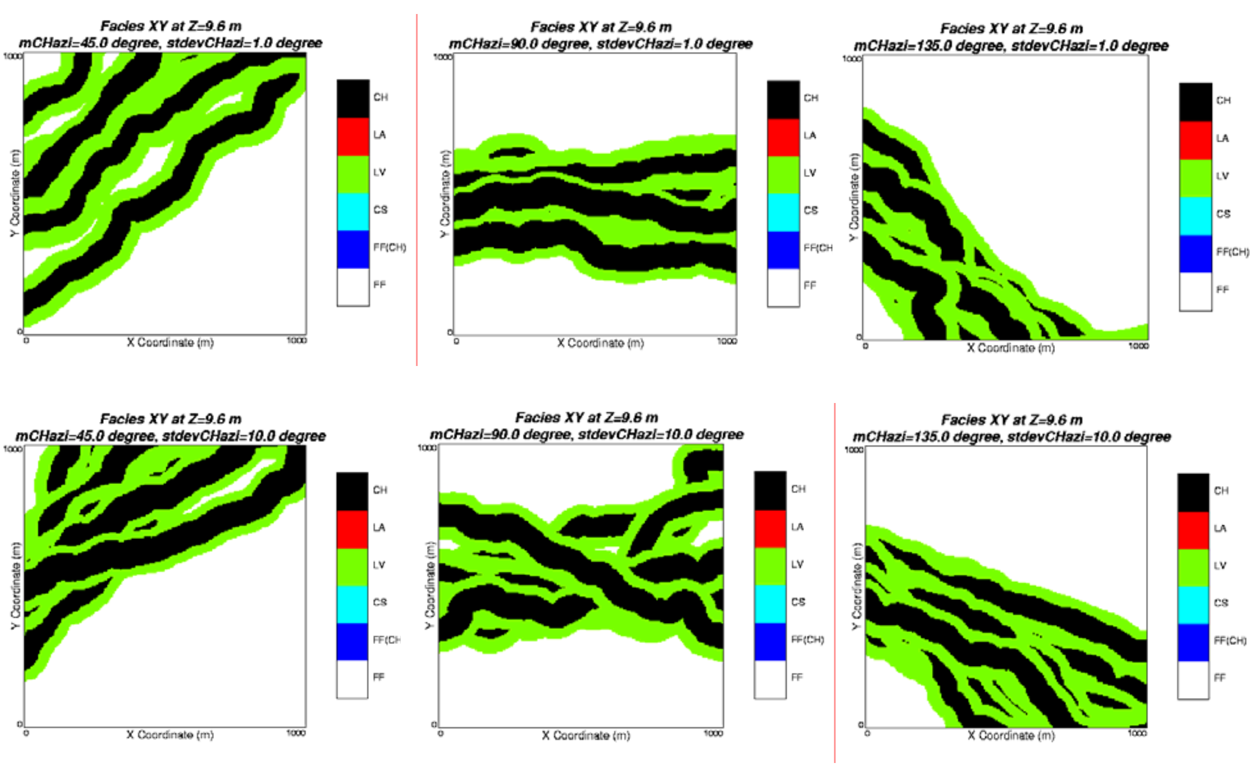


Figure 3-9: Effect of azimuth mean and azimuth standard deviation on architectural element models.

Source location mean = 500 m **Source location mean = 900 m**

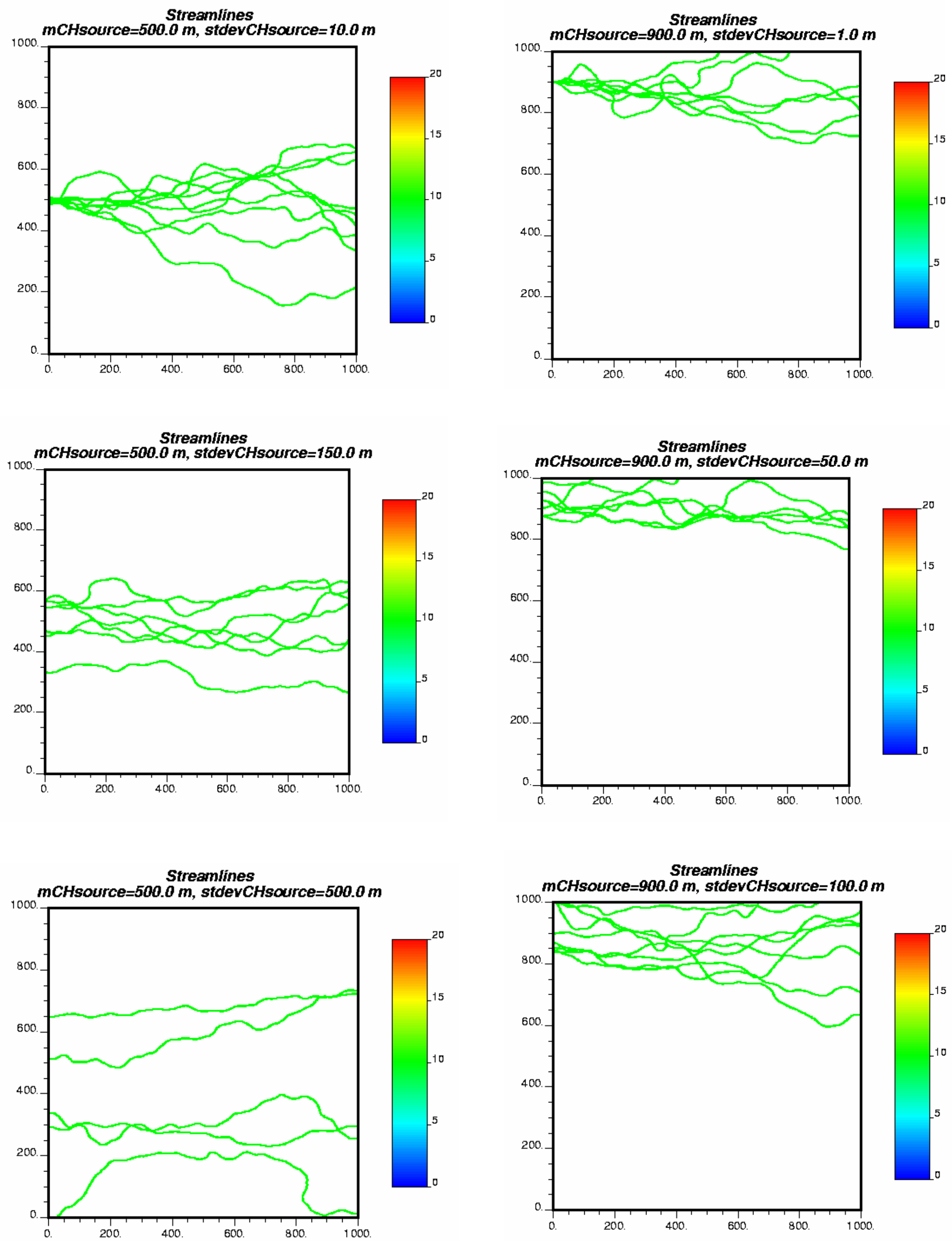


Figure 3-10: Effect of source mean and source standard deviation on overall streamlines for mCHazi of 90 degree and stdevCHazi of 1 degree.

Source location mean = 500 m **Source location mean = 900 m**

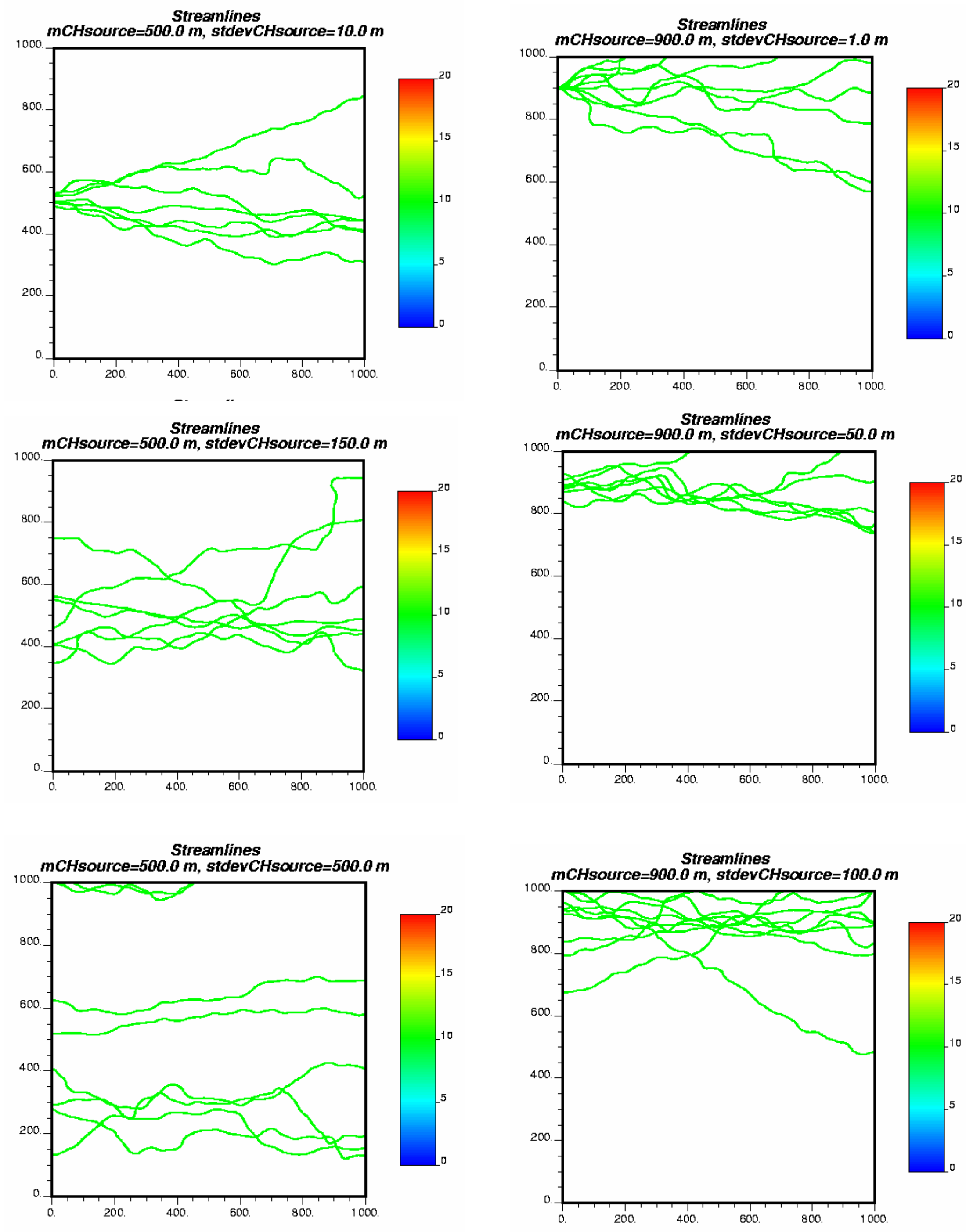
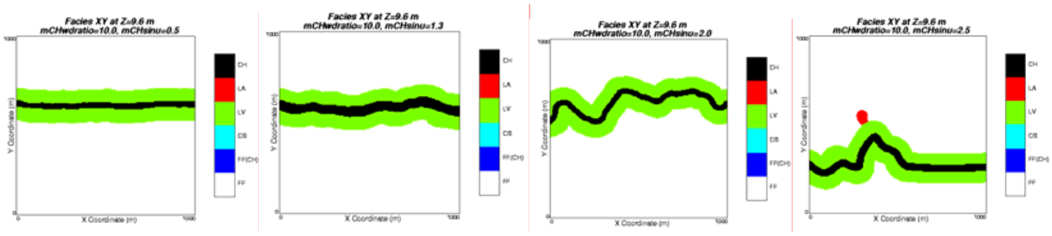
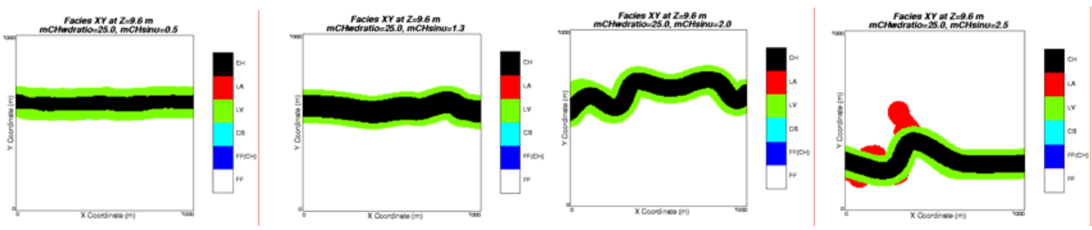


Figure 3-11: Effect of source mean and source standard deviation on overall streamlines for mCHazi of 90 degree and stdevCHazi of 10 degree).

Channel width to depth ratio = 10.0



Channel width to depth ratio = 25.0



Channel width to depth ratio = 40.0

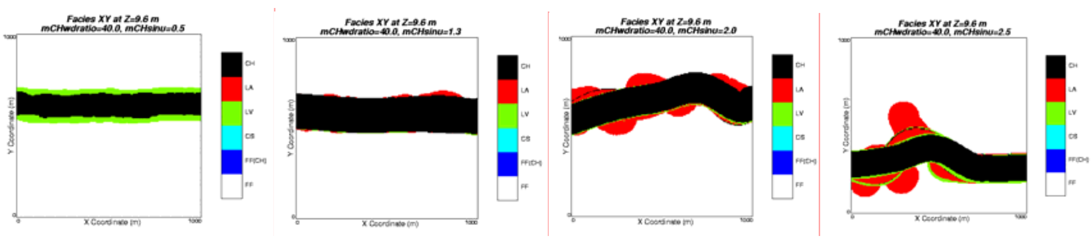
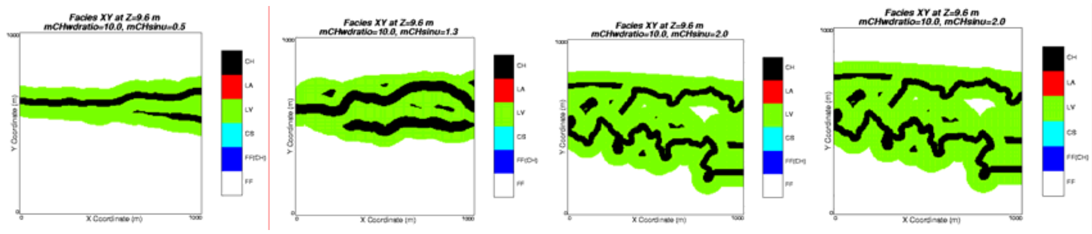
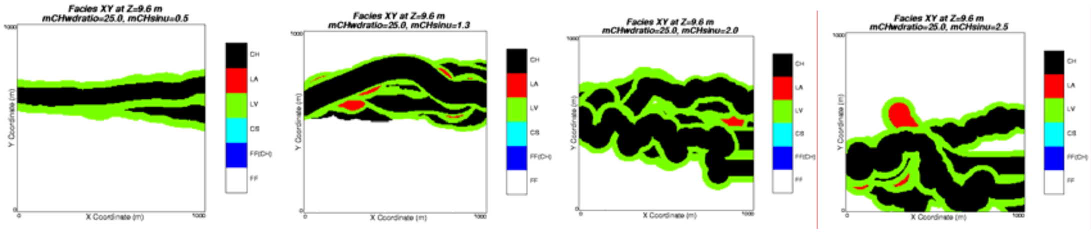


Figure 3-12: Effect of sinuosity and channel width to depth ratio on architectural element models for probAvulOutside = 0.0, probAvulInside = 0.0.

Channel width to depth ratio = 10.0



Channel width to depth ratio = 25.0



Channel width to depth ratio = 40.0

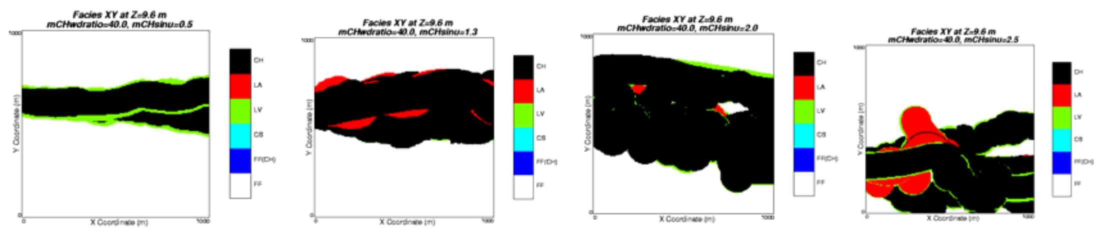


Figure 3-13: Effect of sinuosity and channel width to depth ratio on architectural element models for probAvulOutside = 0.1, probAvulInside = 0.6.

Levee depth = 0.0m, width=0 m, height=0.0 m | **Levee depth = 1.5 m, width=80 m, height=1.5 m** | **Levee depth=3.0 m, width=200 m height=3.0 m**

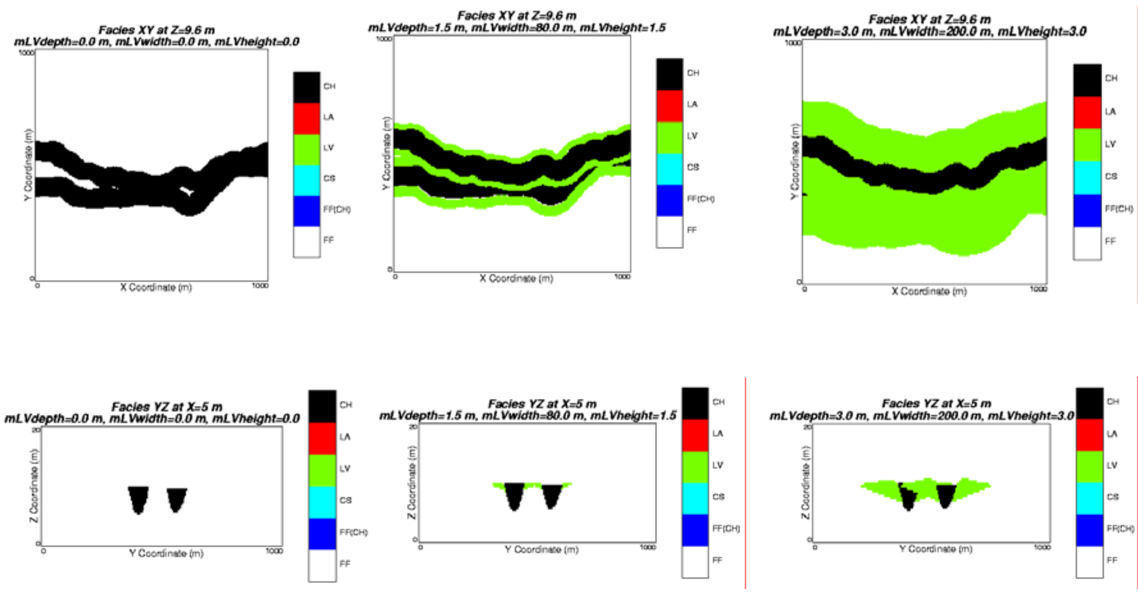


Figure 3-14: Effect of levee depth, width, and height on architectural element models.

Levee asymmetry factor = 0.0 | **Levee asymmetry factor = 0.5** | **Levee asymmetry factor = 1.0**

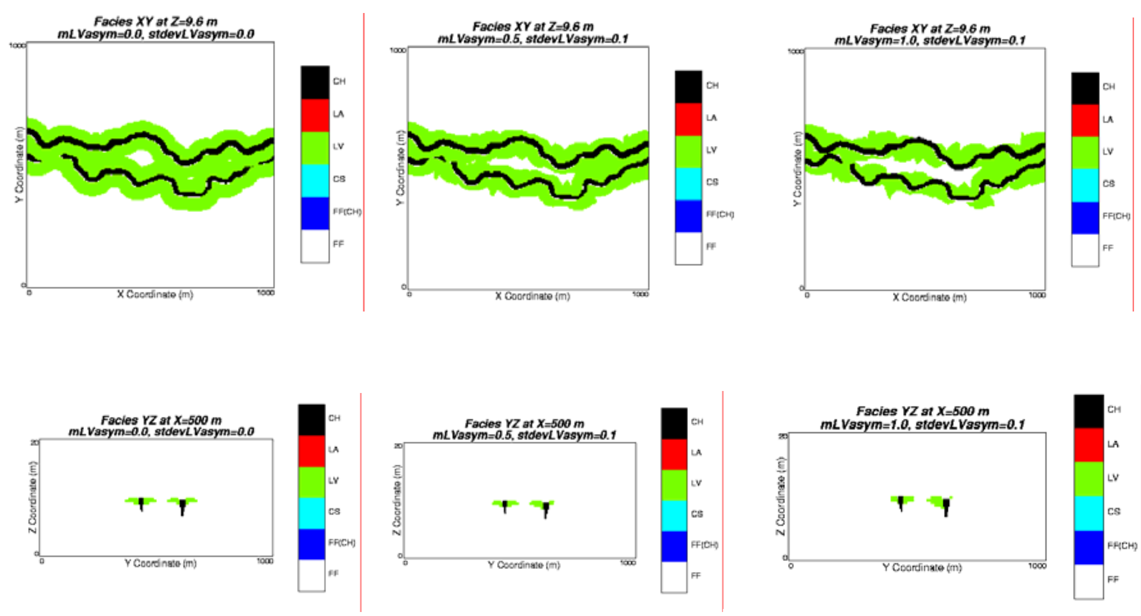


Figure 3-15: Effect of levee asymmetry factor on architectural element models for probAvulOutside of 1.0 and probAvulInside of 0.0.

Levee thinning factor = 0.0   Levee thinning factor = 0.5   Levee thinning factor = 1.0

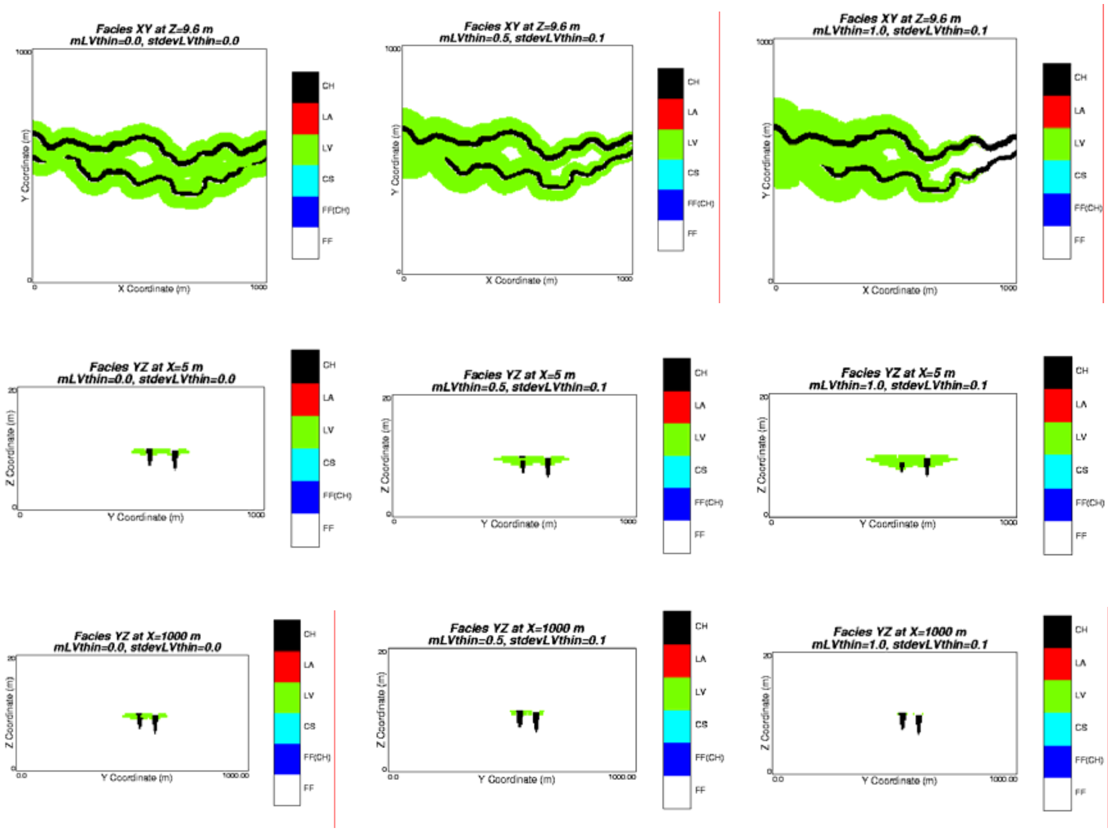


Figure 3-16: Effect of levee proximal to distal thinning factor on architectural element models for probAvulOutside of 1.0 and probAvulInside of 0.0.

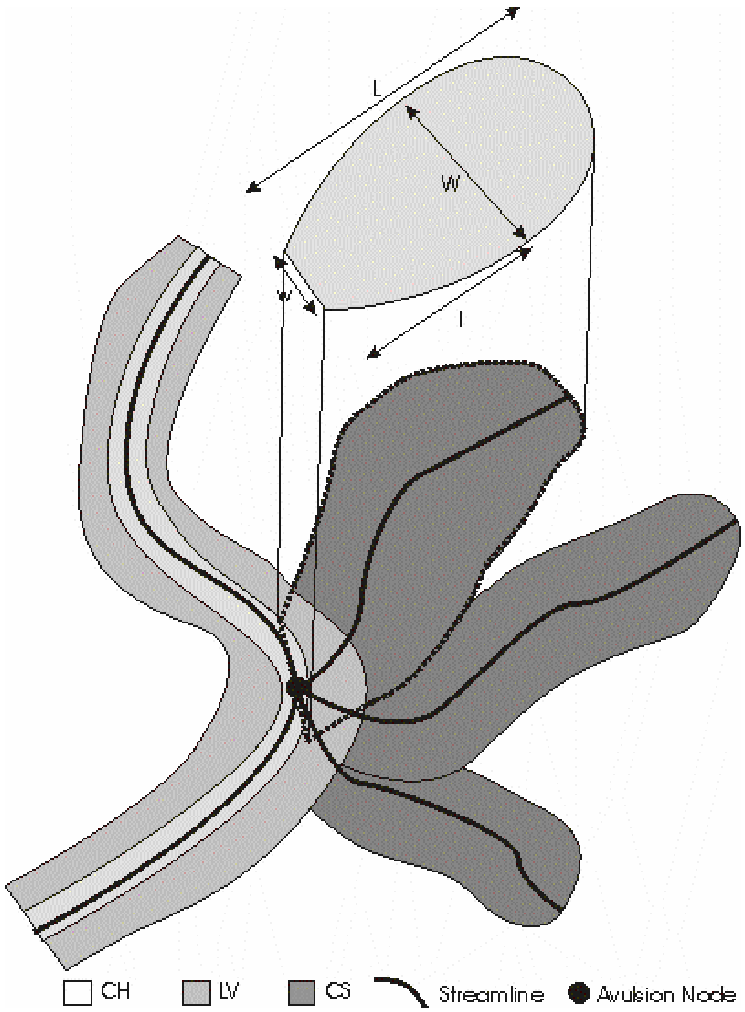
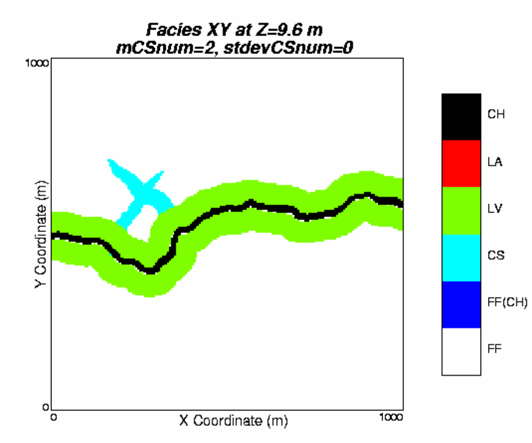
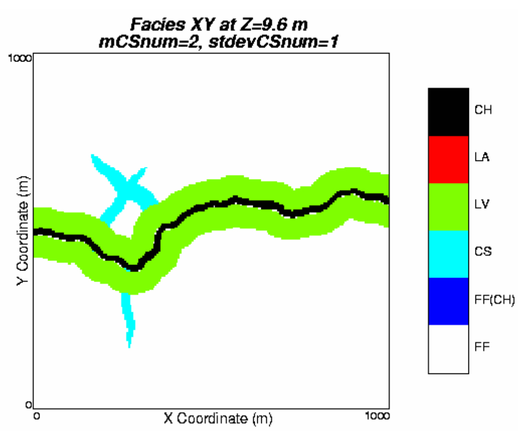


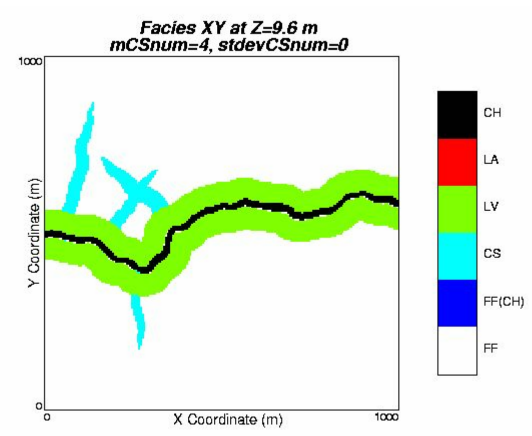
Figure 3-17: Crevasse splay architectural element geometric parameters. *L* is the length of the lobe, *l* is the length along the streamline where the lobe has its maximum width, *W* and *w* is the width along the proximal edge.

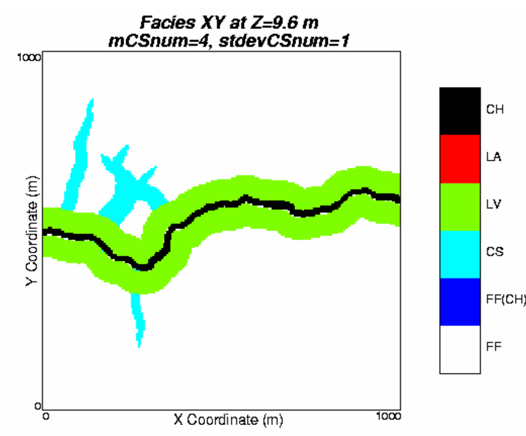
Number of crevasse splays = 2





Number of crevasse splays = 4





Number of lobes = 1 **Number of lobes = 3** **Number of lobes = 5**

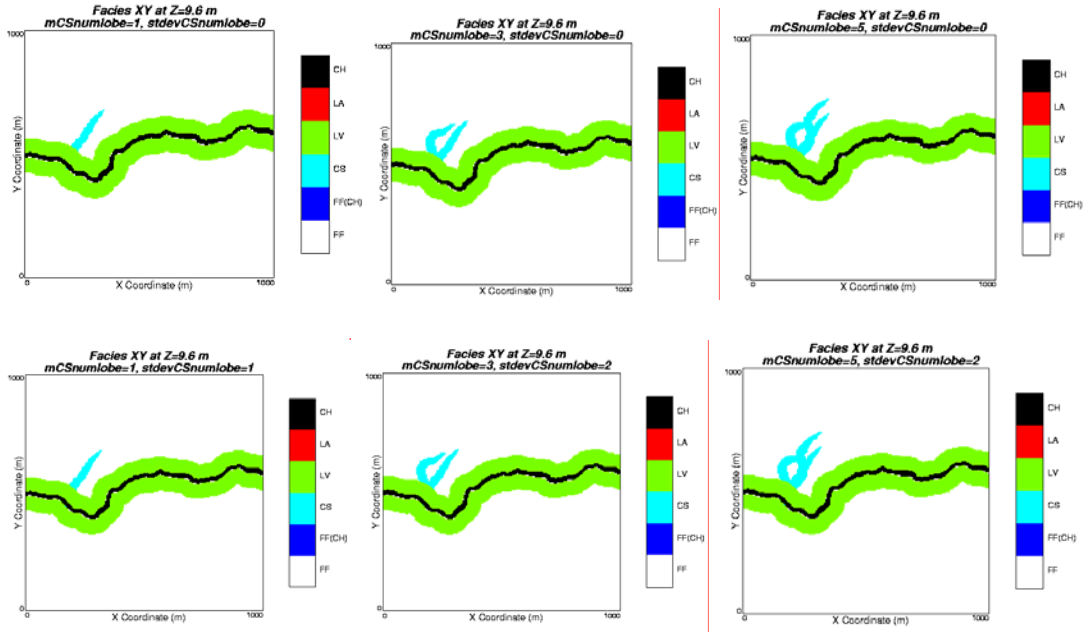
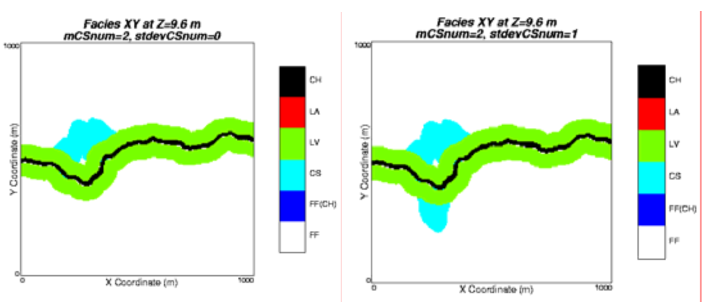
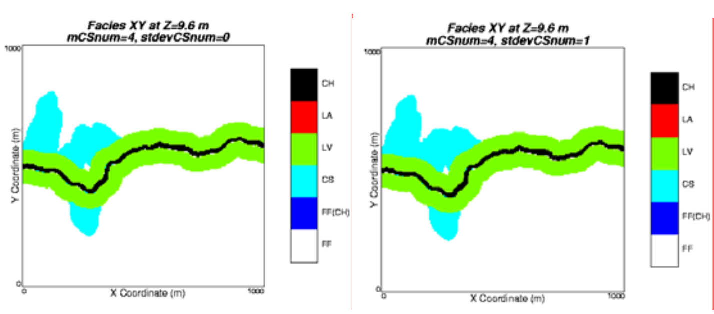


Figure 3-18: Effect of number of crevasse splays for one lobe and number of lobes for one crevasse splay within a single crevasse splay on architectural element models for small lobes (inter fingering).

Number of crevasse splays = 2



Number of crevasse splays = 4



Number of lobes = 1 **Number of lobes = 3** **Number of lobes = 5**

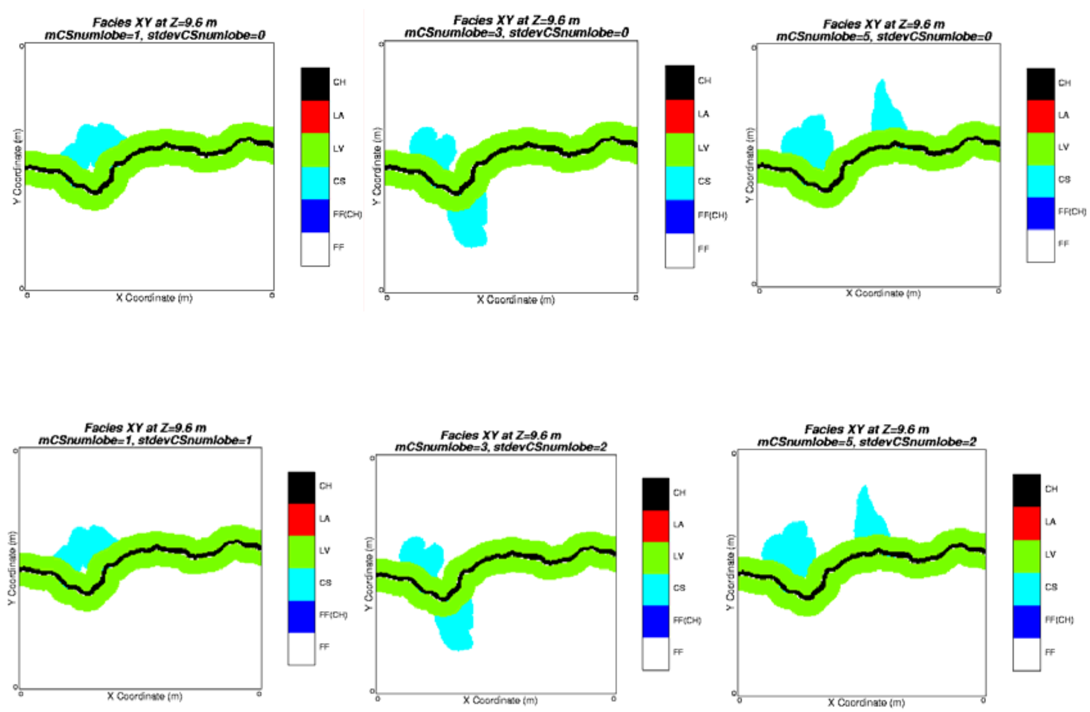


Figure 3-19: Effect of number of crevasse splays for one lobe and number of lobes for two crevasse splays within a single crevasse splay on architectural element models for large lobes (sheet).

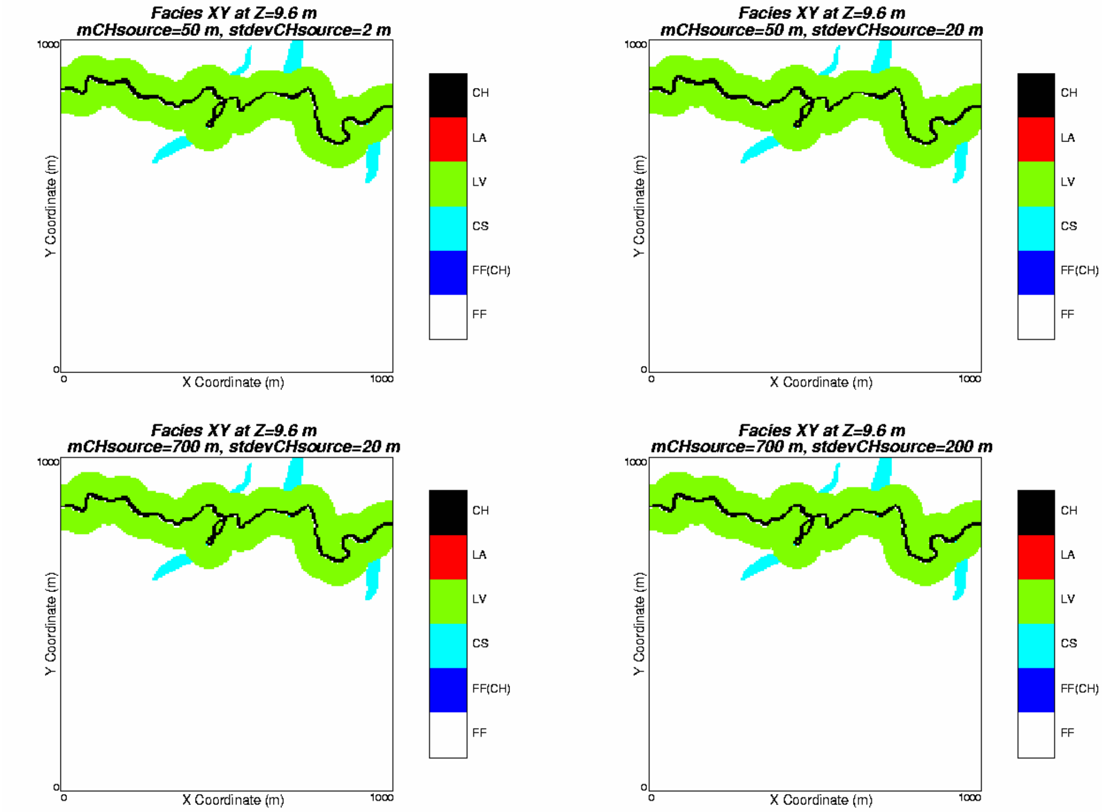


Figure 3-20: Effect of source location for crevasse splay on architectural element models for sinuosity of 2.0.

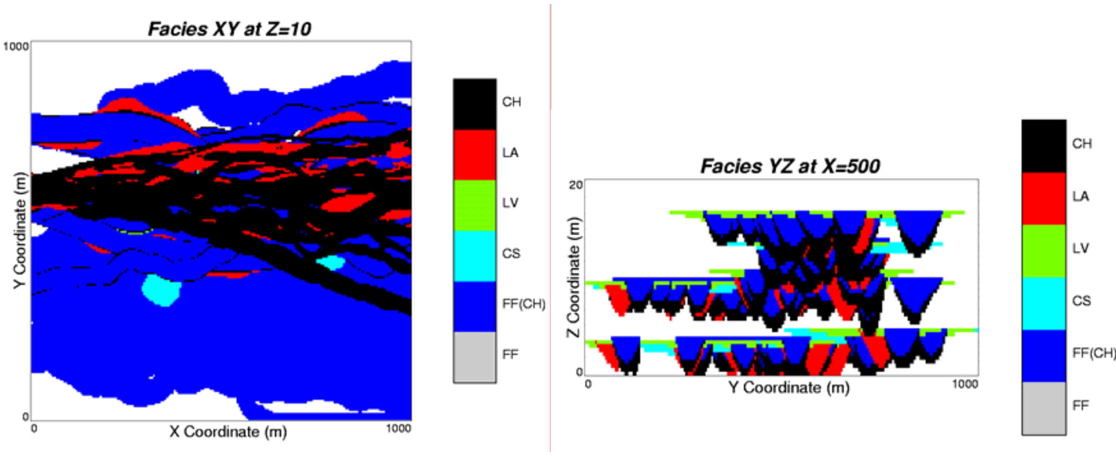


Figure 3-21: Effect of fine grained abandoned channel fill element on architectural element models.

3.1.2.4 Event Schedule Parameters

Flow events and controlling parameters are briefly described as follows:

Avulsion

Avulsion can occur when an active channel changes its path or when an active channel is abandoned and previously inactive one gets activated. Avulsion in Alluvsim refers to the second case while migration refers to the first case. The parameters control this event are probability of avulsion proximal to the model (probAvulOutside) and probability of avulsion within the model (probAvulInside). The location of avulsion is implemented using the concept that avulsion is more likely to occur at the locations of high curvature.

Migration

Migration occurs when an entire meander loop migrates and may be abandoned which results in neck cut offs and chute channels (the channel cuts across the point bar). The parameters control this event include probabilities of avulsion and maximum migration distance (mdistMigrate and stdevdistMigrate).

Aggradation

Aggradation occurs when a channel deposits sediments in the channel and over bank environments. This process is represented by an incremental increase in the elevation of a streamline. So the parameters used for controlling this event are the number of elevation levels (nlevel) and the Z location of each level. Aggradation is also constrained by the vertical trend supplied by the user.

The effect of event schedule parameters will be illustrated along with examples as follows.

Avulsion and Migration

Avulsion and migration events can be defined by the user through the probabilities of avulsion parameters, including the probability of avulsion proximal to the model (probAvulOutside) and that within the model (probAvulInside). Migration is controlled by these two parameters because the current Alluvsim implements in such a way that the sum of probabilities of meander migration, avulsion at proximal, and avulsion within the model must be equal to one. The following figure illustrates how these parameters control avulsion and migration events. Note that the source location (position along the proximal edge of the model) is 500 m and the azimuth of each streamline is 90 degree.

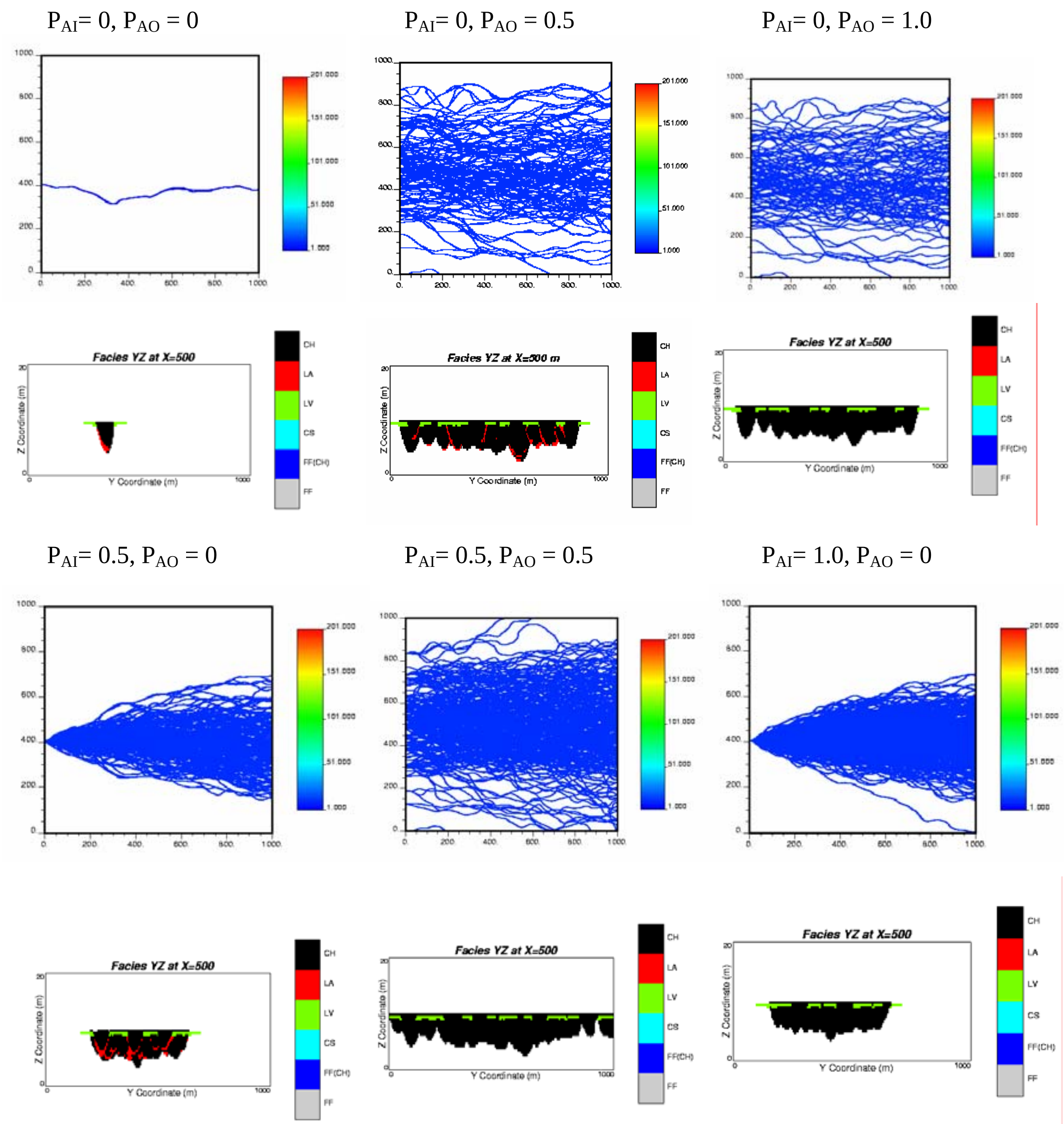


Figure 3-22: Effect of probabilities of avulsion.

Migration

As mentioned earlier, probability of migration is set through probAvulOutside and probAvulInside parameters. Another parameter that affects this event is maximum meander migration distance (mdistMigrate and stdevdistMigrate). Figure 3-23 shows the effect of maximum migration distance. Note that these models were constructed for full migration event, that is probAvulOutside and probAvulInside are 0.

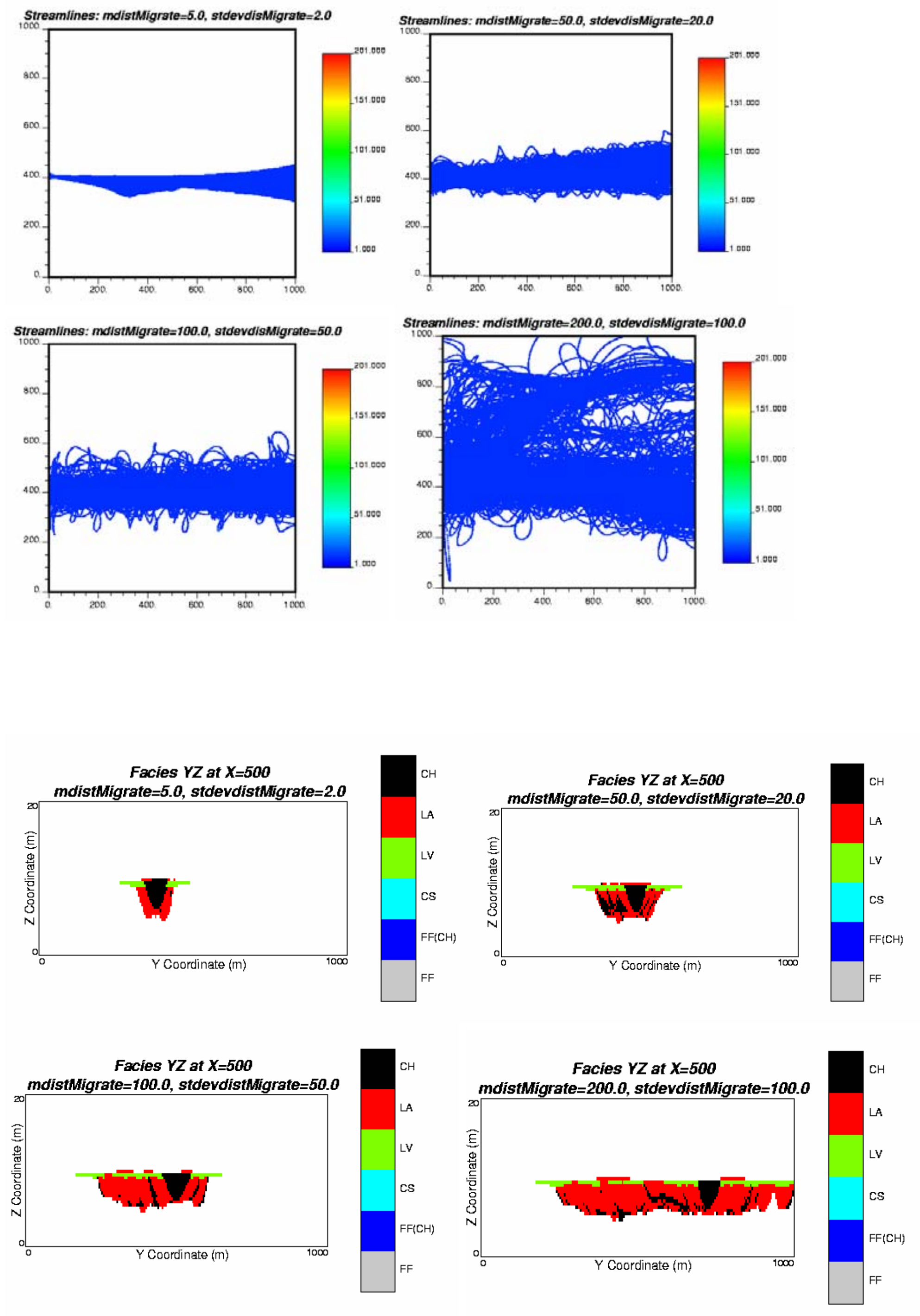


Figure 3-23: Effect of maximum meander migration distance.

Aggradation

The parameters used for controlling aggradation event are the number of elevation levels (nlevel) and vertical spacing of channels relative to Z=0 at the base of the model. The effect of number of aggradation levels in combination with other events are shown in Figure 3-24 to Figure 3-26. Figure 3-24 illustrates the effect of aggradation and full meander migration (probability of avulsion = 0). Figure 3-25 illustrates the effect of aggradation combined with avulsion and migration (probability of avulsion = 0.6). Figure 3-26 illustrates the effect of aggradation and avulsion (probability of avulsion = 1.0). It can be seen that when the lower probAvulOutside and probAvulInside are, the more channels are amalgamated.

The following conclusions can be drawn from these various combination:

1. low aggradation level and low avulsion probability result in well developed LA elements (see Figure 3-24 for nlevel = 1).
2. low aggradation level and high avulsion probability result in amalgamated reservoir (see Figure 3-26 for nlevel =1). How far the amalgamated channel is at different location in X direction depends on the values of avulsion probabilities at proximal and within the model (see Figure 3-26 for nlevel=1).
3. high aggradation level and low avulsion probability result in isolated LA element lenses or PV type shoestring reservoirs (see Figure3-24 for nlevel=6).
4. the higher aggradation level and avulsion probability are, the more disperse the channels become (compare Figure 3-25 and Figure 3-26 for all nlevel).

Aggradation level (nlevel) = 1 **Aggradation level (nlevel) = 3** **Aggradation level (nlevel) = 6**

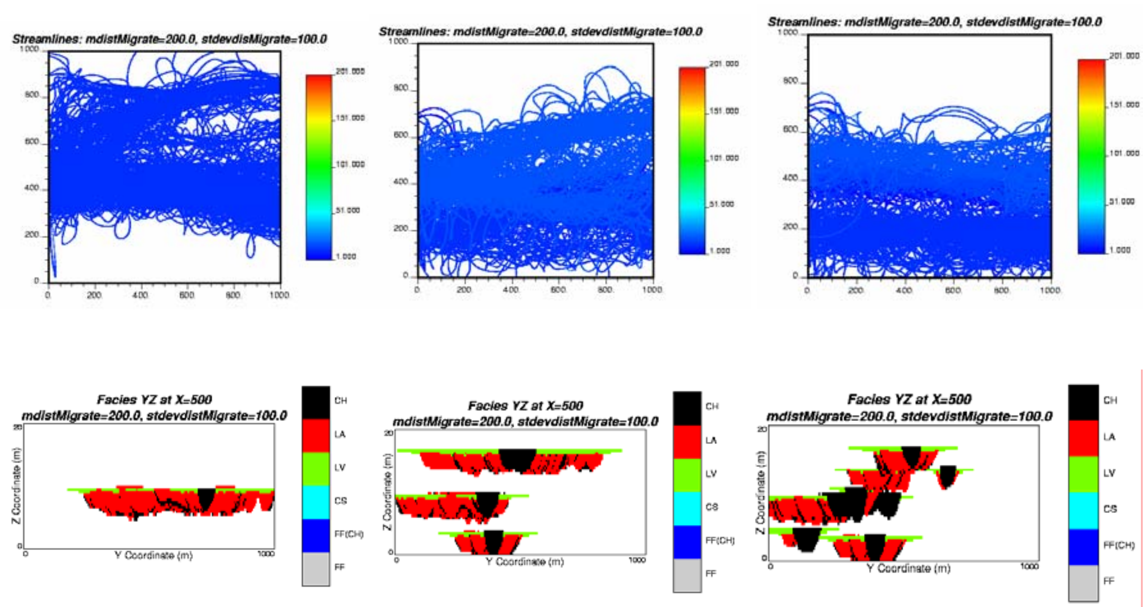
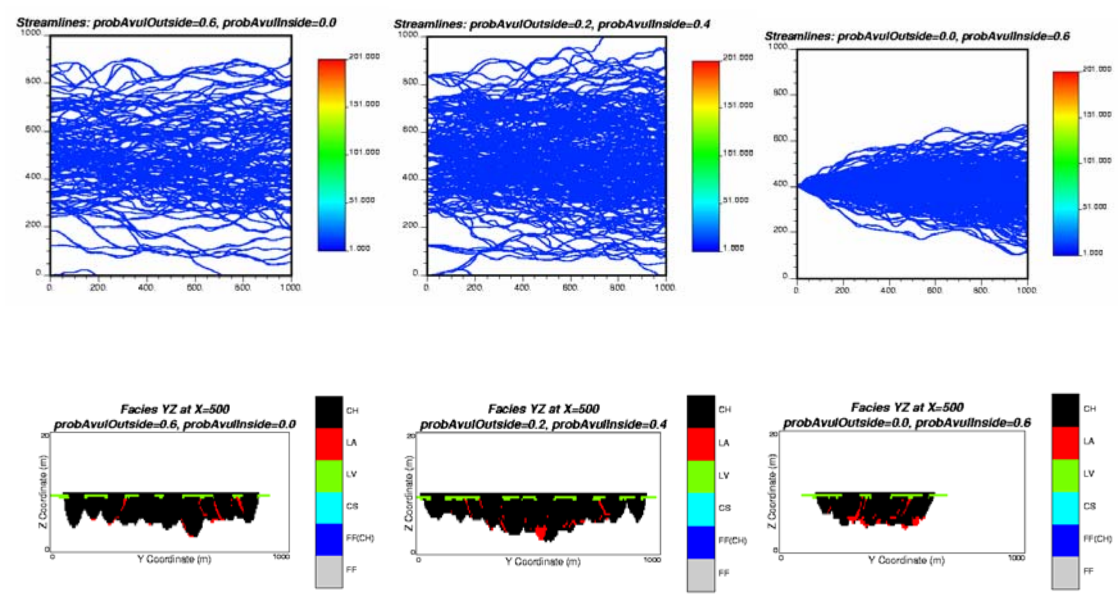
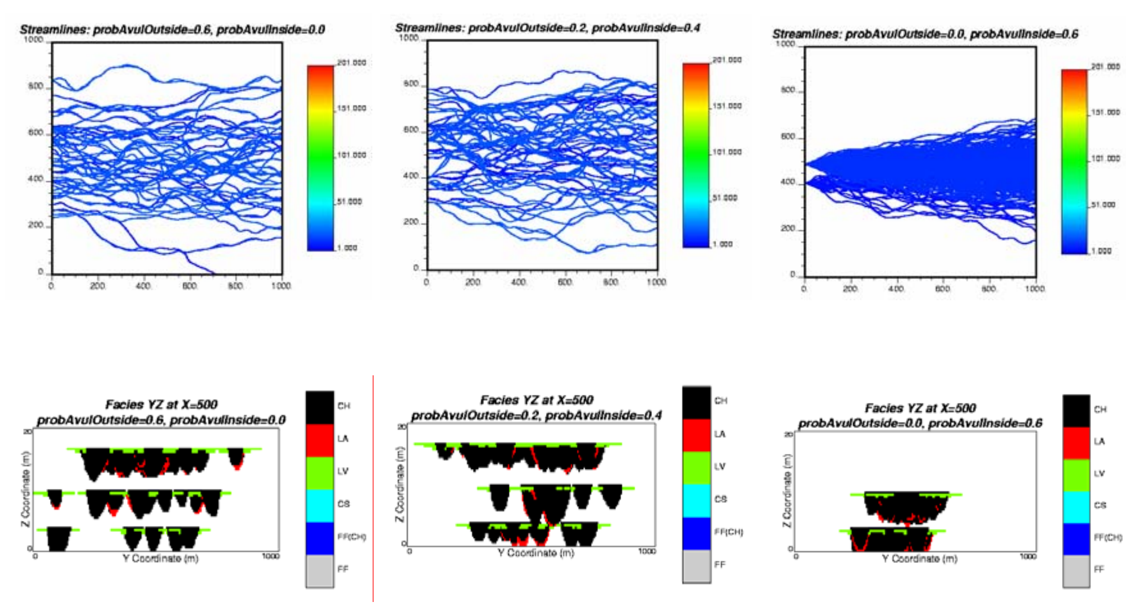


Figure 3-24: Effect of aggradation and migration.

Aggradation level (nlevel) = 1



Aggradation level (nlevel) = 3



Aggradation level (nlevel) = 6

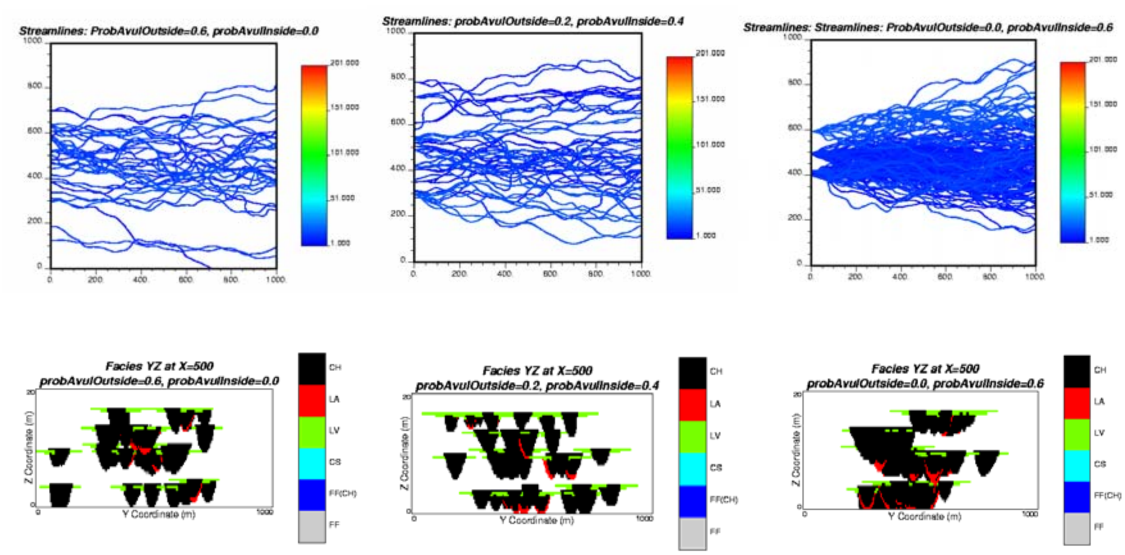
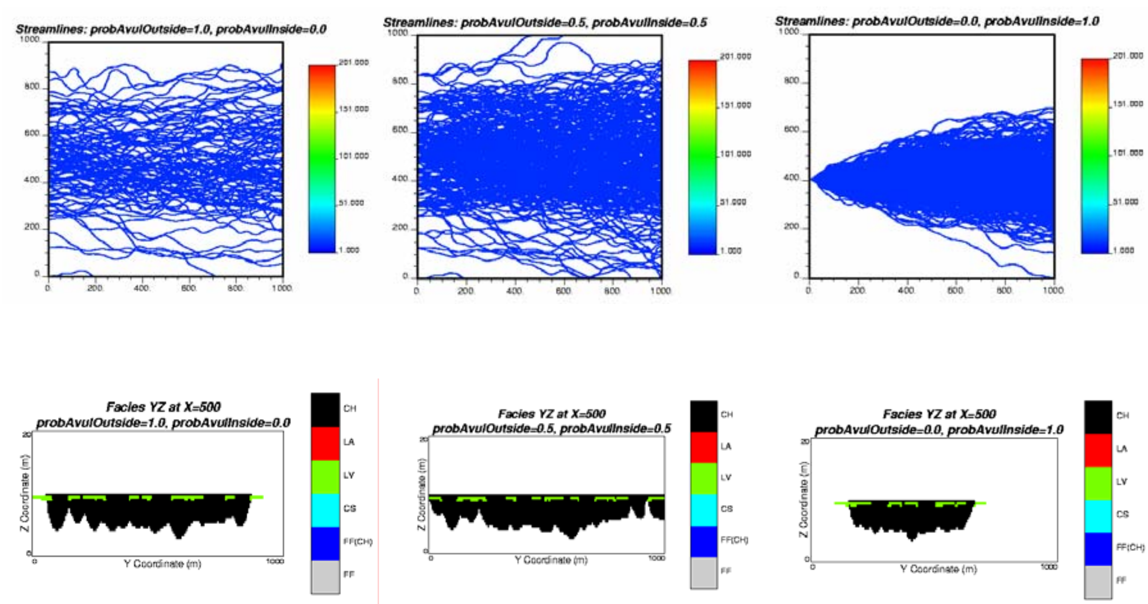
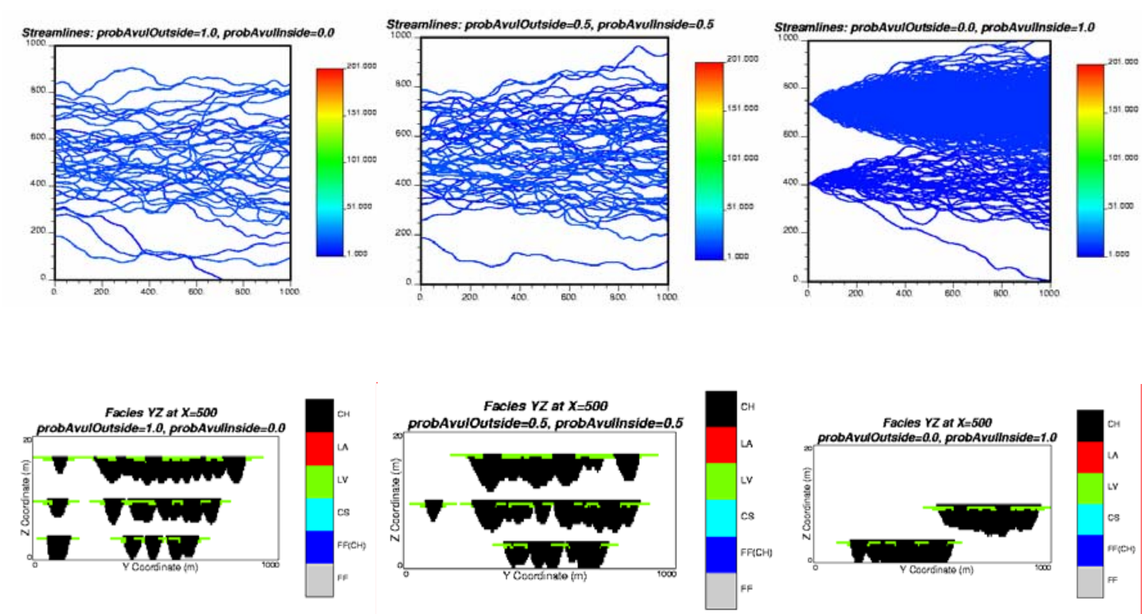


Figure 3-25: Effect of aggradation, avulsion, and migration.

Aggradation level (nlevel) = 1



Aggradation level (nlevel) = 3



Aggradation level (nlevel) = 6

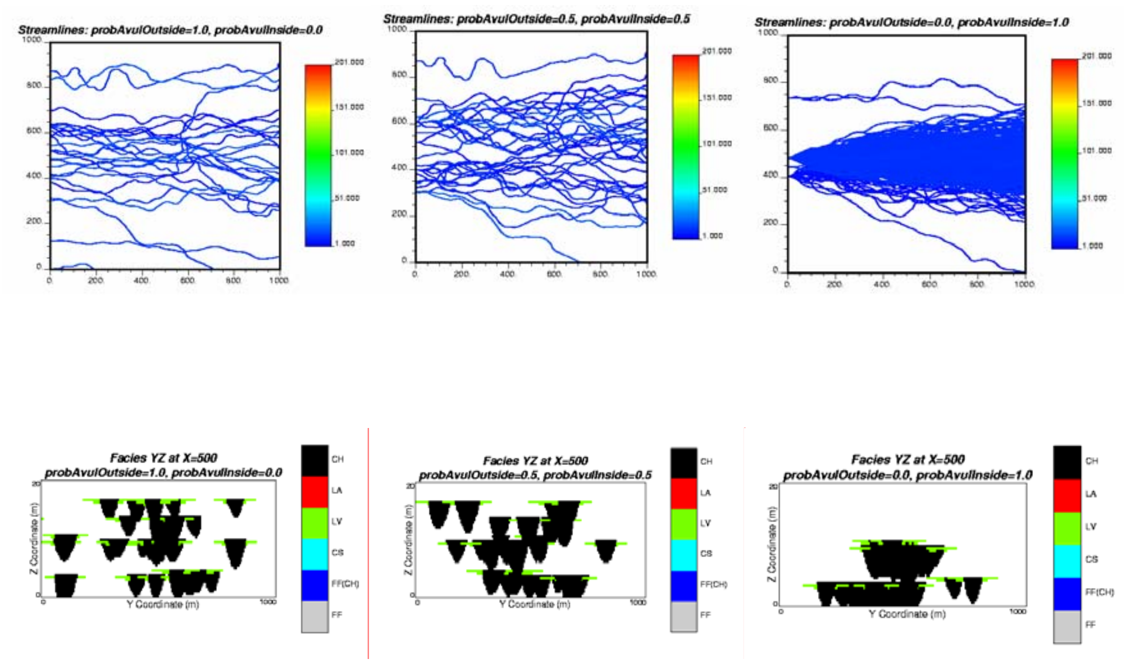


Figure 3-26: Effect of aggradation and avulsion.

3.1.2.5 Conditioning Parameters

As mentioned earlier, Alluvsim program can be used for unconditional or conditional runs. This can be done by specifying the name of the well data file to perform conditional runs. Without the well data file, the program presumes to perform unconditional runs. The effect of different combinations of the number of wells and net intervals is illustrated in Figure 3-27 to 3-31. Although the best streamlines are selected before being placed to honor the well intercept as closely as possible, unwarranted intercepts may be observed especially in the models constructed to honor higher number of wells and intervals. This is because the current implementation allows constructing the model with unwarranted intercept streamlines if a better candidate is not found within the allowable drawing times. The well data used including well locations and net intervals is shown in Table 3-2.

Table 3-2: Well data

Well number	X coordinate (m)	Y coordinate (m)	Z top elevation (m)	Z bottom elevation (m)
1	500	200	13.1	10.0
2	500	500	17.0 7.1	15.1 4.3
3	500	800	13.1	10.0
4	200	500	7.1 13.1	4.3 10.0
5	875	500	7.1	4.3

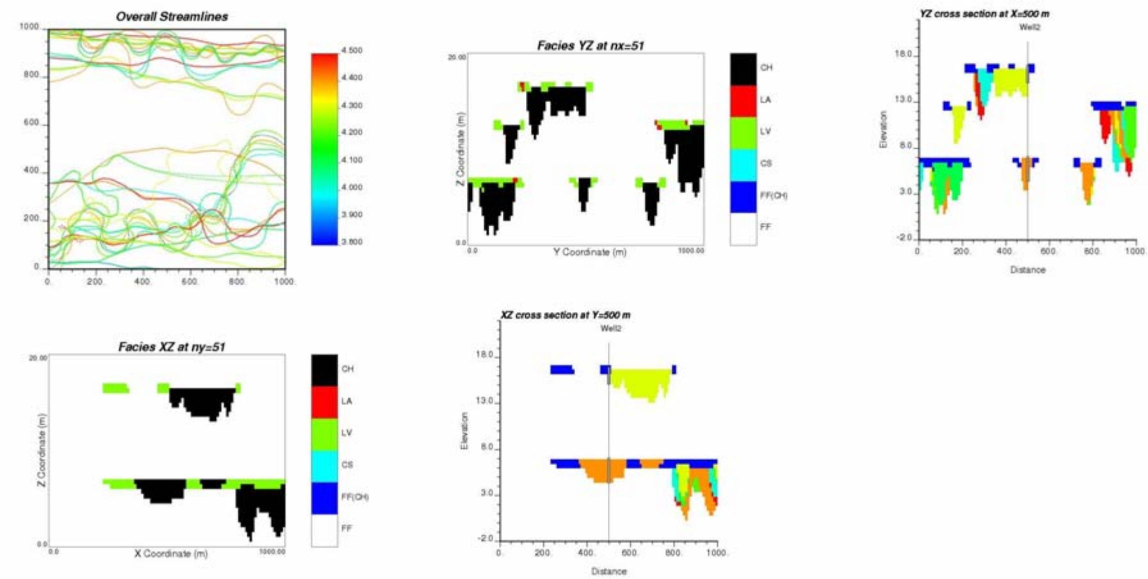


Figure 3-27: Overall streamline model and YZ and XZ cross sections of facies model to honor 1 well and 2 intervals.

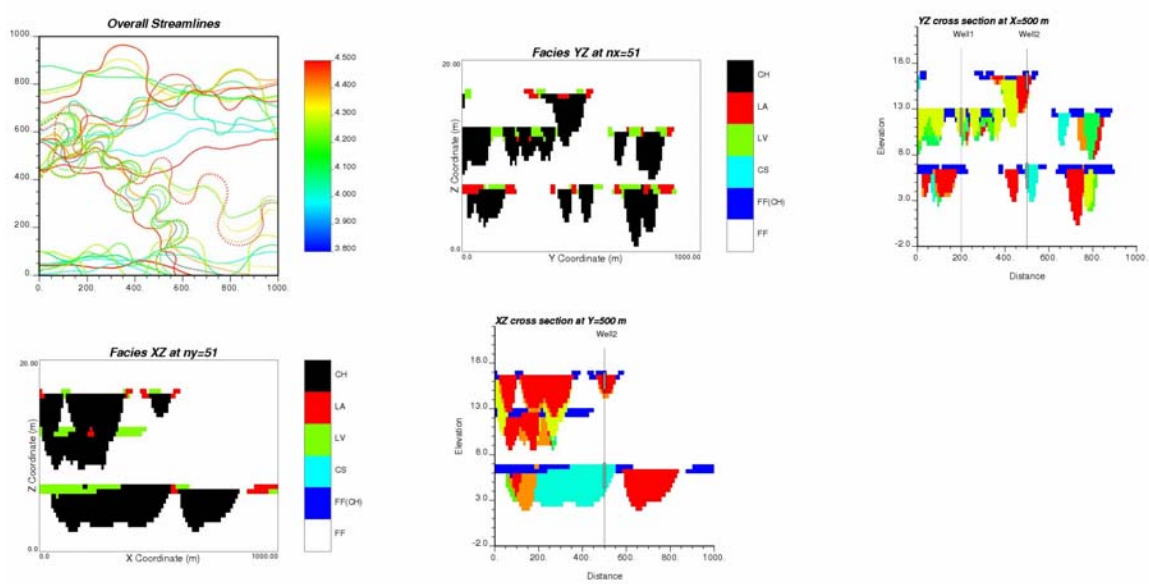


Figure 3-28: Overall streamline model and YZ and XZ cross sections of facies model to honor 2 wells and 3 intervals.

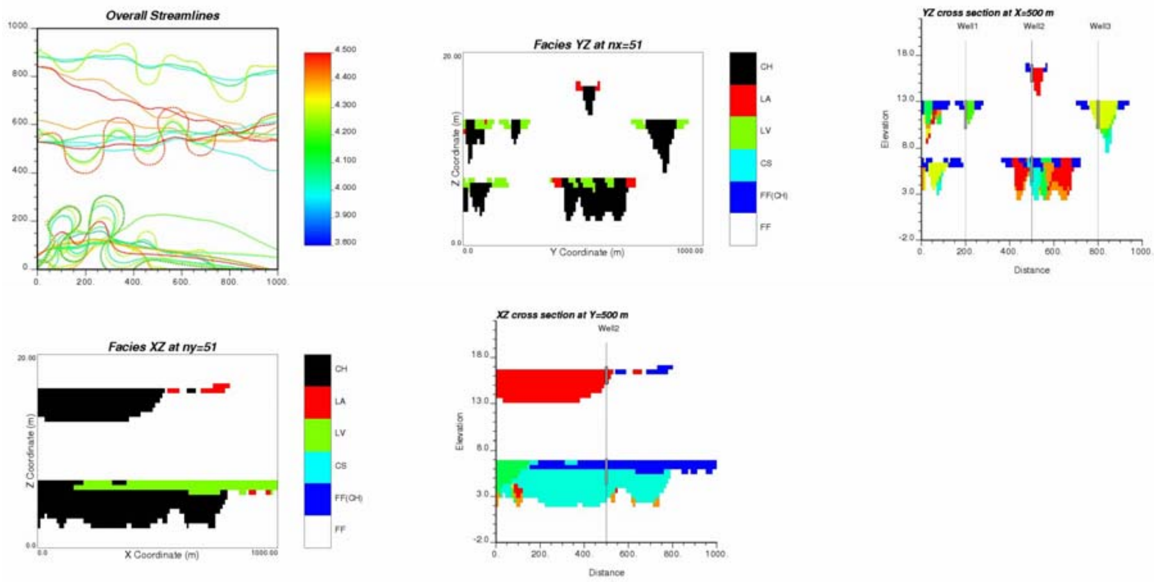


Figure 3-29: Overall streamline model and YZ and XZ cross sections of facies model to honor 3 wells and 4 intervals.

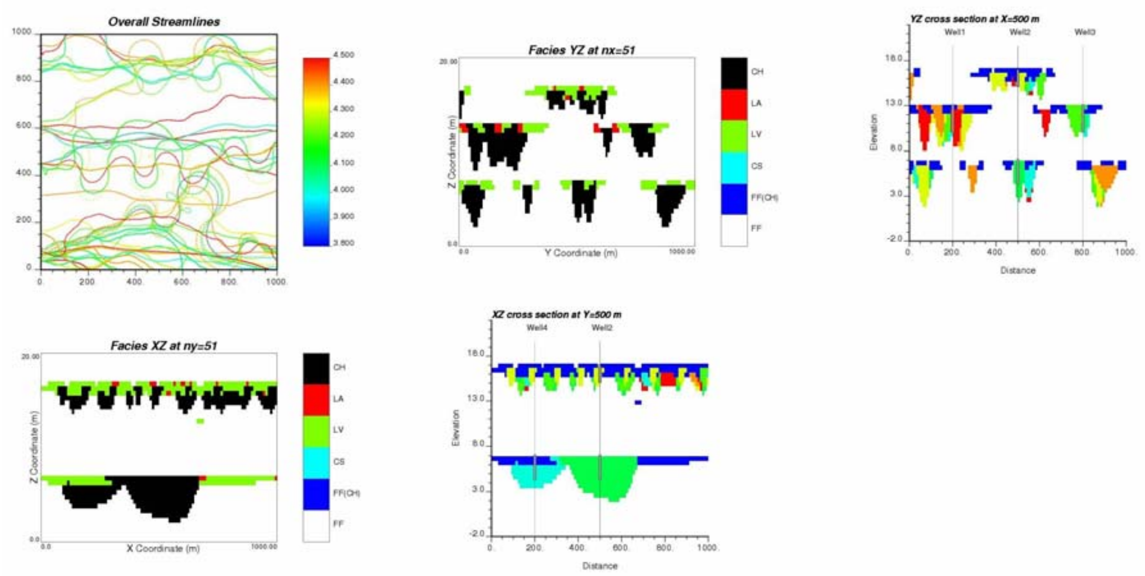


Figure 3-30: Overall streamline model and YZ and XZ cross sections of facies model to honor 4 wells and 5 intervals.

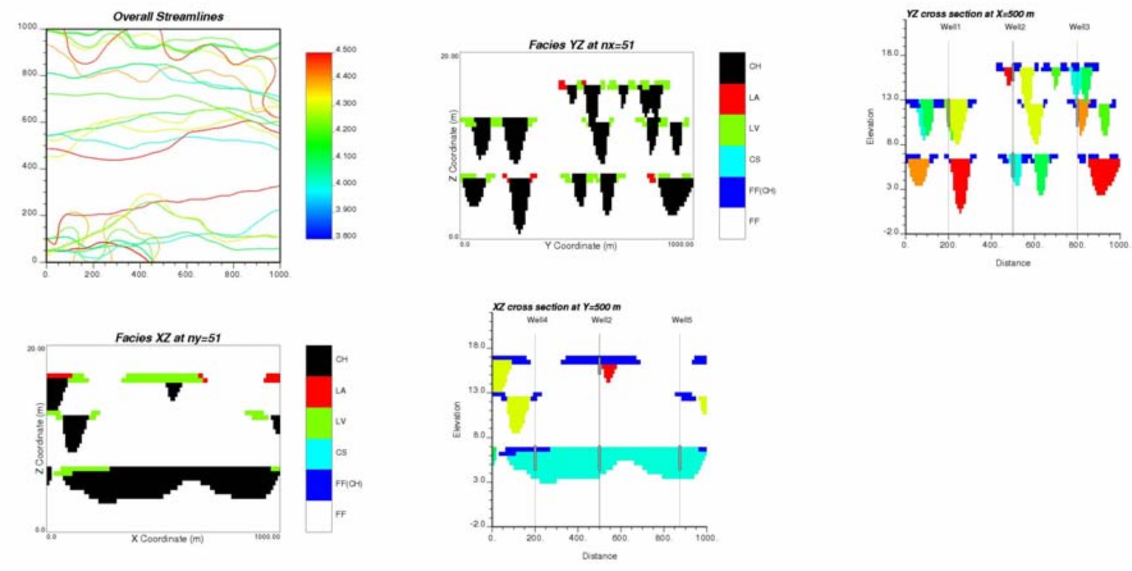


Figure 3-31: Overall streamline model and YZ and XZ cross sections of facies model to honor 5 wells and 6 intervals.

4 How to Set Up and Run Alluvsim

This section will briefly describe the software needed to run Alluvsim and to visualize the output results followed by the steps in running them to obtain the results successfully. The source code is fairly standard FORTRAN and could be compiled on other machines; this discussion focuses on the PC.

4.1 Software Requirements

Alluvsim will run on any 32 bit versions of Windows operating system, including Windows 9x/2000/NT/XP/ME. All you need is Alluvsim application. The source code and executable files for Alluvsim can be downloaded from the CCG website (www.uofaweb.ualberta.ca/ccg). GSLIB contains utility programs that can be used to generate graphics as PostScript files, which can be displayed with a PostScript viewer. GSLIB can be downloaded from www.statios.com. A demo version of WinGslib, which is a graphical interface for GSLIB, can also be downloaded for a 30 day trial. For convenience, these websites also provide the link for downloading GSView and Ghostscript that are needed for viewing PostScript files generated from GSLIB.

Since Alluvsim is a Win32 console application, it will be run under DOS environment. For those who prefer to run under Linux-like environment, Cygwin can be used and downloaded from http://cygwin.com. The Cygwin script can be prepared for multiple runs with different data inputs. Examples of Cygwin scripts can be seen in directory: script/example.

4.2 How to Run Alluvsim

This section describes what needs to be prepared before starting to run Alluvsim program and the steps in running it.

4.2.1 Input Requirement

As described in Section 2, the program will build the fluvial model as specified by the user. These input parameters play a major role in the geometry of the created objects. Therefore, it is necessary for the user to understand what these parameters are and what values they should be assigned. Please refer to Section 3 for more details on how to prepare this input file.

4.2.2 Running the Application

The following steps are used to run the Alluvsim application.

1. To run Alluvsim application, double click Alluvsim executable file in the directory containing this file. A shortcut to Alluvsim application can be created for easy access at a later time.

Alternatively, it can be run in DOS or Cygwin window. First, either give a full pathname for Alluvsim or go to the directory containing Alluvsim executable file. Then, type the command 'alluvsim' to run Alluvsim.

2. A console window will appear with the following information:

   alluvsim Version: 1.000

   Which parameter file do you want to use?

3. At this point, the user has two options to supply the parameter file. The user can either use the generated parameter file or his/her own parameter file.

   To use the generated input parameter file, just press <enter>. Please note that the generated parameter file (allumsim.par) can be edited for later runs. To use your own input parameter file, enter the path name of the file. Then, the program will start running by echoing the data in the input parameter file first followed by displaying the steps in streamline operations at each time step. The program will continue to run until it reaches the maximum number of time step or the specified NTGtarget for all elevation levels. Then the program will be terminated.

   To terminate the program at anytime, press <Ctrl + C> and then the console window will disappear.

4. Once the program finishes running, the result will be written to two output files for constructed models, one for the streamlines and another for the facies, with the names specified in the parameter file. The third output file summarizes a measure of fitness to the conditioning data for each model constructed at different realization. The user then can select the best match to plot the constructed model. Cygwin script for constructing models at different realizations can be found in directory: script/realization.

5. As mentioned earlier, GSLIB has the utility programs to plot these output files. Location maps (locmap) should be used for plotting streamlines while gray- or color-scale maps (pixelplt) can be used for plotting facies in different cross sections. Parameter files are also needed to do these plotting, examples of these input parameters are shown inside the Cygwin script in directory: script/example. In addition, labels and title of these plots can be further modified by text editing the code of these output PostScript files.

   It should be noted that script can be written to combine all the commands to run Alluvsim and GSLIB in one file. This is convenient for running multiple Alluvsim parameter files and associated visualizations. Section 5 provides one example of Cygwin script file and more can be found in directory: script/example.

To run Cygwin script file, do the followings:

1. Launching Cygwin window.
2. Type the full pathname of the script file or change directory to where the script file is.
3. Type the command 'bash run.cyg' (assuming run.cyg is the name of the script file). It will start running according to the commands given in run.cyg.

5 Examples of Alluvsim Unconditional Runs for Different Reservoir Types

This section describes five example Alluvsim models that are based on PV, CB, and SH reservoir types. These models demonstrate the flexibility of the streamline based fluvial technique and provide suggestions for parameter assignment to construct models of each reservoir type.

5.1 Paleo-Valley (PV) Shoestring Type Reservoir

The PV reservoir type is typified by a collection of many shoe string ribbon sand bodies. These channels may be straight to highly sinuous and may contain estuary components. kilometers across with a thickness of several tens of meters. Example of Cygwin script with input parameters for this reservoir type is shown below and can also be found in directory: script/example. It is followed by the resulting streamlines and cross sections.These reservoirs may extend for tens of kilometres along the channels and a few

Cygwin Script with Input Parameters

```
#! /bin/sh
xyslice1=11
xyslice2=25
xyslice3=33

yzslice1=2
yzslice2=100
yzslice3=99

xzslice2=25
xzslice1=50
xzslice3=90

nx=200
ny=200
nz=50

xmn=2.5
ymn=2.5
zmn=0.2

xsiz=5.0
ysiz=5.0
zsiz=0.4
```

```
xyslice1=11
xyslice2=25
xyslice3=33

yzslice1=2
yzslice2=100
yzslice3=99

xzslice2=25
xzslice1=50
xzslice3=90

xmin=0.0
ymin=0.0

xmax=1000.0
ymax=1000.0

vex=20.0

cmin=1
cmax=200
icolor=1

cat<<END>temp.par

          Parameters for Alluvsim Shoestring
          *****************************

START OF PARAMETERS:

none                              - file with well data
0 0 0 0 0 0                       - wcol,xcol,ycol,ztcol,zbcol,fcol
0.0 0.0 0.0                       - xanis,yanis,zanies
0.0 0.0                           - buffer,ztol
horitrend.dat                     - file with the horizontal trend
1                                 - htcol
verttrend.dat                     - file with the vertical trend
1                                 - vtcol
200 200 200                       - ntime,max_assoc,max_withinassoc
7 2. 4. 5. 10. 11. 14. 17.        - nlevel,level elevations
0.10 50.0 20.0                    - NTGtarget,mdistMigrate,stdevdistMigrate
100 10 10                         - CHndraw,ndiscr,nCHcor
1.0 0.0                           - probAvulOutside,probAvulInside
90.0   1.0                        - CH element: mCHazi,stdevCHazi
500.0 150.0                       - CHsource,stdevCHsource
2.0 0.5 0.2                       - mCHdepth,stdevCHdepth,stdevCHdepth2
```

```
10.0 2.0                        - mCHwdratio,stdevCHwdratio
1.5 0.1                         - mCHsinu,stdevCHsinu
1.0 0.1                         - LV Element: mLVdepth,stdevLVdepth
80.0 5.0                        - mLVwidth,stdevLVwidth
1.5 0.2                         - mLVheight,stdevLVheight
0.0 0.0                         - mLVasym,stdevLVasym
0.0 0.0                         - mLVthin,stdevLVthin
2 1                             - CS Element: mCSnum,stdevCSnum
3 2                             - mCSnumlobe,stdevCSnumlobe
50.0 20.0                       - mCSsource,stdevCSsource
200.0 50.0                      - mCSLOLL,stdevCSLOLL
150.0 30.0                      - mCSLOWW,stdevCSLOWW
50.0 20.0                       - mCSLOl,stdevCSLOl
150.0 30.0                      - mCSLOw,stdevCSLOw
0.000 0.000                     - mCSLO_hwratio,stdevCSLO_hwratio
0.010 0.005                     - mCSLO_dwratio,stdevCSLO_dwratio
0.0  0.0                        - FFCH Element: mFFCHprop,stdevFFCHprop
$nx $xmn $xsiz                  - nx,xmn,xsiz
$ny $ymn $ysiz                  - ny,ymn,ysiz
$nz $zmn $zsiz                  - nz,zmn,zsiz
69069 0.05                      - random number seed,color_incr
alluvsimshoestring.out          - file for output facies file
streamlineshoestring.out        - file for output streamlines
none                            - file for measure of fitness with well data

END

alluvsim temp.par

cat<<END>temp.par

          Parameters for PIXELPLT
          ***********************

START OF PARAMETERS:

alluvsimshoestring.out          - file with gridded data
1                               - column number for variable
0.0  1.0e21                     - data trimming limits
faciesxy1.ps                    - file with PostScript output
1                               - realization number
$nx $xmn $xsiz                  - nx,xmn,xsiz
$ny $ymn $ysiz                  - ny,ymn,ysiz
$nz $zmn $zsiz                  - nz,zmn,zsiz
1                               - slice orientation: 1=XY, 2=XZ, 3=YZ
$xyslice1                       - slice number
Facies XY=$xyslice1
```

```
X Coordinate (m)                 - X label
Y Coordinate (m)                 - Y label
0                                -0=arithmetic, 1=log scaling
$icolor 0                        -0=gray scale, 1=color scale
0                                -0=continuous, 1=categorical
0.0  4.5  0.5                    -continuous:  min, max, increm.
6                                -categorical: number of categories
0    7    Flood_Plain            -category(), code(), name()
1    5    Oxbow_Lake
2    3    Point_Bar
3    1    Channel
4    10   Levee
5    6    Crevasse Splay

Color Codes for Categorical Variable Plotting:
     1=red, 2=orange, 3=yellow, 4=light green, 5=green, 6=light blue,
     7=dark blue, 8=violet, 9=white, 10=black, 11=purple, 12=brown,
     13=pink, 14=intermediate green, 15=gray

END

pixelplt temp.par

cat<<END>temp.par

               Parameters for PIXELPLT
               ***********************

START OF PARAMETERS:
alluvsimshoestring.out           - file with gridded data
1                                - column number for variable
0.0  1.0e21                      - data trimming limits
faciesyz1.ps                     - file with PostScript output
1                                - realization number
$nx $xmn $xsiz                   - nx,xmn,xsiz
$ny $ymn $ysiz                   - ny,ymn,ysiz
$nz $zmn $zsiz                   - nz,zmn,zsiz
3  $vex                          - slice orientation: 1=XY, 2=XZ, 3=YZ
$yzslice1                        - slice number
Facies YZ=$yzslice1
Y Coordinate (m)                 - X label
Z Coordinate (m)                 - Z label
0                                - 0=arithmetic, 1=log scaling
$icolor 1 600                    - 0=gray scale, 1=color scale
0                                - 0=continuous, 1=categorical
2.0  3.5  0.5                    - continuous:  min, max, increm.
6                                - categorical: number of categories
```

```
0    7    Flood_Plain                 - category(), code(), name()
1    5    Oxbow_Lake
2    3    Point_Bar
3    1    Channel
4    10   Levee
5    6    Crevasse Splay

Color Codes for Categorical Variable Plotting:
     1=red, 2=orange, 3=yellow, 4=light green, 5=green, 6=light blue,
     7=dark blue, 8=violet, 9=white, 10=black, 11=purple, 12=brown,
     13=pink, 14=intermediate green, 15=gray

END

pixelplt temp.par

cat<<END>temp.par

               Parameters for PIXELPLT
               ***********************

START OF PARAMETERS:

alluvsimshoestring.out        - file with gridded data
1                             - column number for variable
0.0  1.0e21                   - data trimming limits
faciesxy2.ps                  - file with PostScript output
1                             - realization number
$nx $xmn $xsiz                - nx,xmn,xsiz
$ny $ymn $ysiz                - ny,ymn,ysiz
$nz $zmn $zsiz                - nz,zmn,zsiz
1                             - slice orientation: 1=XY, 2=XZ, 3=YZ
$xyslice2                     - slice number
Facies XY=$xyslice2
X Coordinate (m)              - X label
Y Coordinate (m)              - Y label
0                             - 0=arithmetic, 1=log scaling
$icolor 0                     - 0=gray scale, 1=color scale
0                             - 0=continuous, 1=categorical
2.0  3.5  0.5                 - continuous:  min, max, increm.
6                             - categorical: number of categories
0    7    Flood_Plain         - category(), code(), name()
1    5    Oxbow_Lake
2    3    Point_Bar
3    1    Channel
4    10   Levee
5    6    Crevasse Splay
```

```
Color Codes for Categorical Variable Plotting:
     1=red, 2=orange, 3=yellow, 4=light green, 5=green, 6=light blue,
     7=dark blue, 8=violet, 9=white, 10=black, 11=purple, 12=brown,
     13=pink, 14=intermediate green, 15=gray

END

pixelplt temp.par

cat<<END>temp.par

               Parameters for PIXELPLT
               ***********************

START OF PARAMETERS:
alluvsimshoestring.out            - file with gridded data
1                                 - column number for variable
0.0  1.0e21                       - data trimming limits
faciesyz2.ps                      - file with PostScript output
1                                 - realization number
$nx $xmn $xsiz                    - nx,xmn,xsiz
$ny $ymn $ysiz                    - ny,ymn,ysiz
$nz $zmn $zsiz                    - nz,zmn,zsiz
3  $vex                           - slice orientation: 1=XY, 2=XZ, 3=YZ
$yzslice2                         - slice number
Facies YZ=$yzslice2
Y Coordinate (m)                  - X label
Z Coordinate (m)                  - Z label
0                                 - 0=arithmetic, 1=log scaling
$icolor 1 600                     - 0=gray scale, 1=color scale
0                                 - 0=continuous, 1=categorical
0.0  4.5  0.5                     - continuous:  min, max, increm.
6                                 - categorical: number of categories
0    7    Flood_Plain             - category(), code(), name()
1    5    Oxbow_Lake
2    3    Point_Bar
3    1    Channel
4    10    Levee
5    6    Crevasse Splay

Color Codes for Categorical Variable Plotting:
     1=red, 2=orange, 3=yellow, 4=light green, 5=green, 6=light blue,
     7=dark blue, 8=violet, 9=white, 10=black, 11=purple, 12=brown,
     13=pink, 14=intermediate green, 15=gray

END
```

```
cat<<END>temp.par

                  Parameters for LOCMAP
                  *********************

START OF PARAMETERS:

streamlineshoestring.out          - file with data
2   3   4                         - columns for X, Y, variable
0.   100000.                      - trimming limits
locmaptime.ps                     - file for PostScript output
$xmin $xmax                       - xmn,xmx
$ymin $ymax                       - ymn,ymx
0                                 - 0=data values, 1=cross validation
0                                 - 0=arithmetic,  1=log scaling
$icolor 0                         - 0=gray scale,  1=color scale
-1                                - 0=no labels,   1=label each location
$cmin $cmax    50.                - gray/color scale: min, max, increm
0.1                               - label size: 0.1(sml)-1(reg)-10(big)
Streamlines
1 0 1                             - kline,kpies,kdots
1                                 - category column

END

locmap temp.par

cat<<END>temp.par

                  Parameters for PLOTEM
                  *********************

START OF PARAMETERS:

alluvsimshoestring.ps             - output file
2  2  1.1                         - number of plots in X and Y
faciesxy1.ps
faciesxy2.ps
locmaptime.ps
faciesyz1.ps

END

plotem temp.par

rm temp.par
rm faciesxy1.ps faciesxy2.ps
```

rm faciesyz1.ps faciesyz2.ps
rm locmaptime.ps

PostScript Output

An example of low NTG PV type reservoir model is shown in Figure 5-1.

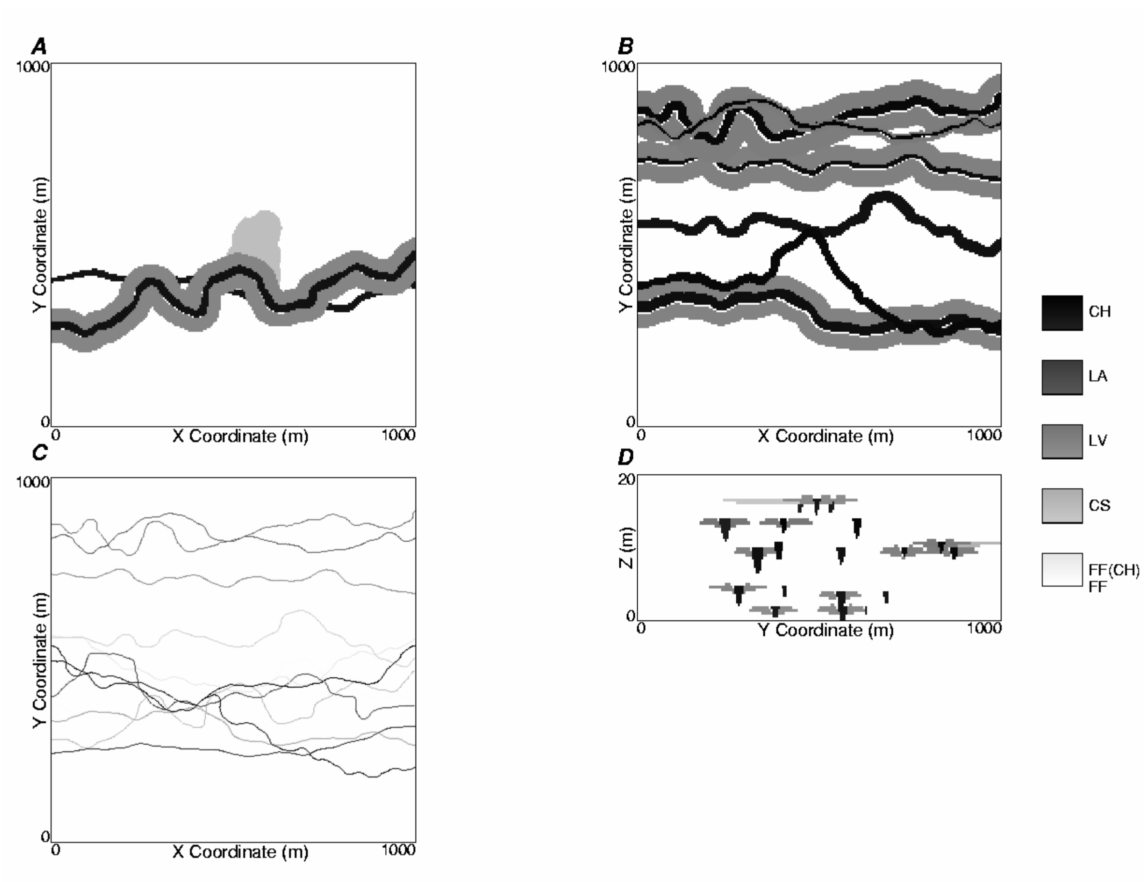


Figure 5-1: An example Alluvsim PV type reservoir model. A – plan section (Z=5 m), B – plan section (Z=10 m), C – all streamlines (grey scale from 1=white to n=black) and D – cross section (X=10 m). Note grey scale assignment for architectural elements is varied to aid in differentiating amalgamated elements.

5.2 Channel and Bar Bodies (CB) Type Jigsaw Reservoir

The jigsaw reservoir type is characterized by high NTG with no major gaps. These reservoir form from coarse grained meandering and braided fluvial styles. In these coarse grained systems, the channels typically have high width to depth ratios. Example of input parameters for this reservoir type is shown below followed by the resulting streamlines and cross sections. Cygwin script for this example can be found in directory: script/example.

Input Parameters

```
                    Parameters for Alluvsim JigSaw
                    ***************************

START OF PARAMETERS:
none                             - file with well data
0 0 0 0 0 0                      - wcol,xcol,ycol,ztcol,zbcol,fcol
0.0 0.0 0.0                      - xanis,yanis,zanies
0.0 0.0                          - buffer,ztol
horitrend.dat                    - file with the horizontal trend
1                                - htcol
verttrend.dat                    - file with the vertical trend
1                                - vtcol
300 300 300                      - ntime,max_assoc,max_withinassoc
6 4. 5. 10. 11. 14. 17.          - nlevel,level elevations
0.30 50.0 20.0                   - NTGtarget,mdistMigrate,stdevdistMigrate
100 10 10                        - CHndraw,ndiscr,nCHcor
0.05 0.60                        - probAvulOutside,probAvulInside
90.0   1.0                       - CH element: mCHazi,stdevCHazi
500.0 150.0                      - CHsource, stdevCHsource
4.0 0.5 0.2                      - mCHdepth,stdevCHdepth,stdevCHdepth2
20.0 2.0                         - mCHwdratio,stdevCHwdratio
1.3 0.1                          - mCHsinu,stdevCHsinu
1.0 0.1                          - LV Element: mLVdepth,stdevLVdepth
100.0 5.0                        - mLVwidth,stdevLVwidth
0.0 0.0                          - mLVheight,stdevLVheight
0.0 0.0                          - mLVasym,stdevLVasym
0.0 0.0                          - mLVthin,stdevLVthin
-1 1                             - CS Element: mCSnum,stdevCSnum
0 2                              - mCSnumlobe,stdevCSnumlobe
50.0 20.0                        - mCSsource,stdevCSsource
200.0 50.0                       - mCSLOLL,stdevCSLOLL
150.0 30.0                       - mCSLOWW,stdevCSLOWW
50.0 10.0                        - mCSLOl,stdevCSLOl
150.0 30.0                       - mCSLOw,stdevCSLOw
0.000 0.000                      - mCSLO_hwratio,stdevCSLO_hwratio
0.010 0.005                      - mCSLO_dwratio,stdevCSLO_dwratio
0.7  0.05                        - FFCH Element: mFFCHprop,stdevFFCHprop
$nx $xmn $xsiz                   - nx,xmn,xsiz
$ny $ymn $ysiz                   - ny,ymn,ysiz
$nz $zmn $zsiz                   - nz,zmn,zsiz
69069 0.05                       - random number seed,color_incr
alluvsimjigsaw.out               - file for output facies file
streamlinejigsaw.out             - file for output streamlines
none                             - file for measure of fitness with well data
```

PostScript Output

As mentioned in Section 4, streamline and facies output files obtained from running Alluvsim can be visualized using GSLIB. Figure 5-2 shows the postscript output of streamlines, XY cross section, and YZ cross section for CB type jigsaw reservoir model. Note the braided and meandering streamline associations and the formation of FF(CH) baffles. The high NTG and poor preservation of FF elements is accomplished with a high NTG and few aggradation levels.

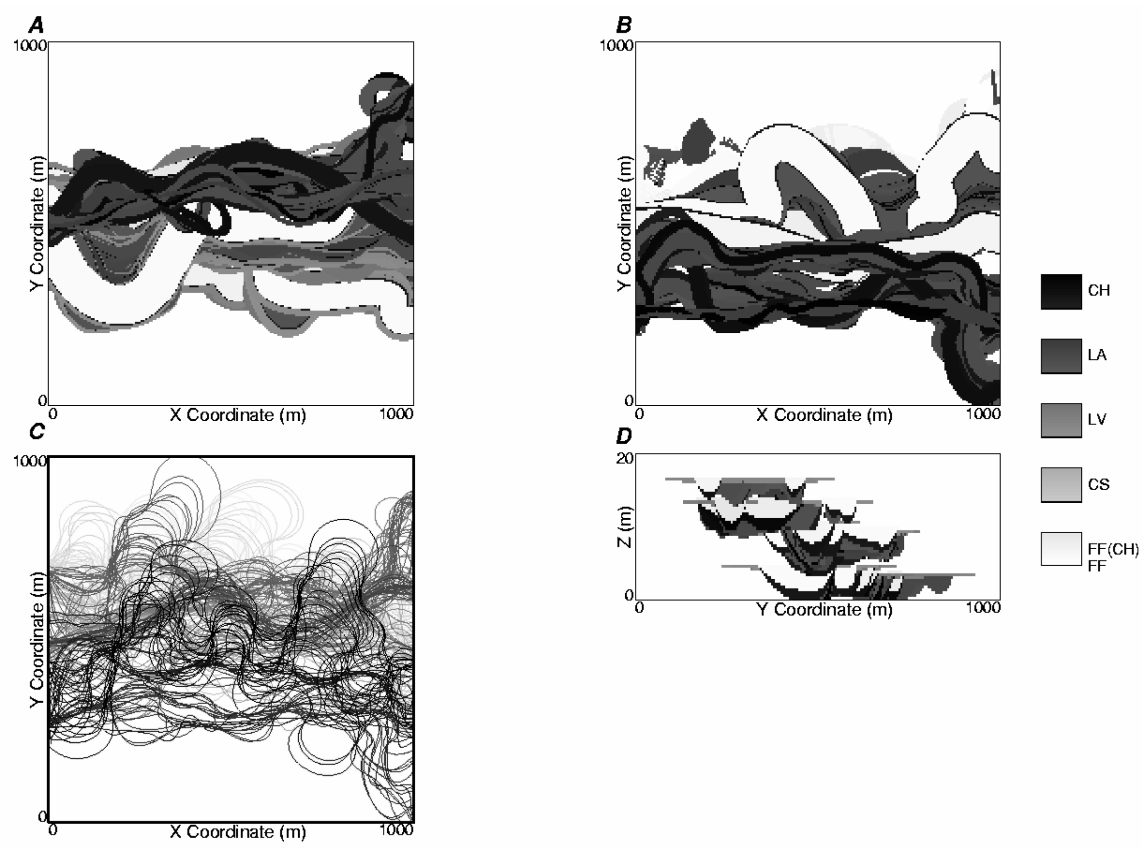


Figure 5-2: An example Alluvsim CB type jigsaw reservoir model. A – plan section (Z=5 m), B – plan section (Z=10 m), C – all streamlines (grey scale from 1=white to n=black) and D – cross section (X=10 m). Note grey scale assignment for architectural elements is varied to aid in differentiating amalgamated elements. Note the meandering and braided features in the streamlines.

5.3 Channel and Bar Bodies (CB) Type Labyrinth Reservoir

CB type labyrinth reservoirs are characterized by poorly connected associations of CH and LA element pods and lenses. These reservoirs often originate from fine grained and anastomosing fluvial styles. An example of input parameters used to construct CB type Labyrinth reservoir model is shown below followed by the resulting streamlines and facies model. Cygwin script for this example can be found in directory: script/example.

Input Parameters

```
                        Parameters for Alluvsim Labyrinth
                        *****************************

START OF PARAMETERS:
none                              - file with well data
0 0 0 0 0 0                       - wcol,xcol,ycol,ztcol,zbcol,fcol
0.0 0.0 0.0                       - xanis,yanis,zanies
0.0 0.0                           - buffer,ztol
horitrend.dat                     - file with the horizontal trend
1                                 - htcol
verttrend.dat                     - file with the vertical trend
1                                 - vtcol
300 300 300                       - ntime,max_assoc,max_withinassoc
9 4. 5. 6. 8. 10. 11. 14. 17. 19. - nlevel,level elevations
0.30 50.0 20.0                    - NTGtarget,mdistMigrate,stdevdistMigrate
100 10 10                         - CHndraw,ndiscr,nCHcor
0.05 0.05                         - probAvulOutside,probAvulInside
90.0   10.0                       - CH element: mCHazi,stdevCHazi
500.0 200.0                       - CHsource,stdevCHsource
4.0 0.5 0.2                       - mCHdepth,stdevCHdepth,stdevCHdepth2
20.0 2.0                          - mCHwdratio,stdevCHwdratio
1.3 0.1                           - mCHsinu,stdevCHsinu
1.0 0.1                           - LV Element: mLVdepth,stdevLVdepth
40.0 2.0                          - mLVwidth,stdevLVwidth
0.0 0.0                           - mLVheight,stdevLVheight
0.0 0.0                           - mLVasym,stdevLVasym
0.0 0.0                           - mLVthin,stdevLVthin
-1 1                              - CS Element: mCSnum,stdevCSnum
0 2                               - mCSnumlobe,stdevCSnumlobe
50.0 20.0                         - mCSsource,stdevCSsource
200.0 50.0                        - mCSLOLL,stdevCSLOLL
150.0 30.0                        - mCSLOWW,stdevCSLOWW
50.0 10.0                         - mCSLOl,stdevCSLOl
150.0 30.0                        - mCSLOw,stdevCSLOw
0.000 0.000                       - mCSLO_hwratio,stdevCSLO_hwratio
0.010 0.005                       - mCSLO_dwratio,stdevCSLO_dwratio
0.5  0.05                         - FFCH Element: mFFCHprop,stdevFFCHprop
$nx $xmn $xsiz                    - nx,xmn,xsiz
$ny $ymn $ysiz                    - ny,ymn,ysiz
$nz $zmn $zsiz                    - nz,zmn,zsiz
69069 0.05                        - random number seed,color_incr
alluvsimlabyrinth.out             - file for output facies file
streamlinelabyrinth.out           - file for output streamlines
none                              - file for measure of fitness with well data
```

PostScript Output

Figure 5-3 shows the postscript output of streamlines, XY cross section, and YZ cross section for CB type labyrinth reservoir model. Note the meandering and braided features in the streamlines. The isolated channel associations may be indicative of a high rate of accommodation generation characteristic of the transition systems tract (TST). These are formed in the model by applying a low NTG, many aggradation levels and low probability of avulsion to allow for significant LA element development.

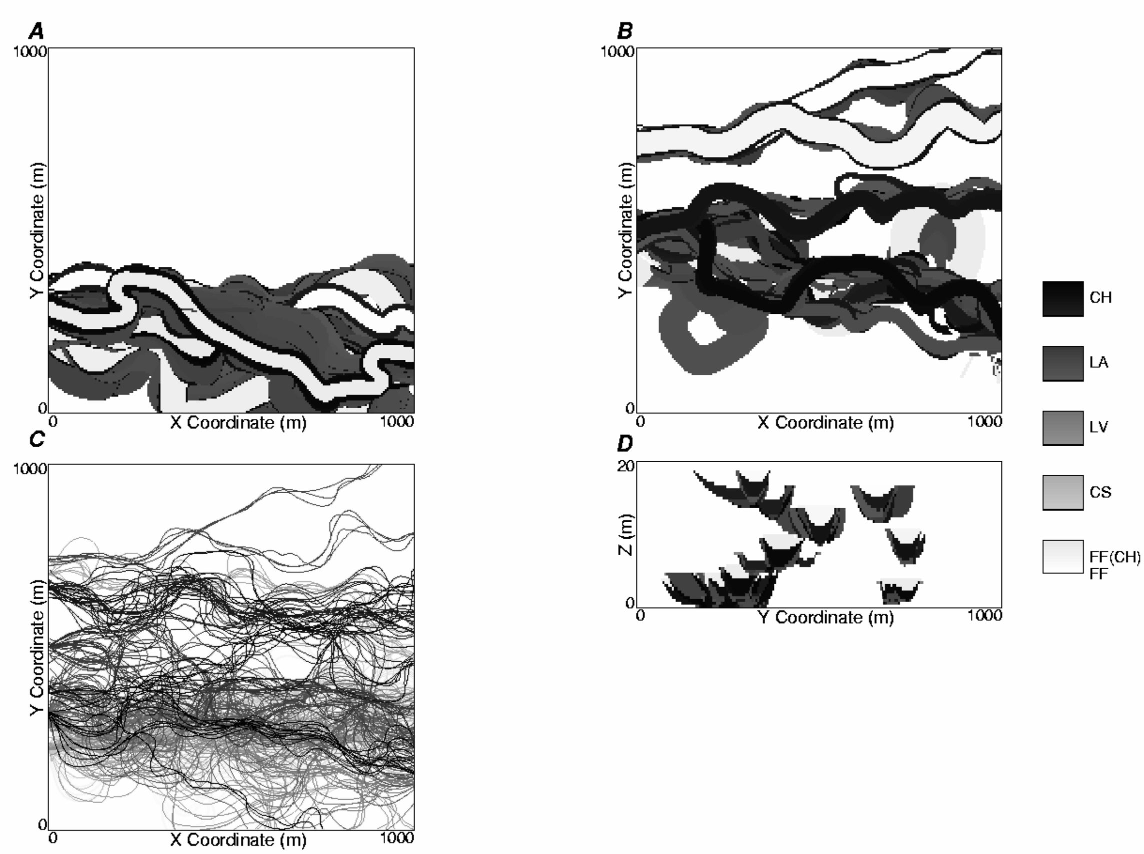


Figure 5-3: An example Alluvsim CB type labyrinth reservoir model. A – plan section (Z=5 m), B – plan section (Z=10 m), C – all streamlines (grey scale from 1=white to n=black) and D – cross section (X=10 m). Note grey scale assignment for architectural elements is varied to aid in differentiating amalgamated elements.

5.4 Sheet (SH) Type Reservoir

SH type reservoirs generally form gravel dominated fluvial styles. This style is analogous to the layer cake reservoir style. Two SH type reservoir models are shown. Figure 5-4 shows a SH type model based on a distal setting while Figure 5-5 shows the one based on a proximal setting. Examples of input parameters used to construct both SH type reservoir models are shown below followed by the resulting streamlines and facies models. Cygwin scripts for both of these examples can be found in directory: script/example.

Input Parameters

```
                  Parameters for Alluvsim Meander Sheet (Distal SH type)
                  **********************************************

START OF PARAMETERS:
none                          - file with well data
0 0 0 0 0 0                   - wcol,xcol,ycol,ztcol,zbcol,fcol
0.0 0.0 0.0                   - xanis,yanis,zanies
0.0 0.0                       - buffer,ztol
horitrend.dat                 - file with the horizontal trend
1                             - htcol
verttrend.dat                 - file with the vertical trend
1                             - vtcol
200 200 200                   - ntime,max_assoc,max_withinassoc
5 4. 8. 10. 14. 19.           - nlevel,level elevations
0.50 50.0 20.0                - NTGtarget,mdistMigrate,stdevdistMigrate
100 10 10                     - CHndraw,ndiscr,nCHcor
0.02 0.05                     - probAvulOutside,probAvulInside
90.0   1.0                    - CH element: mCHazi,stdevCHazi
500.0 150.0                   - CHsource
6.0 0.5 0.2                   - mCHdepth,stdevCHdepth,stdevCHdepth2
20.0 2.0                      - mCHwdratio,stdevCHwdratio
1.3 0.1                       - mCHsinu,stdevCHsinu
2.0 0.1                       - LV Element: mLVdepth,stdevLVdepth
160.0 5.0                     - mLVwidth,stdevLVwidth
0.0 0.0                       - mLVheight,stdevLVheight
0.0 0.0                       - mLVasym,stdevLVasym
0.0 0.0                       - mLVthin,stdevLVthin
-1 1                          - CS Element: mCSnum,stdevCSnum
0 2                           - mCSnumlobe,stdevCSnumlobe
50.0 20.0                     - mCSsource,stdevCSsource
200.0 50.0                    - mCSLOLL,stdevCSLOLL
150.0 30.0                    - mCSLOWW,stdevCSLOWW
50.0 10.0                     - mCSLOl,stdevCSLOl
150.0 30.0                    - mCSLOw,stdevCSLOw
0.000 0.000                   - mCSLO_hwratio,stdevCSLO_hwratio
0.010 0.005                   - mCSLO_dwratio,stdevCSLO_dwratio
0.0 0.0                       - FFCH Element: mFFCHprop,stdevFFCHprop
$nx $xmn $xsiz                - nx,xmn,xsiz
$ny $ymn $ysiz                - ny,ymn,ysiz
$nz $zmn $zsiz                - nz,zmn,zsiz
69069 0.05                    - random number seed,color_incr
alluvsimmeandersh.out         - file for output facies file
streamlinemeandersh.out       - file for output streamlines
fitnessmeandersh.out          - file for measure of fitness with well data
```

PostScript Output

Figure 5-4 shows the postscript output of streamlines, XY cross section, and YZ cross section for SH type reservoir model based on a distal setting. The streamline associations show a high degree of meandering and little avulsion. In Figure 5-5, a SH type model based on a proximal setting is shown such as an alluvial fan. The streamline associations show a high degree of avulsion and braiding and a dispersive pattern. SH reservoir type models are generated with high NTG and many time steps to allow for amalgamate net facies.

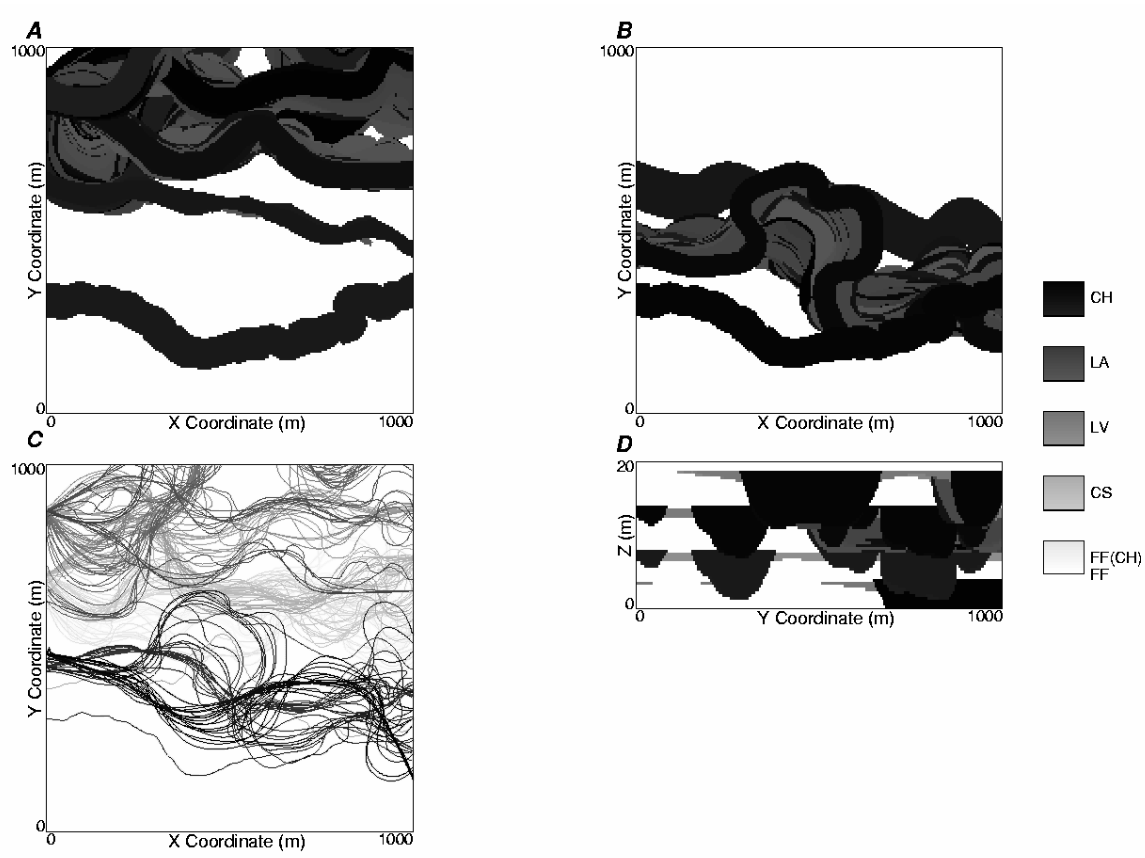


Figure 5-4: An example Alluvsim distal SH type reservoir model. A – plan section (Z=5 m), B – plan section (Z=10 m), C – all streamlines (grey scale from 1=white to n=black) and D – cross section (X=10 m). Note grey scale assignment for architectural elements is varied to aid in differentiating amalgamated elements.

Input Parameters

```
                         Parameters for Alluvsim Braided Sheet (Proximal SH type)
                         ************************************************

START OF PARAMETERS:
none                              - file with well data
0 0 0 0 0 0                       - wcol,xcol,ycol,ztcol,zbcol,fcol
0.0 0.0 0.0                       - xanis,yanis,zanies
0.0 0.0                           - buffer,ztol
horitrend.dat                     - file with the horizontal trend
1                                 - htcol
verttrend.dat                     - file with the vertical trend
1                                 - vtcol
200 200 200                       - ntime,max_assoc,max_withinassoc
6 4. 5. 10. 11. 14. 17.           - nlevel,level elevations
0.50 50.0 20.0                    - NTGtarget,mdistMigrate,stdevdistMigrate
100 10 10                         - CHndraw,ndiscr,nCHcor
0.2 0.8                           - probAvulOutside,probAvulInside
90.0   1.0                        - CH element: mCHazi,stdevCHazi
500.0 150.0                       - CHsource,stdevCHsource
4.0 0.5 0.2                       - mCHdepth,stdevCHdepth,stdevCHdepth2
40.0 4.0                          - mCHwdratio,stdevCHwdratio
1.3 0.1                           - mCHsinu,stdevCHsinu
0.0 0.0                           - LV Element: mLVdepth,stdevLVdepth
0.0 0.0                           - mLVwidth,stdevLVwidth
0.0 0.0                           - mLVheight,stdevLVheight
0.0 0.0                           - mLVasym,stdevLVasym
0.0 0.0                           - mLVthin,stdevLVthin
-1 1                              - CS Element: mCSnum,stdevCSnum
0 2                               - mCSnumlobe,stdevCSnumlobe
50.0 20.0                         - mCSsource,stdevCSsource
200.0 50.0                        - mCSLOLL,stdevCSLOLL
150.0 30.0                        - mCSLOWW,stdevCSLOWW
50.0 10.0                         - mCSLOl,stdevCSLOl
150.0 30.0                        - mCSLOw,stdevCSLOw
0.000 0.000                       - mCSLO_hwratio,stdevCSLO_hwratio
0.010 0.005                       - mCSLO_dwratio,stdevCSLO_dwratio
0.1  0.02                         - FFCH Element: mFFCHprop,stdevFFCHprop
$nx $xmn $xsiz                    - nx,xmn,xsiz
$ny $ymn $ysiz                    - ny,ymn,ysiz
$nz $zmn $zsiz                    - nz,zmn,zsiz
69069 0.05                        - random number seed, color_incr
alluvsimbraidsh.out               - file for output facies file
streamlinebraidsh.out             - file for output streamlines
none                              - file for measure of fitness with well data
```

PostScript Output

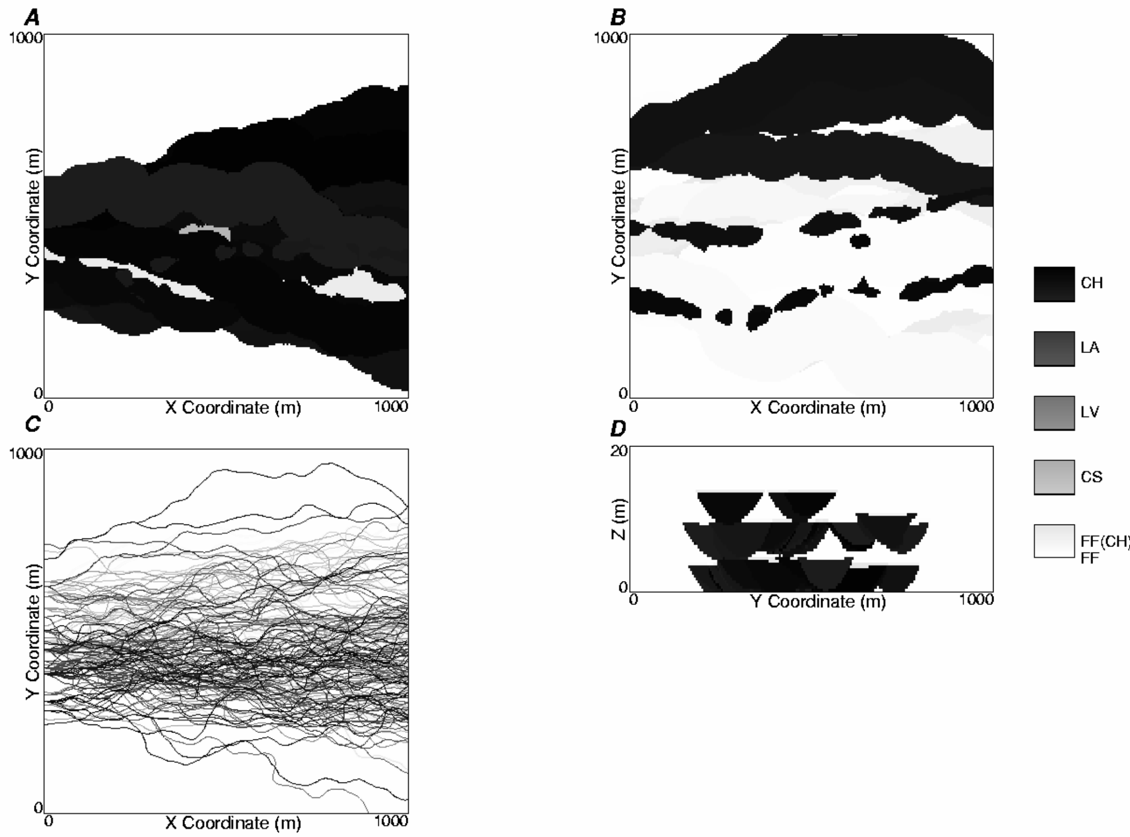


Figure 5-5: An example Alluvsim proximal SH type reservoir model. A – plan section (Z=5 m), B – plan section (Z=10 m), C – all streamlines (grey scale from 1=white to n=black) and D – cross section (X=10 m). Note grey scale assignment for architectural elements is varied to aid in differentiating amalgamated elements.

6 Example of Alluvsim Conditional Run to Honor Well Data

The Alluvsim algorithm was applied to construct a conditional net element model. An example of input parameters and well data used to construct a model to honor five wells with six element intervals identified is shown below followed by the resulting streamline and facies models. Cygwin script for this example can be found in directory: script/realization.

Input Parameters

```
                        Parameters for ALLUVSIM
                        ***********************
START OF PARAMETERS:
welldata_5well6CH.dat           - file with well data
1 2 3 4 7 9                     - wcol,xcol,ycol,ztcol,zbcol,fcol
50.0 50.0 1.0                   - xanis,yanis,zanis
50.0 10.0                       - buffer, ztol
none                            - file with tbhe horizontal trend
1                               - htcol
none                            - file with the vertical trend
1                               - vtcol
100 100 100                     - ntime,max_assoc,max_withinassoc
3 7.0 13.0 17.0                 - nlevel,level elevations
0.2 50.0 20.0                   - NTGtarget,mdistMigrate,stdevdistMigrate
100 10 10                       - CHndraw,ndiscr,nCHcor
0.3 0.3                         - probAvulOutside,probAvulInside
90.0 1.0                        - CH element: mCHazi,stdevCHazi
500.0 -1.0                      - mCHsource,stdevCHsource
4.0 0.5 0.2                     - mCHdepth,stdevCHdepth,stdevCHdepth2
15.0 2.0                        - mCHwdratio,stdevCHwdratio
1.3 0.2                         - mCHsinu,stdevCHsinu
1.0 0.1                         - LV Element: mLVdepth,stdevLVdepth
80.0 5.0                        - mLVwidth,stdevLVwidth
1.0 0.1                         - mLVheight,stdevLVheight
0.0 0.0                         - mLVasym,stdevLVasym
0.0 0.0                         - mLVthin,stdevLVthin
0 0                             - CS Element: mCSnum,stdevCSnum
0 0                             - mCSnumlobe,stdevCSnumlobe
50.0 20.0                       - mCSsource,stdevCSsource
200.0 50.0                      - mCSLOLL,stdevCSLOLL
30.0 10.0                       - mCSLOWW,stdevCSLOWW
100.0 20.0                      - mCSLOl,stdevCSLOl
20.0 10.0                       - mCSLOw,stdevCSLOw
```

0.03 0.05	- mCSLO_hwratio,stdevCSLO_hwratio
0.02 0.05	- mCSLO_dwratio,stdevCSLO_dwratio
0.0 0.0	- FFCH Element: mFFCHprop,stdevFFCHprop
100 5.0 10.0	- nx,xmn,xsiz
100 5.0 10.0	- ny,ymn,ysiz
40 0.25 0.5	- nz,zmn,zsiz
19512 .1	- random number seed, color_incr
alluvsim.out	- file for output facies file
streamline.out	- file for output updated streamlines
fitness.out	- file for a measure of fitness with well data

Well Data

The following is the well data including well locations, net intervals, and element codes for each interval in GEOEAS format of the well data file for 5 wells and 6 intervals.

WellData
9
well
x
y
ztop
x
y
zbot
interceptcode
facies

2	500.	500.	17.0	500.	500.	15.1	2	4
2	500.	500.	7.1	500.	500.	4.3	2	4
1	500.	200.	13.1	500.	200.	10.0	2	4
3	500.	800.	13.1	500.	800.	10.0	2	4
4	200.	500.	7.1	200.	500.	4.3	2	4
5	875.	500.	7.1	875.	500.	4.3	2	4

PostScript Output

Figure 6-1 shows the postscript output of streamlines, YZ cross section, and XZ cross section for model constructed to honor five wells and six intervals.

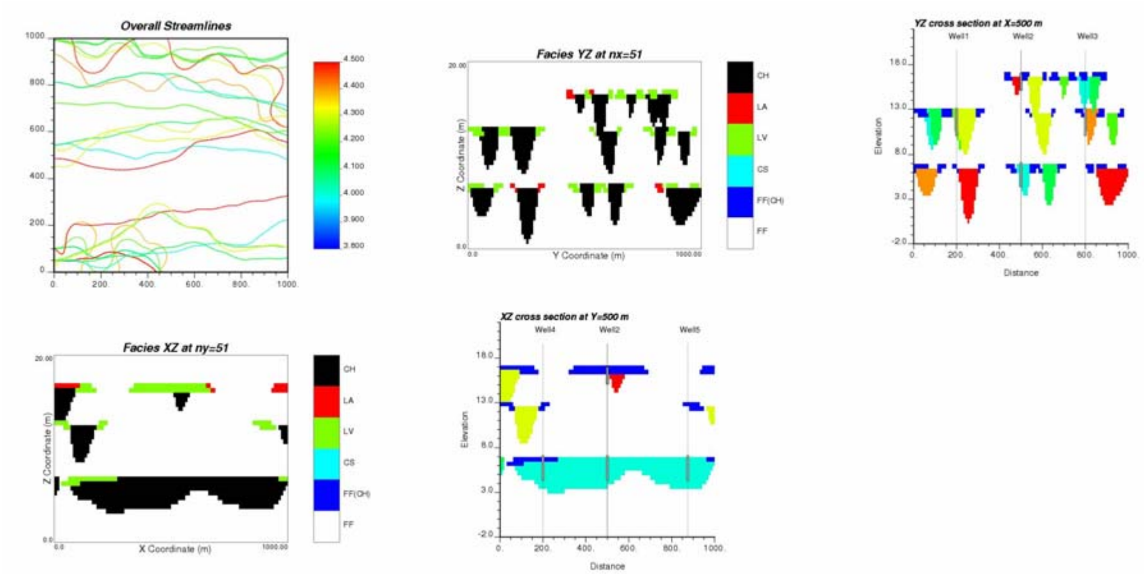


Figure 6-1: An example conditional model from Alluvsim to honor five wells and six interval.

References

1. Pyrcz, M.J., *Integration of Geologic Information into Geostatistical Models*, Ph.D. Thesis, University of Alberta, Edmonton, 2004.
2. Miall, A.D. *The Geology of Fluvial Deposits.* Springer, New York, 1996.
3. Zabel, F., Pyrcz, M.J., Deutsch, C.V., *Multiple-well Conditioning Event-based Fluvial Models*, Center for Computational Geostatistics, Report Seven, 2005.
4. Deutsch, C.V. and Journel, A.G., *GSLIB: Geostatistical Software Library and User's Guide*, 2nd Edition, Oxford University Press, 1998.

Glossary

Avulsion
Avulsion can occur when an active channel changes its path or when an active channel is abandoned and previously inactive one gets activated.

Aggradation
Aggradation occurs when a channel deposits sediments in the channel and over bank environments.

Migration
Migration occurs when an entire meander loop migrates and may be abandoned which results in neck cut offs and chute channels (the channel cuts across the point bar).

Fluvial Architectural Elements
Architectural elements are defined as components within the deposition that are characterized by a distinct facies assemblage, internal geometry and external form. Architectural elements are generally larger than individual facies units and are smaller than a channel fill. Architectural elements have a predictable form and morphology and are characteristic of the associated sedimentary processes. Fluvial architectural elements include lateral accretion, crevasse splays, down stream accretion deposits etc.

Lateral Accretion
Lateral accretion (LA) deposits are represented as the volume of channel abandoned during channel migration. LA elements are characterized by wedge channel fills distributed along the inside of meaner bends. These elements are formed during channel migration towards the cut bank.

Levee
Levee elements (LV) form when there is an accumulation of multiple flooding events separated by erosion. The internal LV geometry is composed of overlapping lenses that have dips of two to ten degrees and are thinning and fining away from the channel axis. The external geometry of LV elements is characterized by a wedge that are thickest adjacent to the channel and thinning toward the over bank. LV elements may extend for large distances from the channel (e.g. up to a one kilometer).

Crevasse Splay
Crevasse splay elements (CS) differ from LV in their genesis. They form from a significant local breach in the LV element as opposed to general flooding and represent sedimentation over a shorter time scale. This tapping of the channel results in the availability of the coarser component of channel sediment load than available during LV element construction.
The internal geometry of CS elements may include low angel accretion surfaces with fining away from the channel axis and coarsening upwards associated with lateral progradation. CS element external geometry is commonly identified as discrete lobes with fingers extending beyond the lobe. CS elements extend beyond natural levees onto the floodplain. In flood prone settings, the CS elements may extend over ten kilometres in length and five kilometres in width and may form amalgamated aprons along the channel. A CS

element may have a thickness of less than a meter to several meters and may form amalgamated successions of tens of meters. Crevasse splays form lens-shaped bodies up to 10 km long and 5 km wide. They are typically 2-6 m thick.

Abandoned Channel

Abandoned channel elements (FF(CH)) represent low energy channel fills that are muddy sand to pure mud. They form due to rapid channel abandonment. If channel abandonment is very abrupt (i.e. rapid avulsion, neck cut-off) then there is a strong contrast between the FF(CH) and CH elements. Slow abandonment leads to fining upward fills.