# *Using the GeoFluv™ approach to Design and Evaluate Reclamation Landforms*

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**Carlson Software, Rocky Mountain Region**

# Drawings and many photographs used in this talk are from these sources:

- Rosgen, D., 1996. **Applied River Morphology,** Wildland Hydrology, Pagosa Springs, Colorado, fig. 2-1, 2-7, 4-2, 4-22, 5-3, 5-15, 5-79, 5-161, 5-185.

- Bloom, A.L., 1978. **Geomorphology, a systematic analysis of late Cenozoic landforms,** Prentice Hall, New Jersey, p. 270.

# Traditional Reclamation Practices

**Long, constant-gradient slopes**
**Gradient terraces**
**Rip-rapped drains**

# *Something just tells you it isn't right . . .*

# Conventional steep slope reclamation did not meet goals

- Terrace and down-drain structures can require long-term maintenance
- Terraced slopes do not provide desired topographic diversity
- Potential for recurrent failure and regular maintenance may interfere with bond release

# Dept. of Interior “National” and “Best of the Best” 2004 reclamation awards

***There is something new happening in landform design. It’s the future. It’s natural. Be a part of it.***

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# Landform Grading Goals

- Provide long-term stabilization for steep slopes and drainages
- Provide great topographic diversity to enhance plant and wildlife opportunities
- Be cost-effective
- Promote reclamation bond release

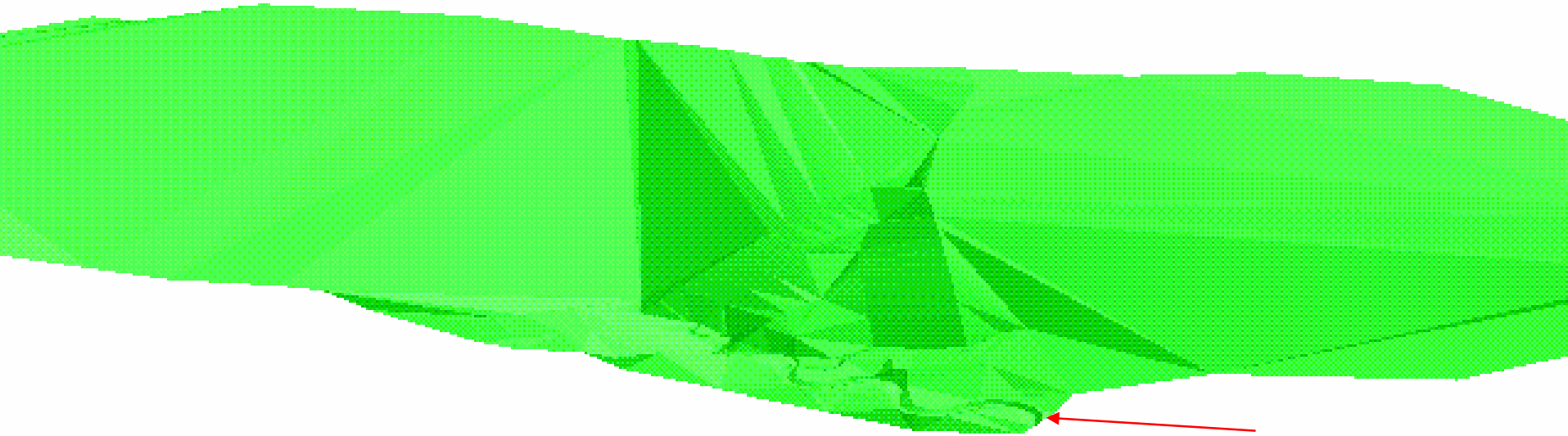
## *Natural Regrade module with GeoFluv™ (Patent Pending)*

**The *GeoFluv™* approach asks ,**

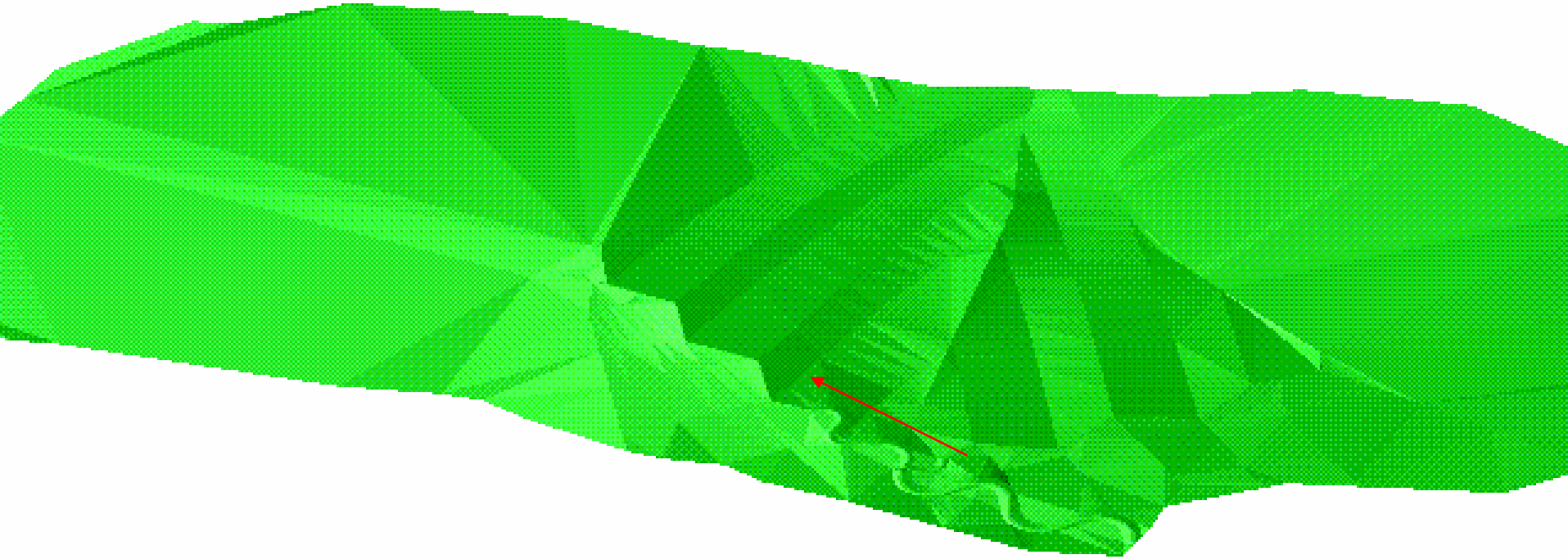
***What would be a stable, natural landform?***

**and designs and builds that.**

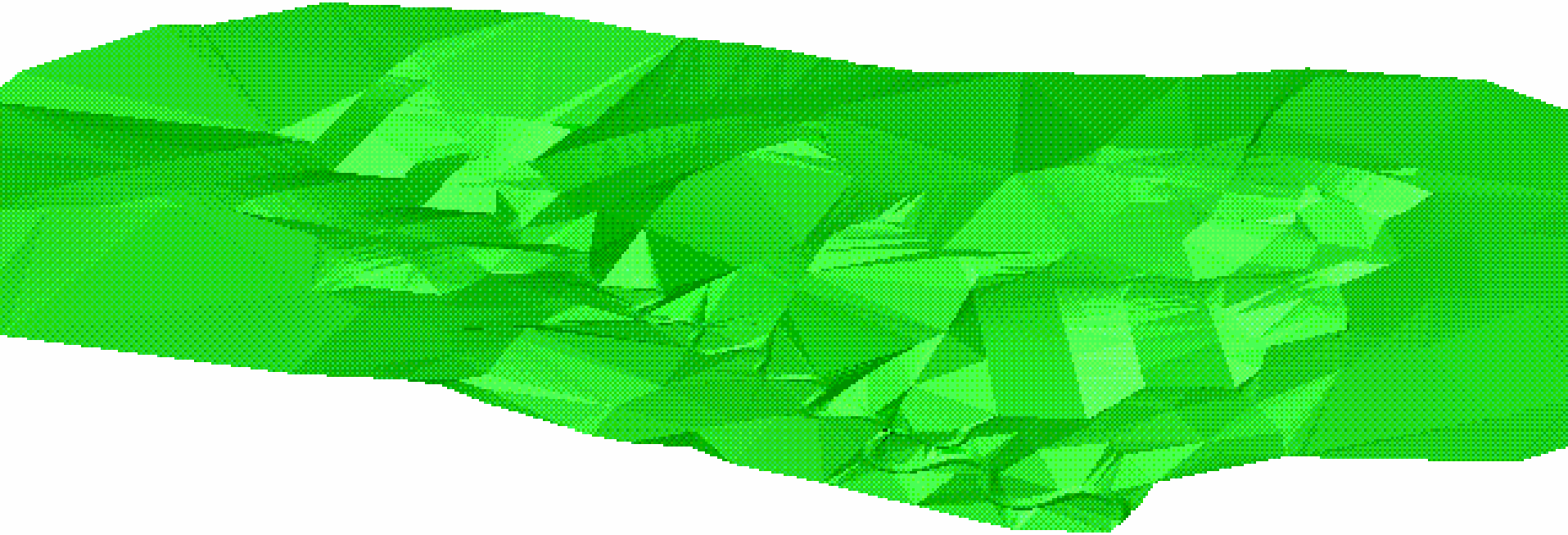
# Initiation of erosion headward from *local base level*



# Erosion continues by channel headcutting and mass wasting

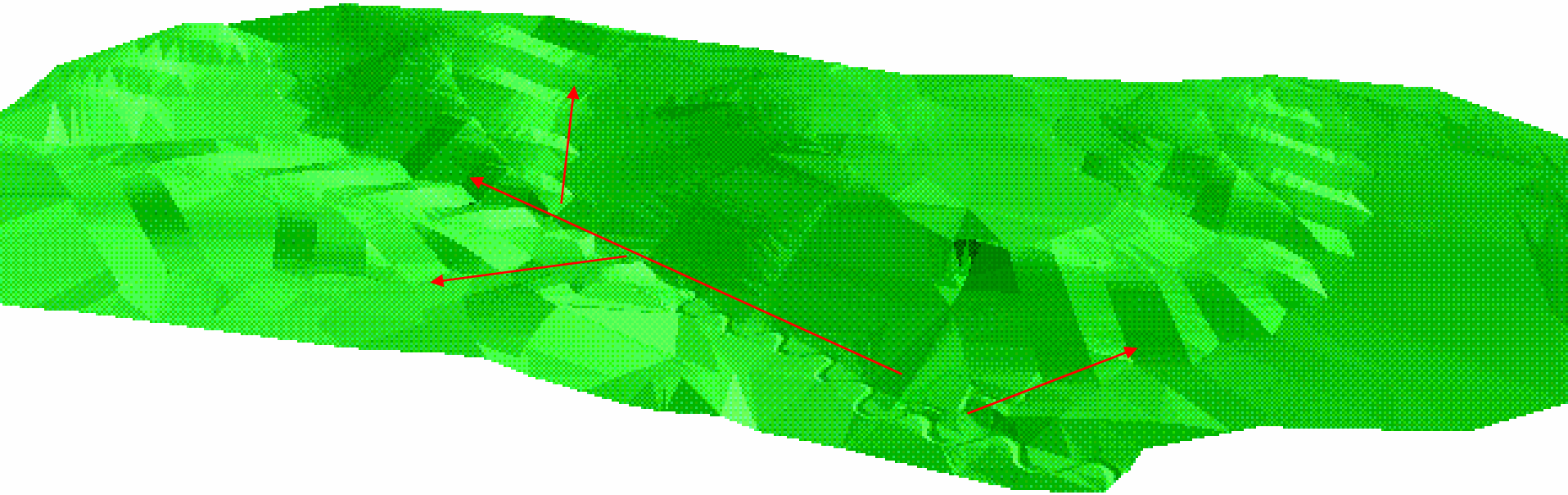


# Landscape dissection approaching *hydrologic balance*



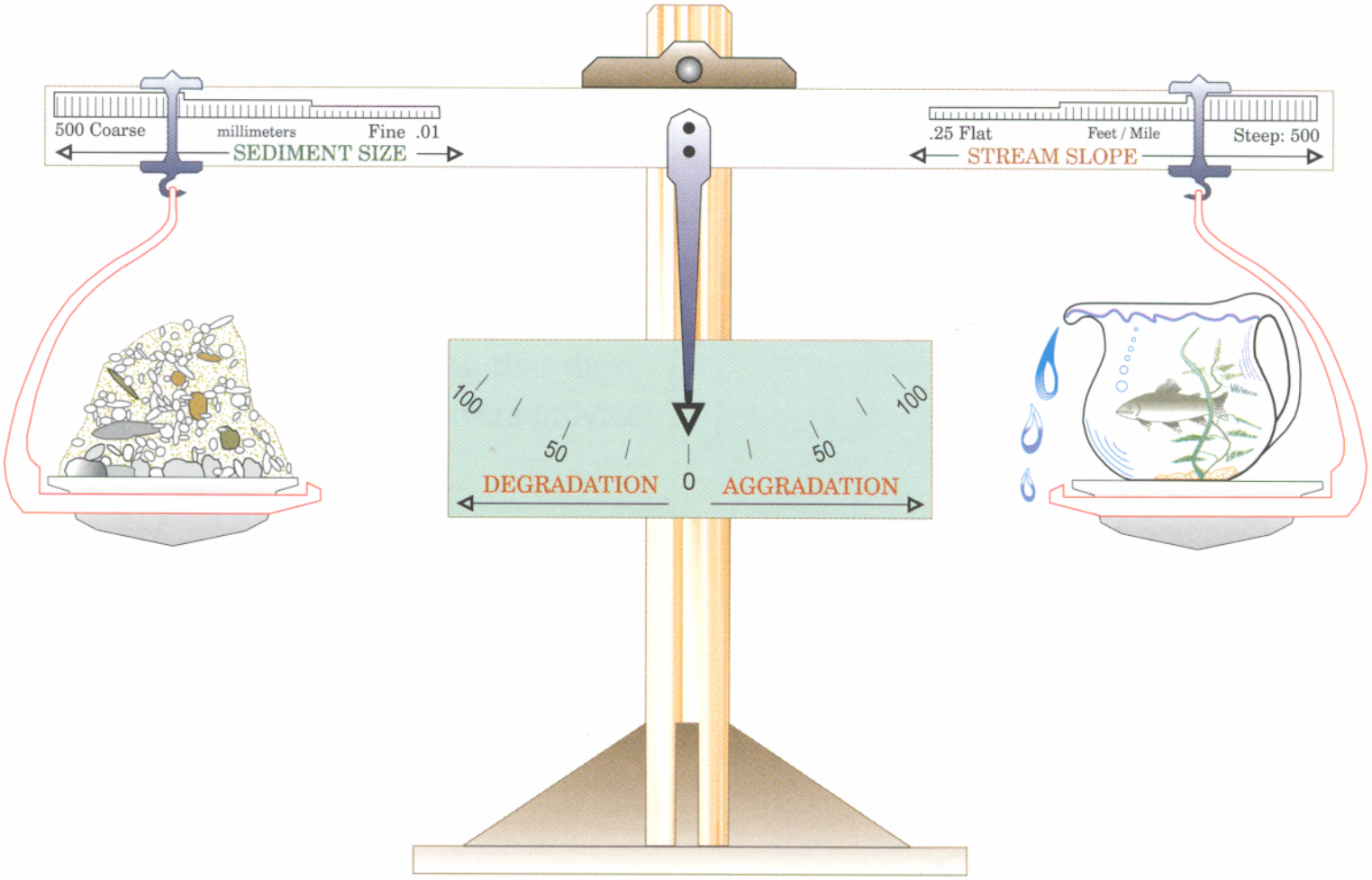
# Landform has achieved geomorphic stability

***drainage density, channel geometry, complex slope profiles optimized***



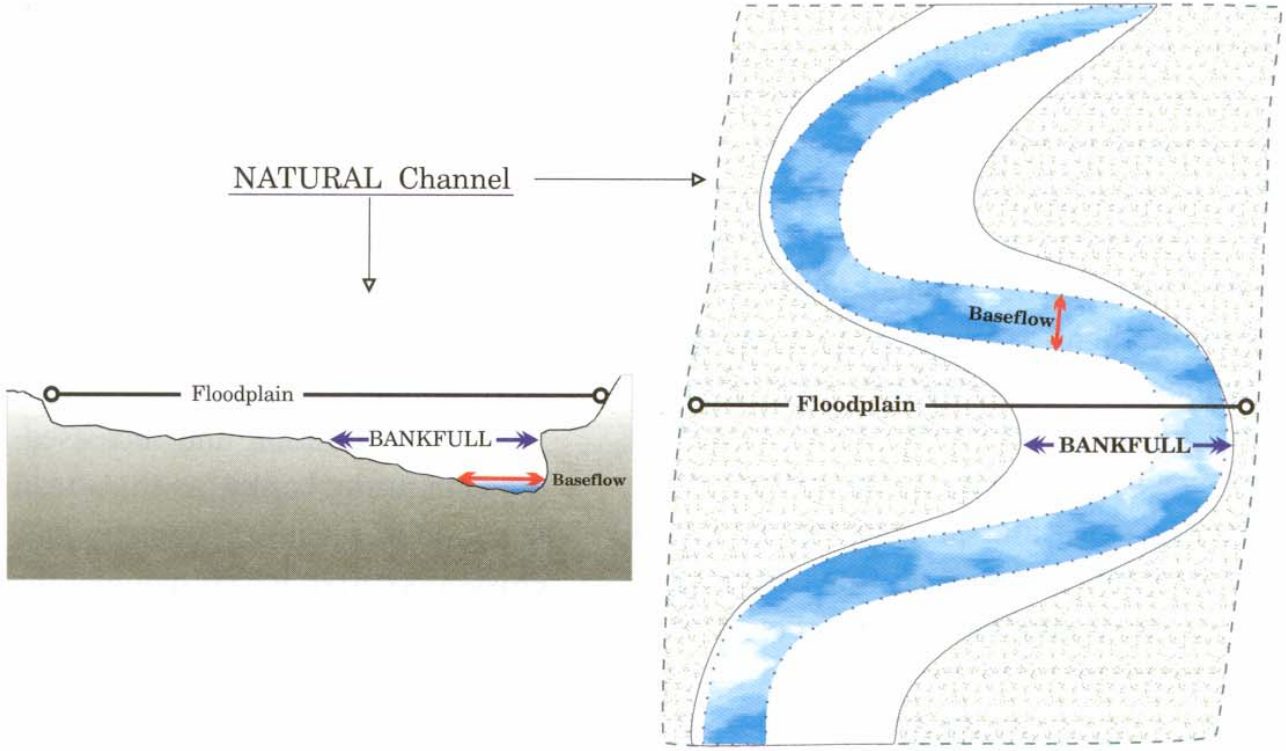
# Hydrologic Balance

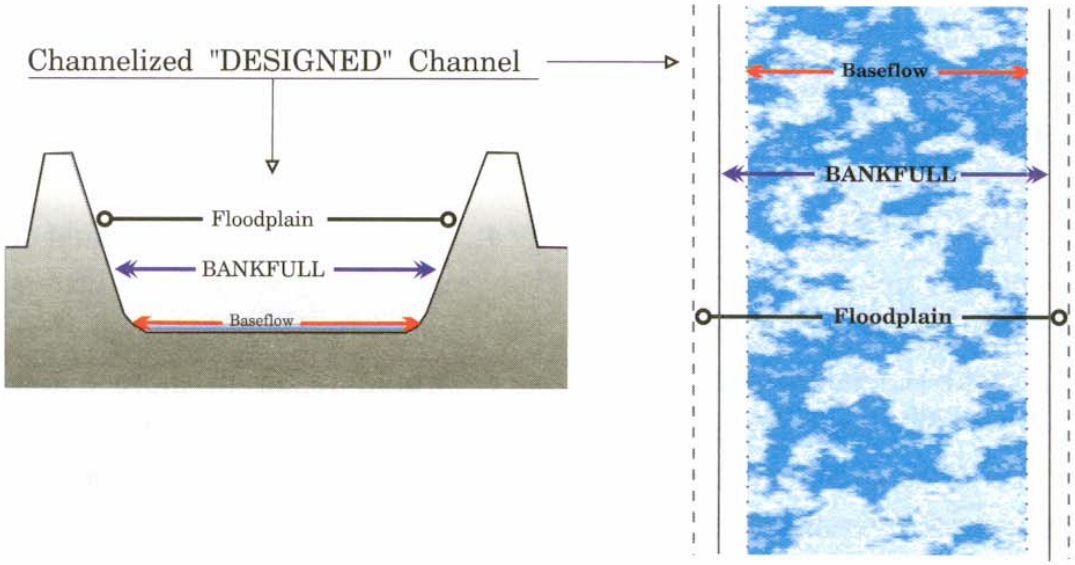
- What does this mean for stream channels?



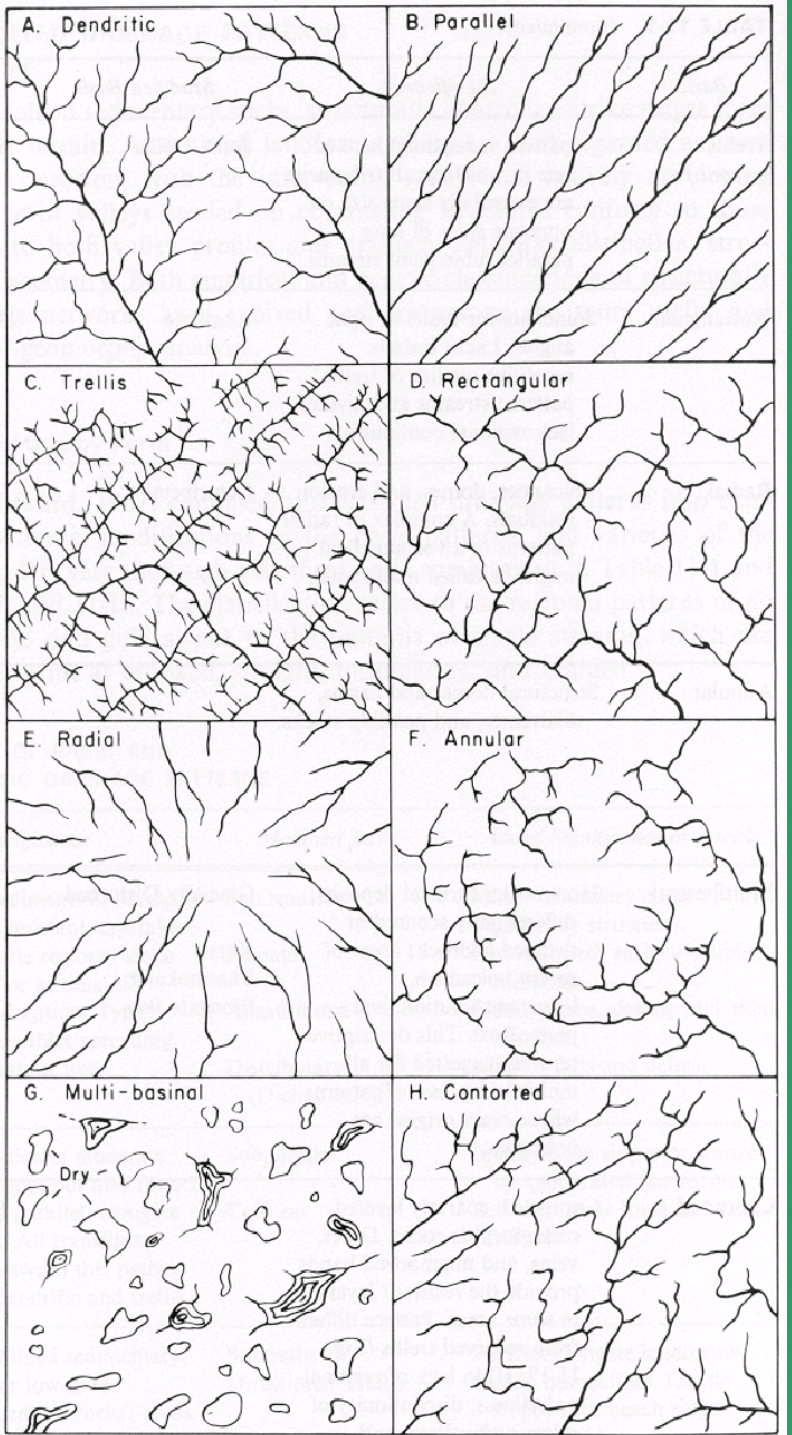

( Sediment LOAD ) x ( Sediment SIZE ) $\propto$ ( Stream SLOPE ) x ( Stream DISCHARGE )

**Bankfull width is a critical channel dimension.**


NATURAL Channel
Floodplain
BANKFULL
Baseflow
Baseflow
Floodplain
BANKFULL


Channelized "DESIGNED" Channel
Floodplain
BANKFULL
Baseflow
Baseflow
BANKFULL
Floodplain

**Channel pattern and drainage density vary.**


A. Dendritic
B. Parallel
C. Trellis
D. Rectangular
E. Radial
F. Annular
G. Multi-basinal
Dry
H. Contorted

# Drainage density

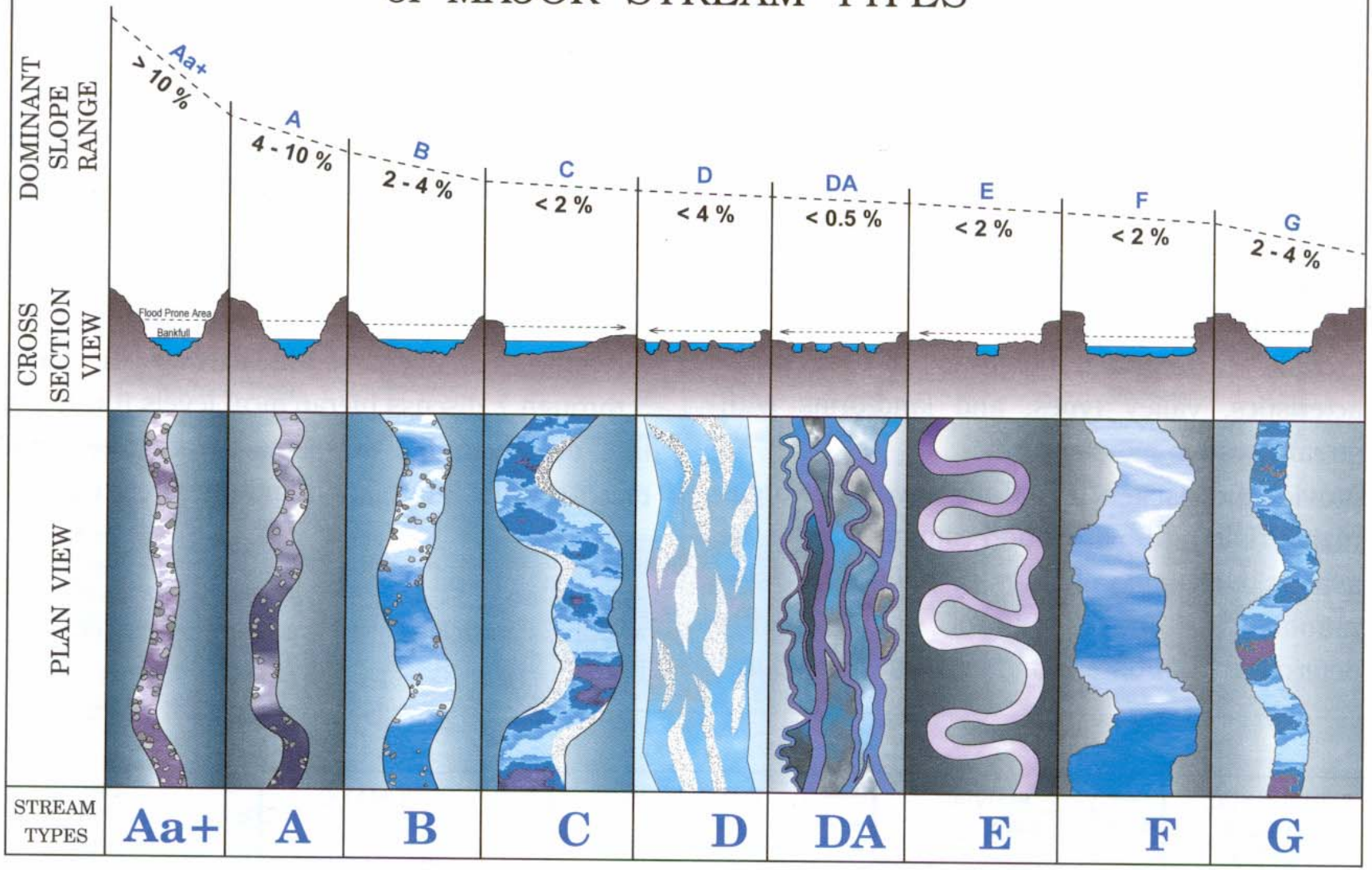
# Slope profile

# Different types of channels have different critical dimensions.

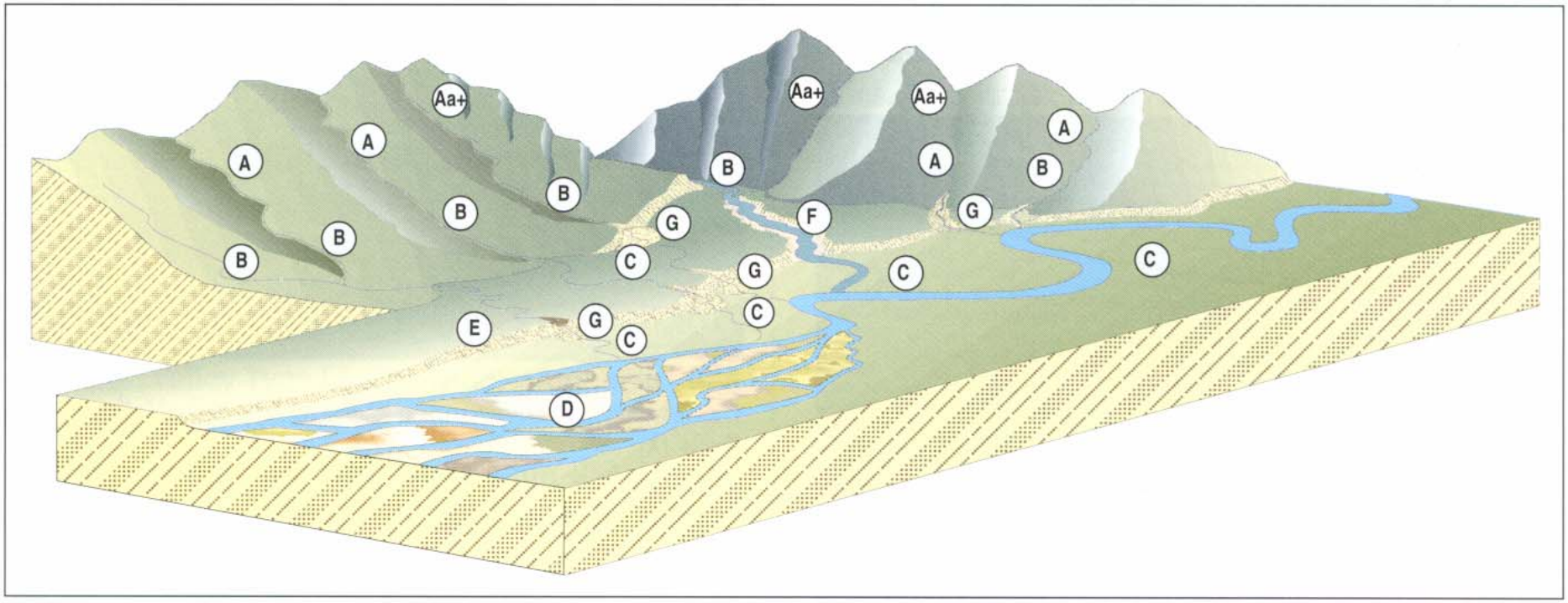
- Channel Cross Section
- Slope
- Sinuosity
- et cetera

- These interrelated factors are defined for different channel types.

# LONGITUDINAL, CROSS-SECTIONAL and PLAN VIEWS of MAJOR STREAM TYPES



**Different channel types are stable in different places.**


Aa+
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Aa+
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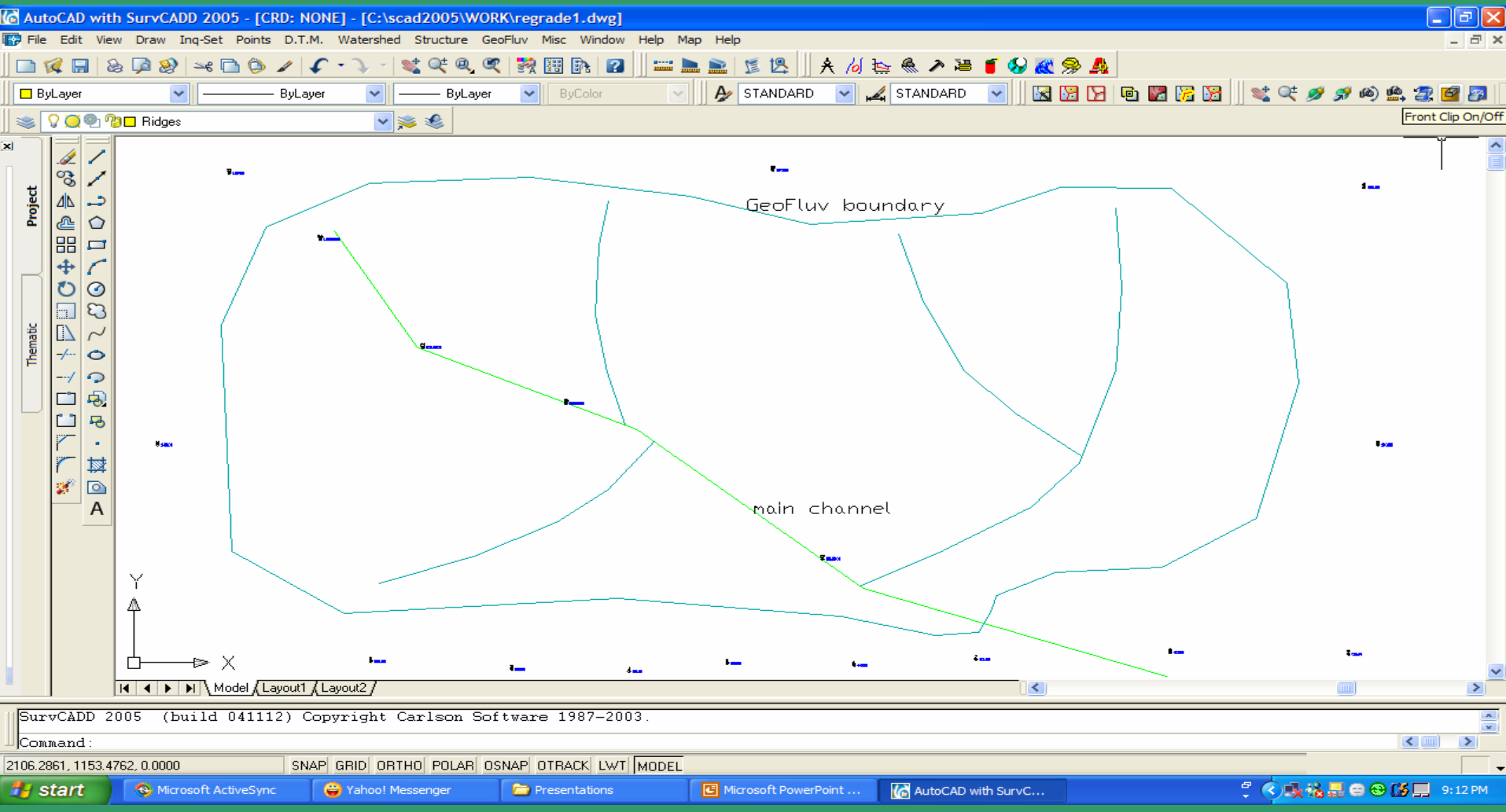
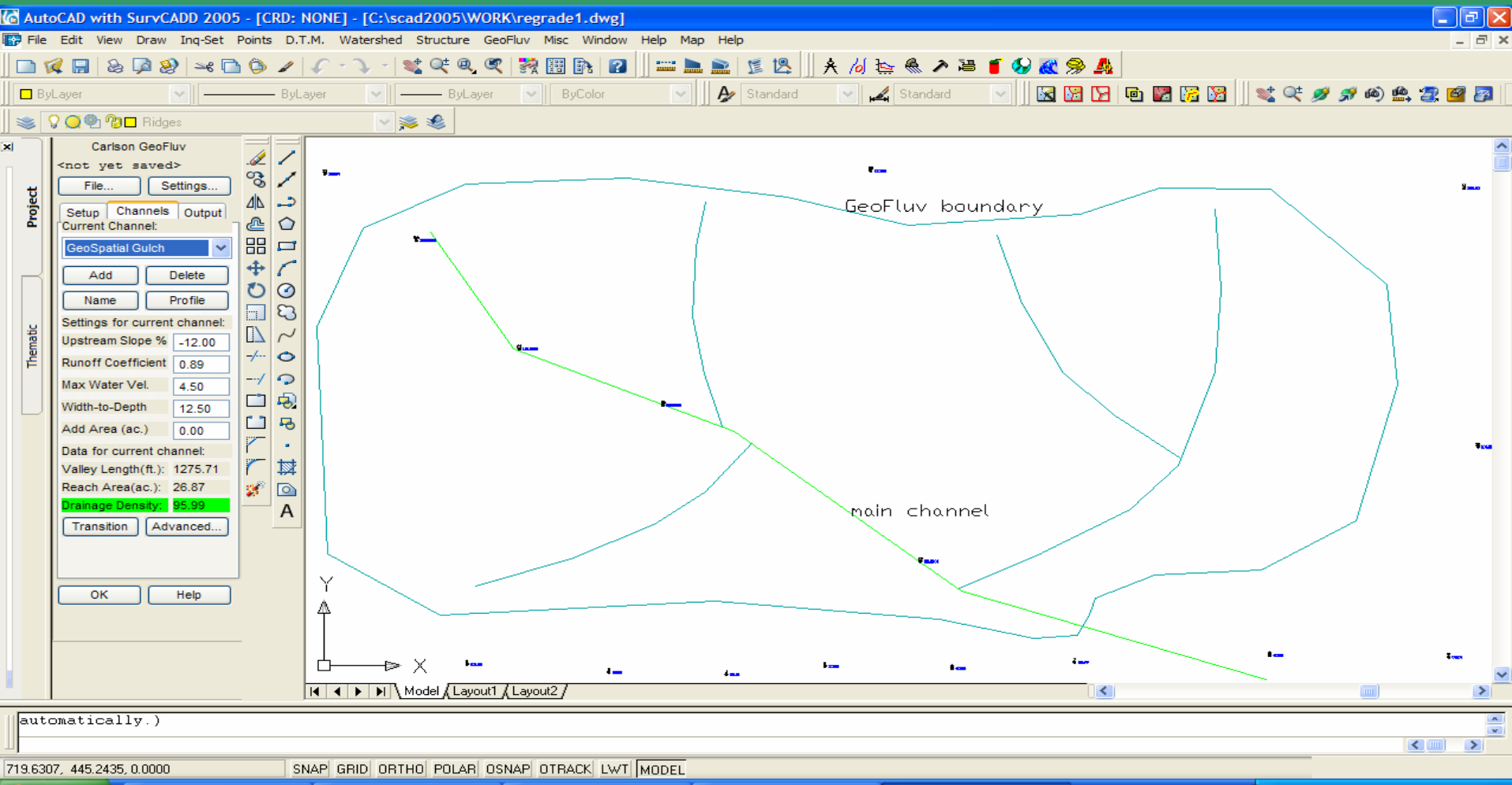
C
E
G
D

# landforms grade into each other

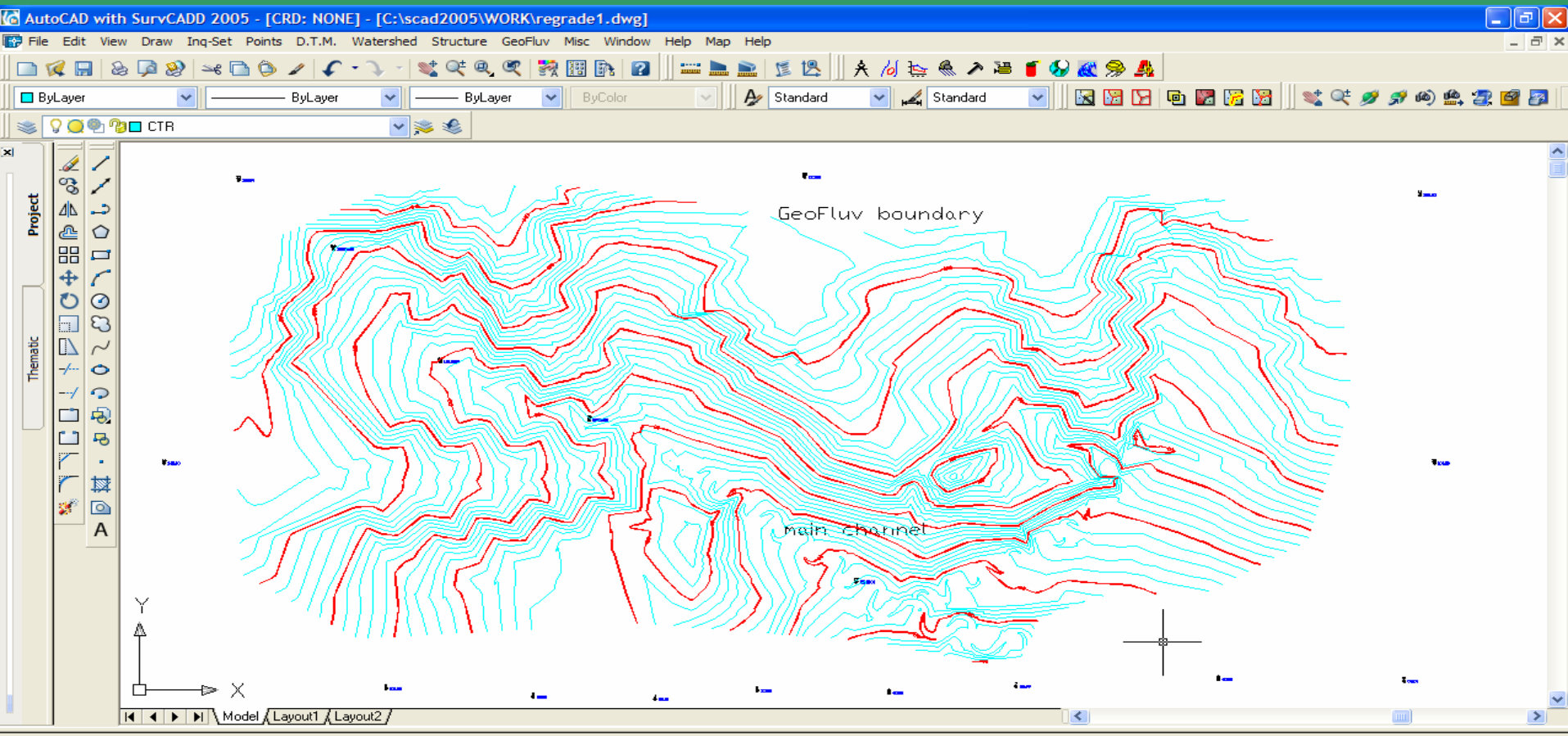
# Sketch a GeoFluv™ boundary and dendritic valley drainage pattern



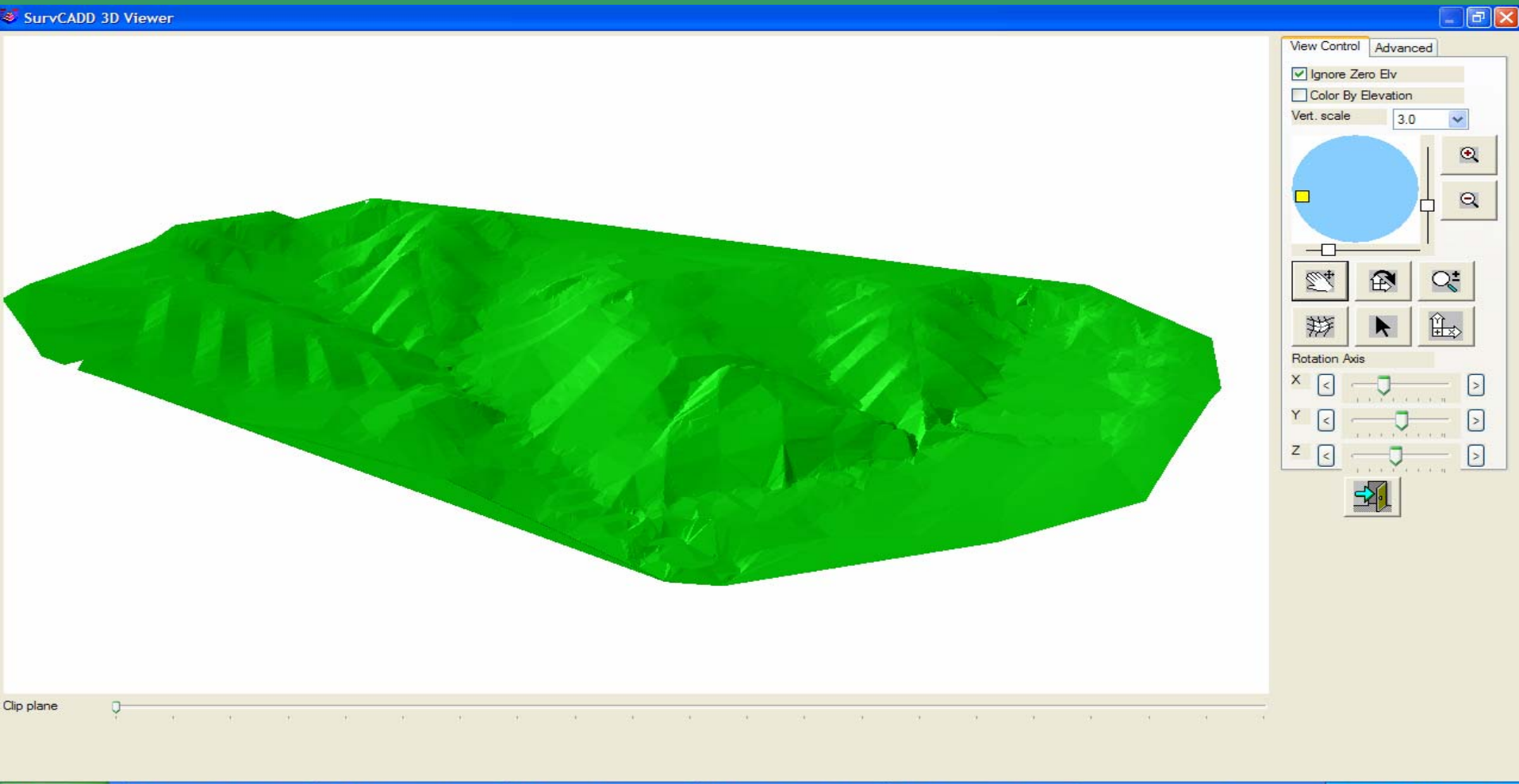
# GeoFluv™ dialog box leads the user through the process



# Natural Regrade creates a design for a stable landform that satisfies user inputs



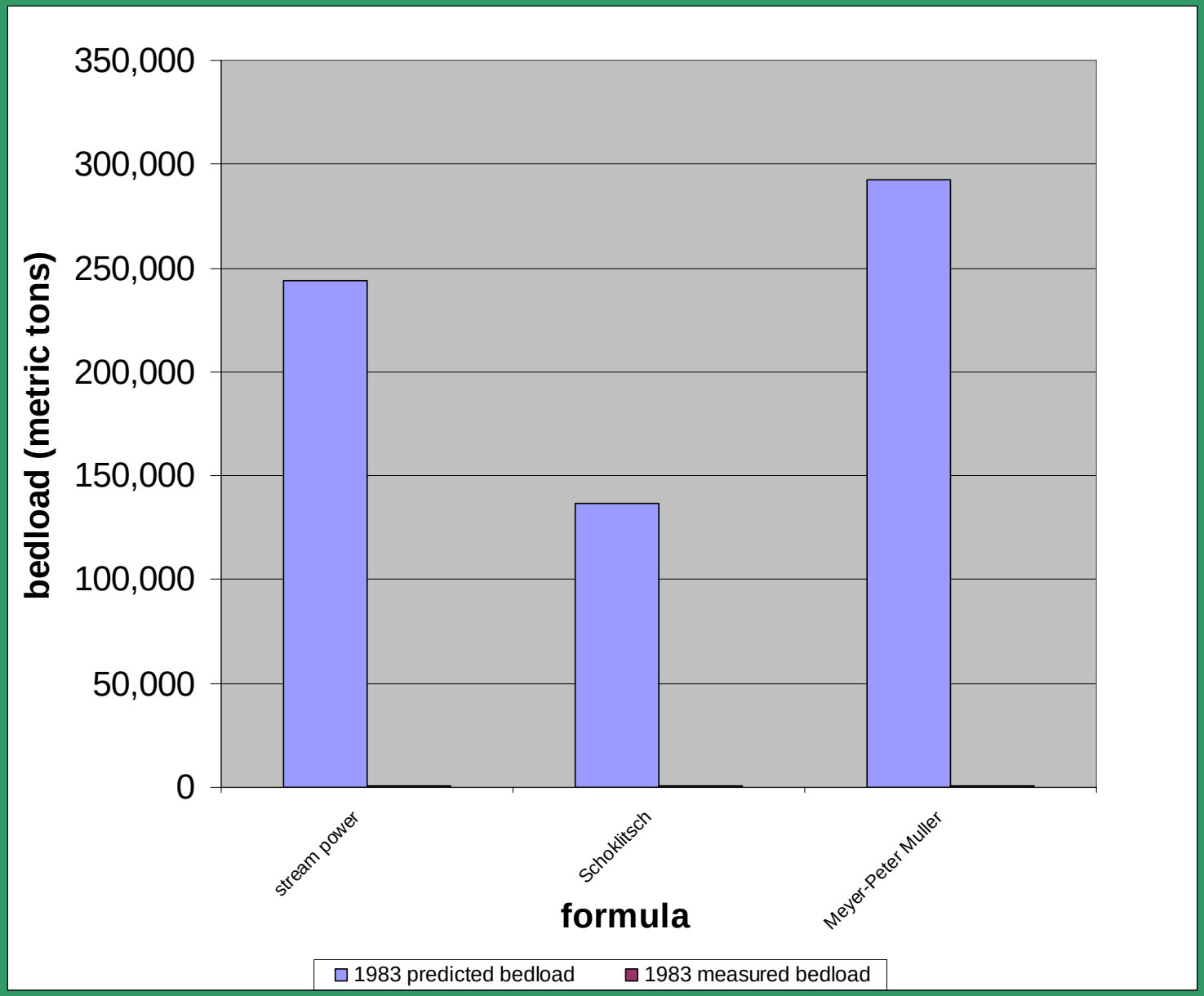
# Powerful 3D viewer aids final design editing of the draft landform



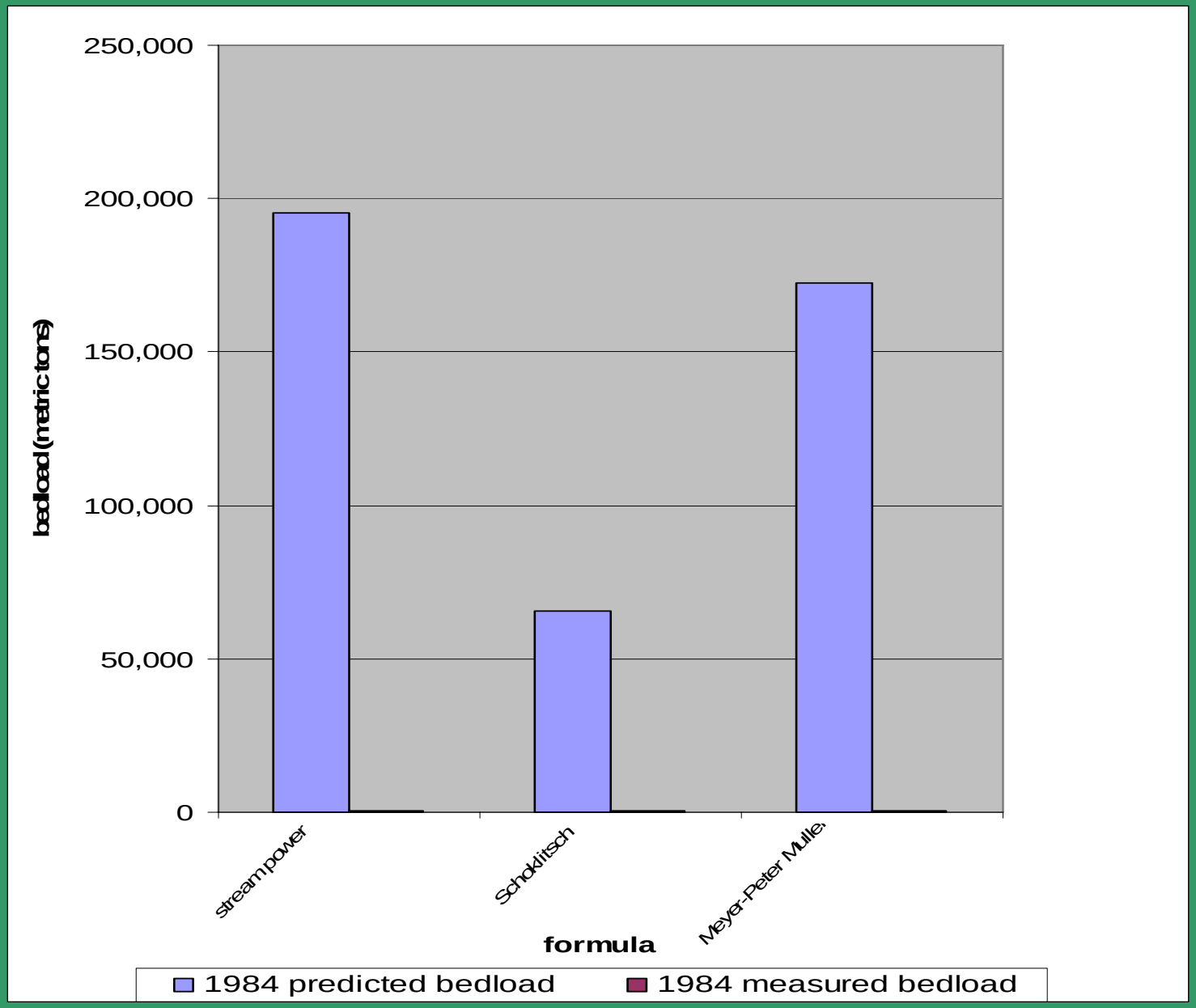
# Why use an empirical approach?

# It is 237,500 miles to the moon.

# 1983 Predicted versus Measured Bedload



# 1984 Predicted versus Measured Bedload



# What input parameters do these formulae use?

- Water surface slope
- Grain size
- Unit discharge
- Critical discharge
- Total discharge
- Bed roughness
- Particle roughness
- Effective particle diameter
- Water depth

# What are some inputs that these formulae omit?

- Sediment supply: landslides, debris flows, avalanches, bank stability
- Geology: type of rock, resistance to erosion, particle shape
- Soil: particle size, cohesiveness
- Instream storage: pools, log jams, bedforms
- Bed armor
- Climate: storm intensity, duration, snowmelt
- Vegetation: type, cover, density, rooting depth
- Land use: runoff coefficients, stream bank condition, wildlife and livestock
- et cetera

**The empirical approach uses measurements and relationships determined in the area of interest.**

**During the process of collecting these measurements, other important characteristics of the area can be observed.**

# That’s Why

## (Empirical Approach Advantages)

# Determining local input values in the field

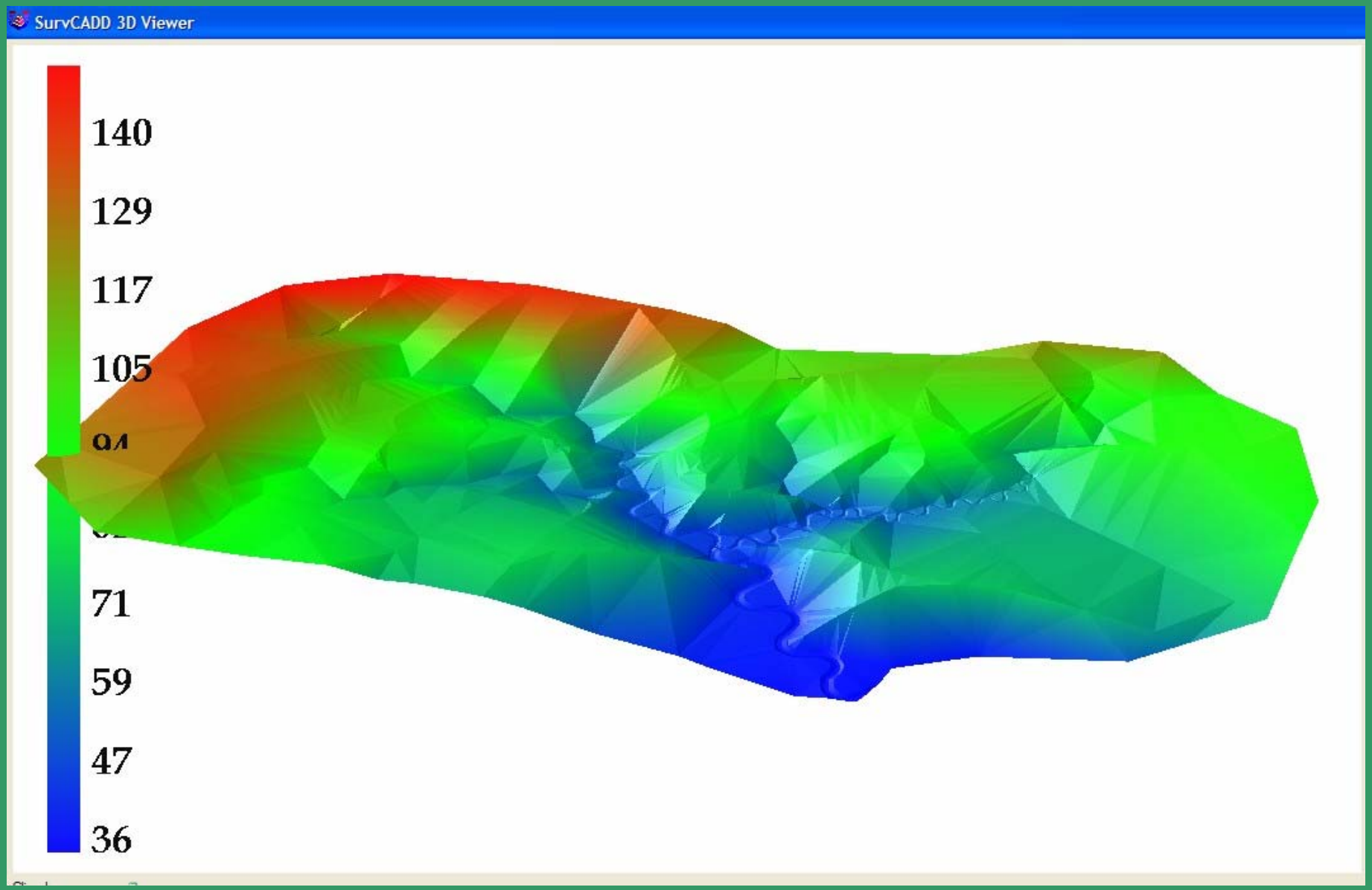
# Collecting inputs in Indiana

# Landforms follow same principles, but vary in response to local climate, earth materials, and vegetation

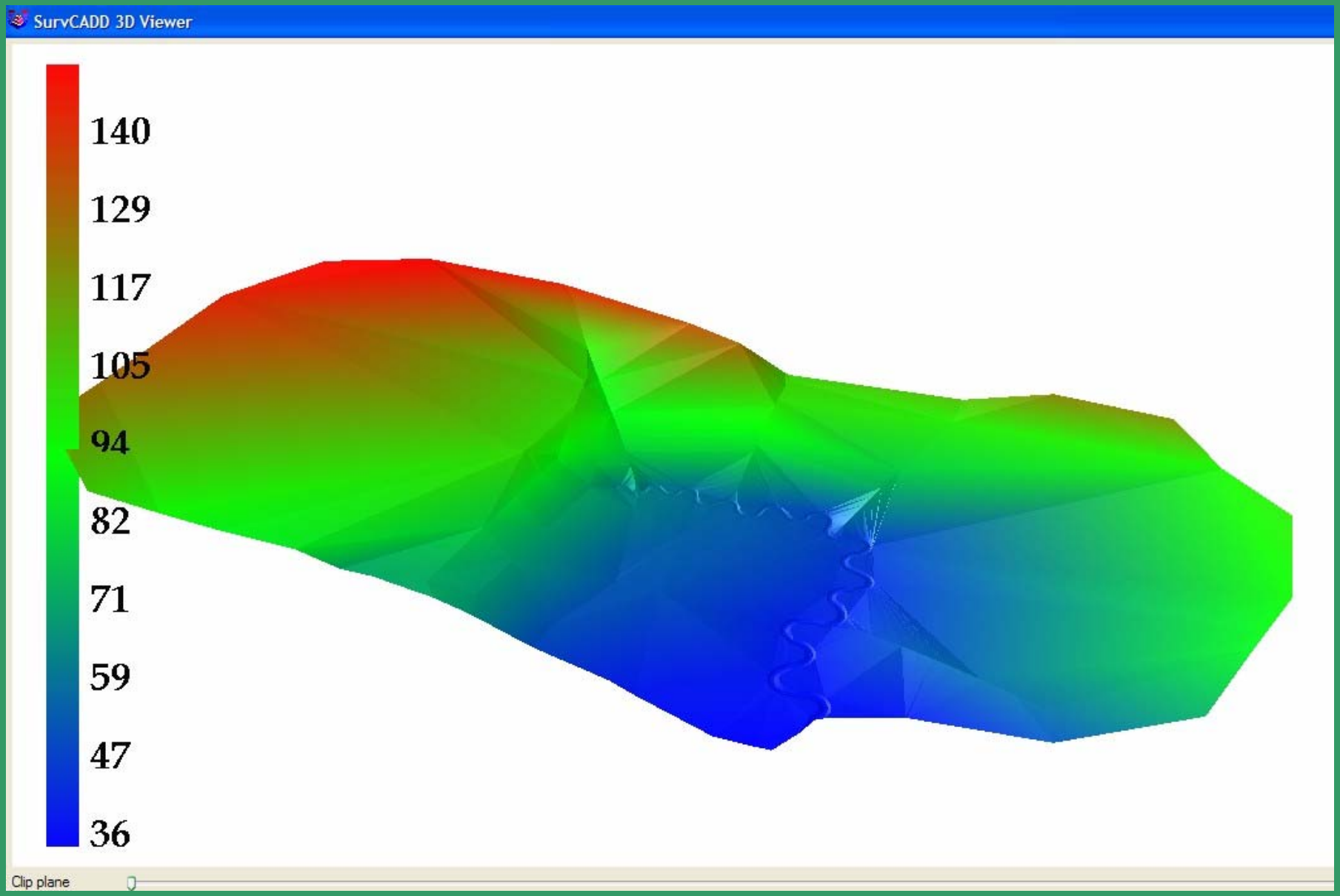
# Meandering “C” channel south of Cairns

# Let’s take a look at how local inputs vary the GeoFluv™ design

# Inputs up north

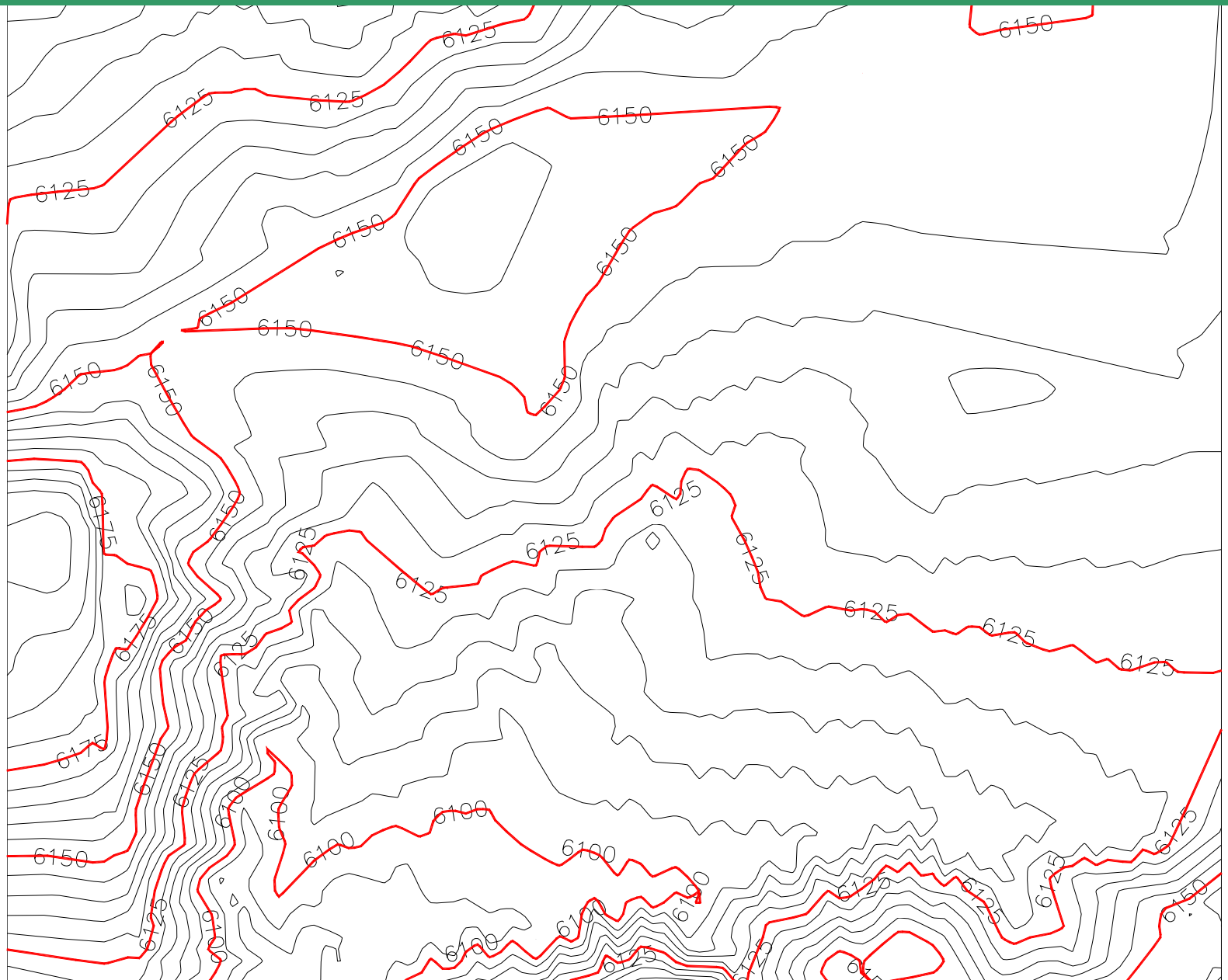


# Inputs about 80 kilometers south



# When we get the inputs right, how well does GeoFluv work?

# GeoFluv™ final surface configuration designed using computer and electronically output to field equipment



# GPS guides trucks to dump fill in lifts, ‘layer cake’ fashion

# As lifts are added, general shape of GeoFluv landform emerges

# Dozers guided by Carlson-o.e.m. machine control software smooth edges

# Topsoil and seeding complete the stable GeoFluv landform

# Designing special wildlife enhancement feature saved moving millions of yards against highwall

# Dept. of Interior “National” and “Best of the Best” 2004 reclamation awards

***There is something new happening in landform design. It’s the future. It’s natural. Be a part of it.***

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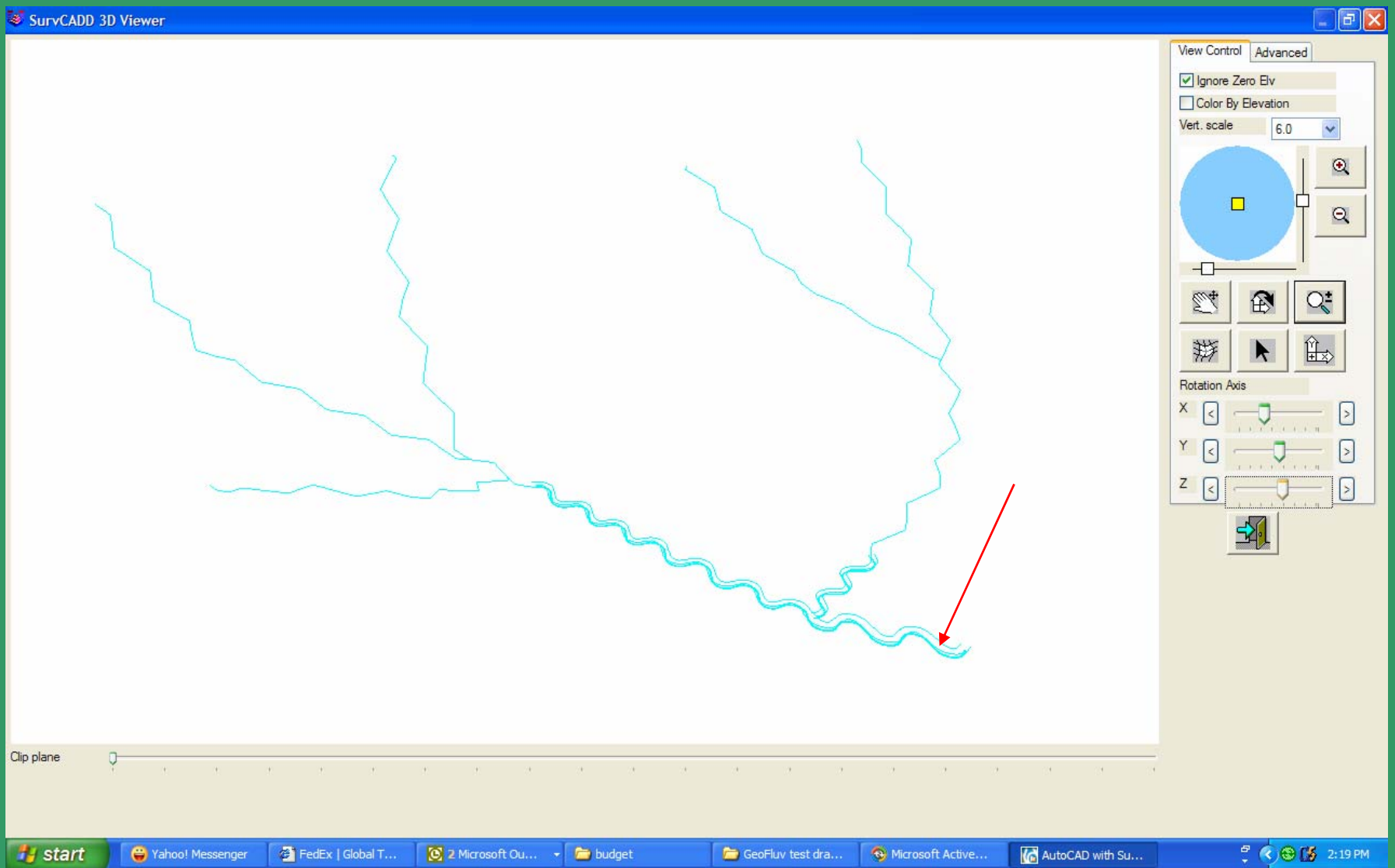
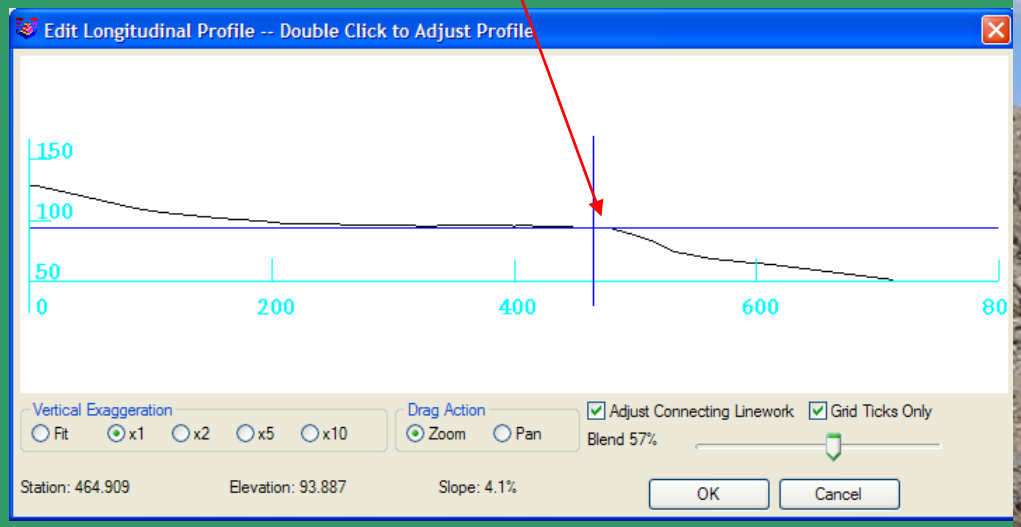
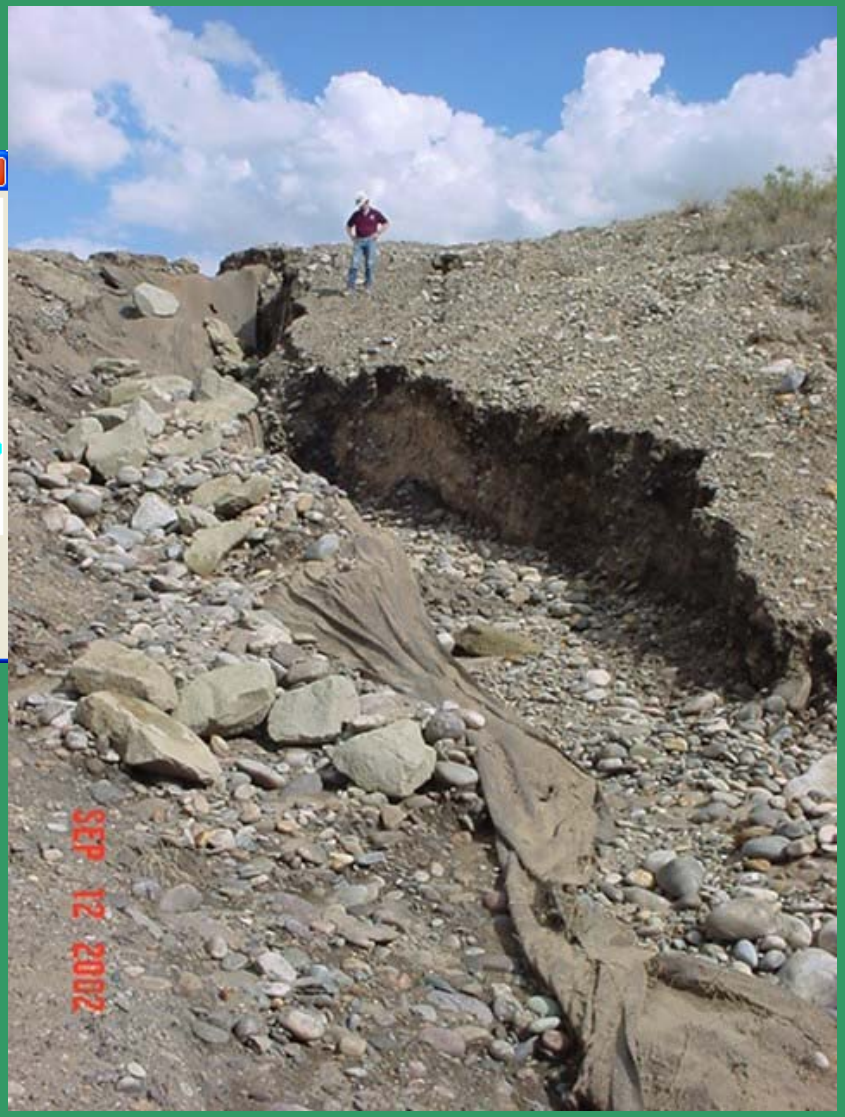
# Check the local *base level*



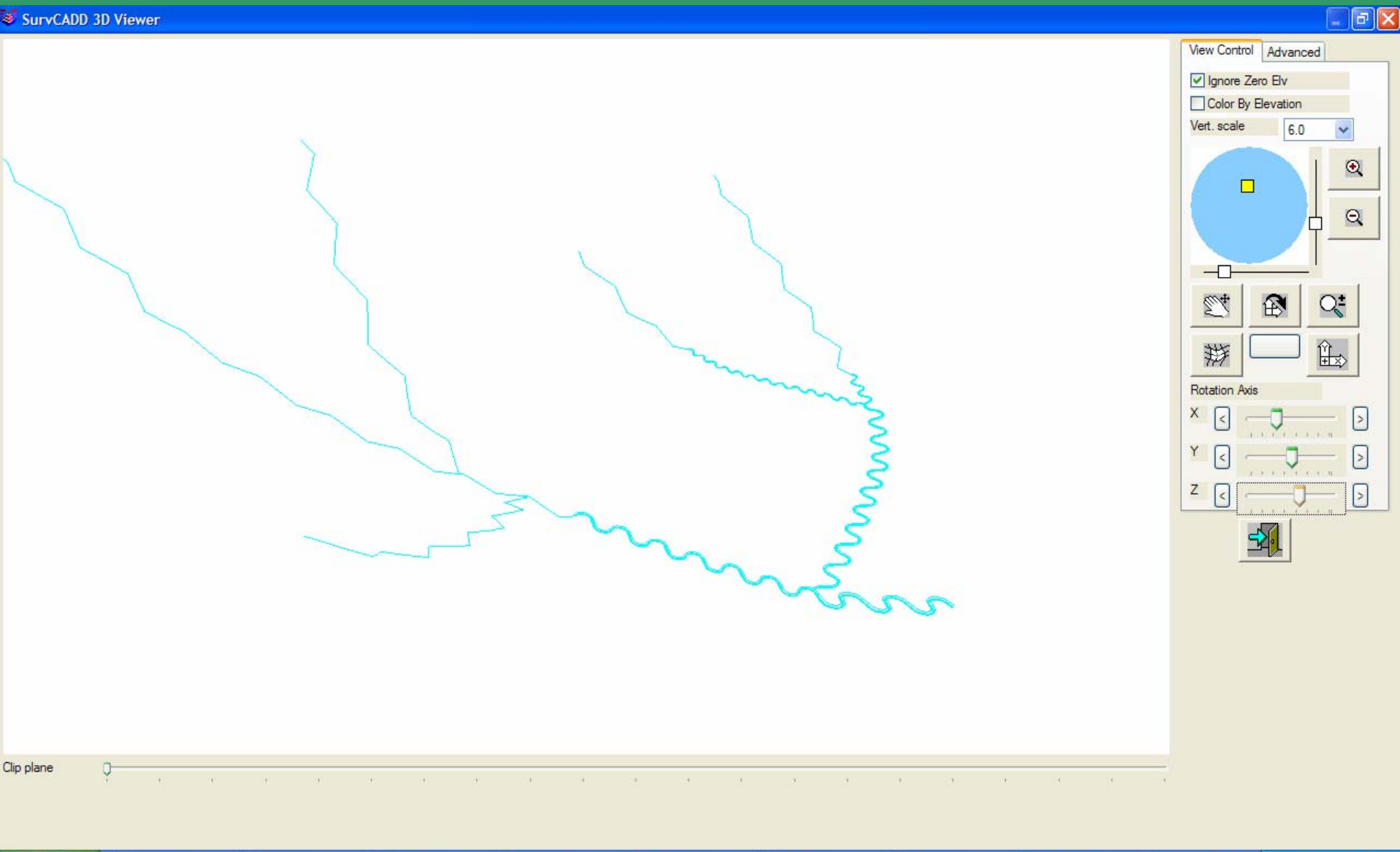
# Check *slope downstream* of the *base level*

# *Knickpoints* can be BIG problems

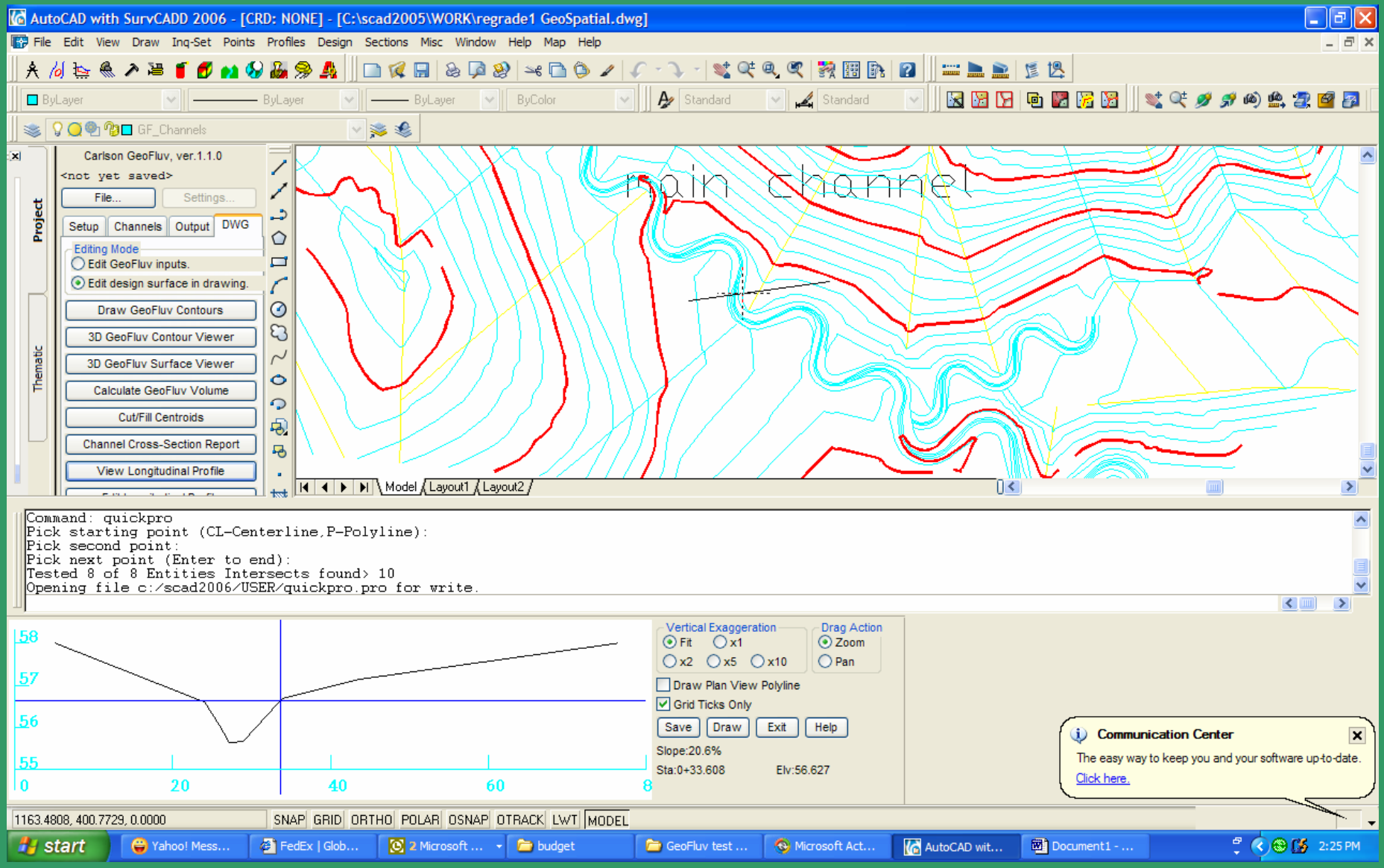


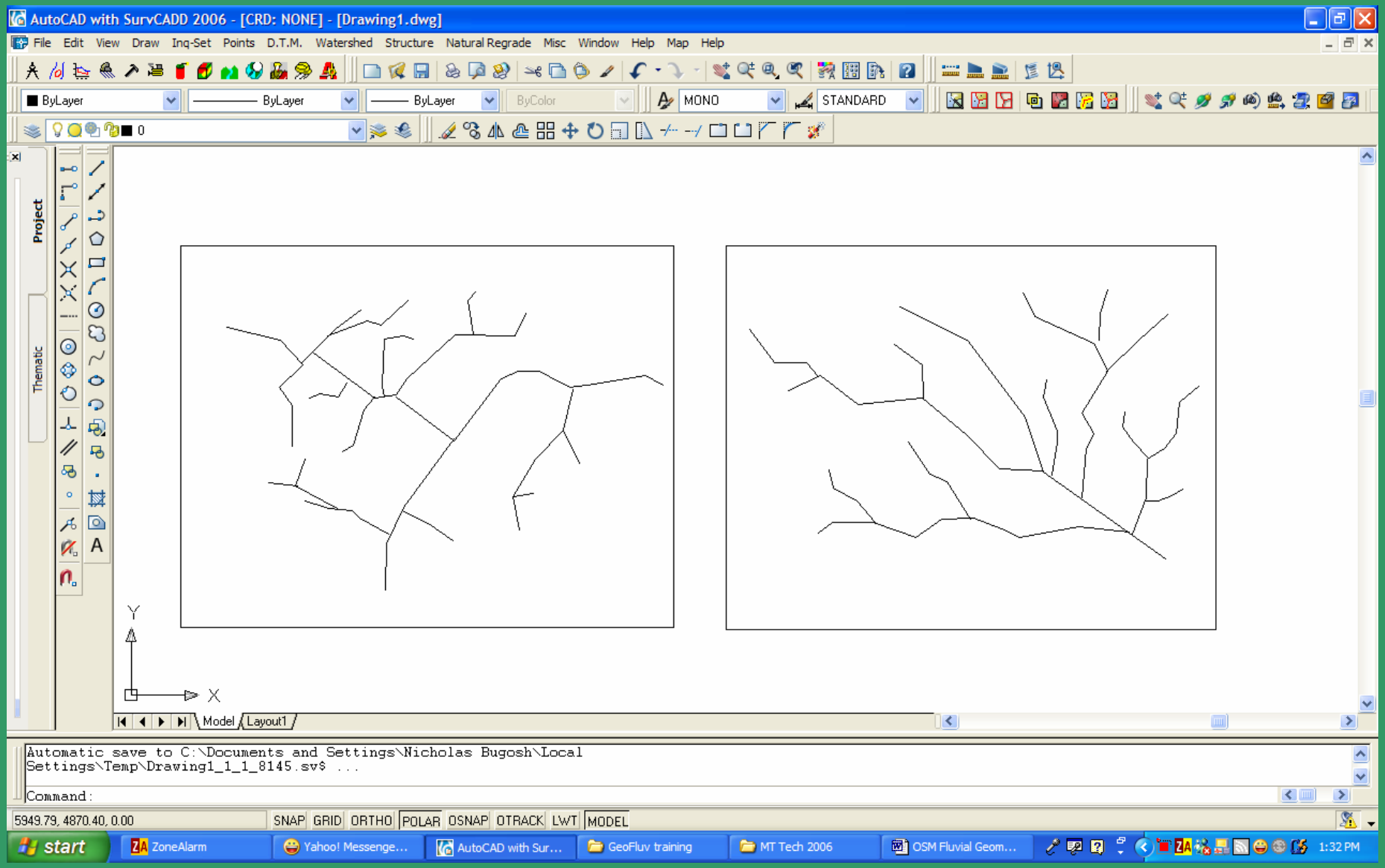
# Integrated concave longitudinal channel profile 3D network



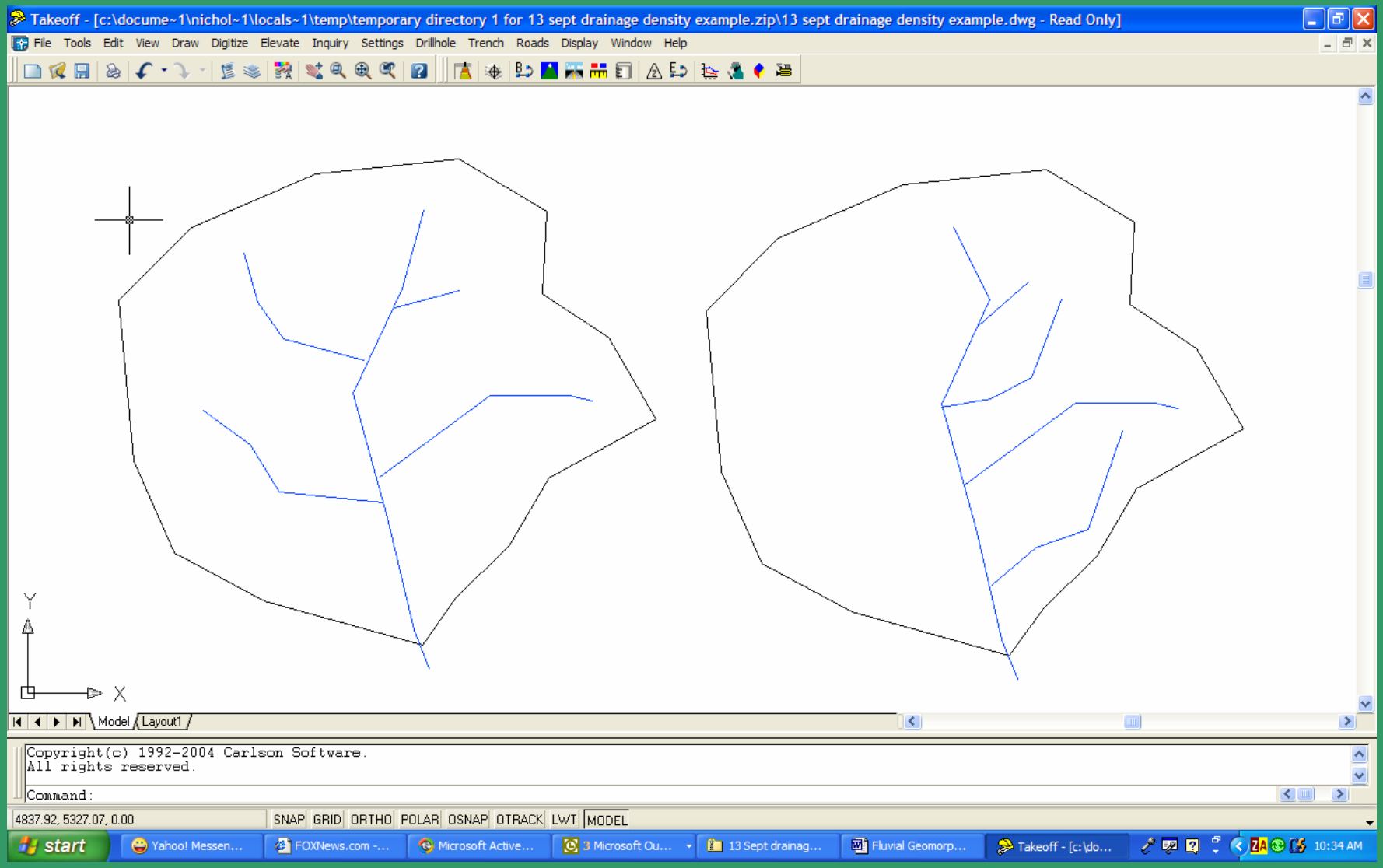
# Channel plan & cross sectional geometry based on bankfull, has floodprone area



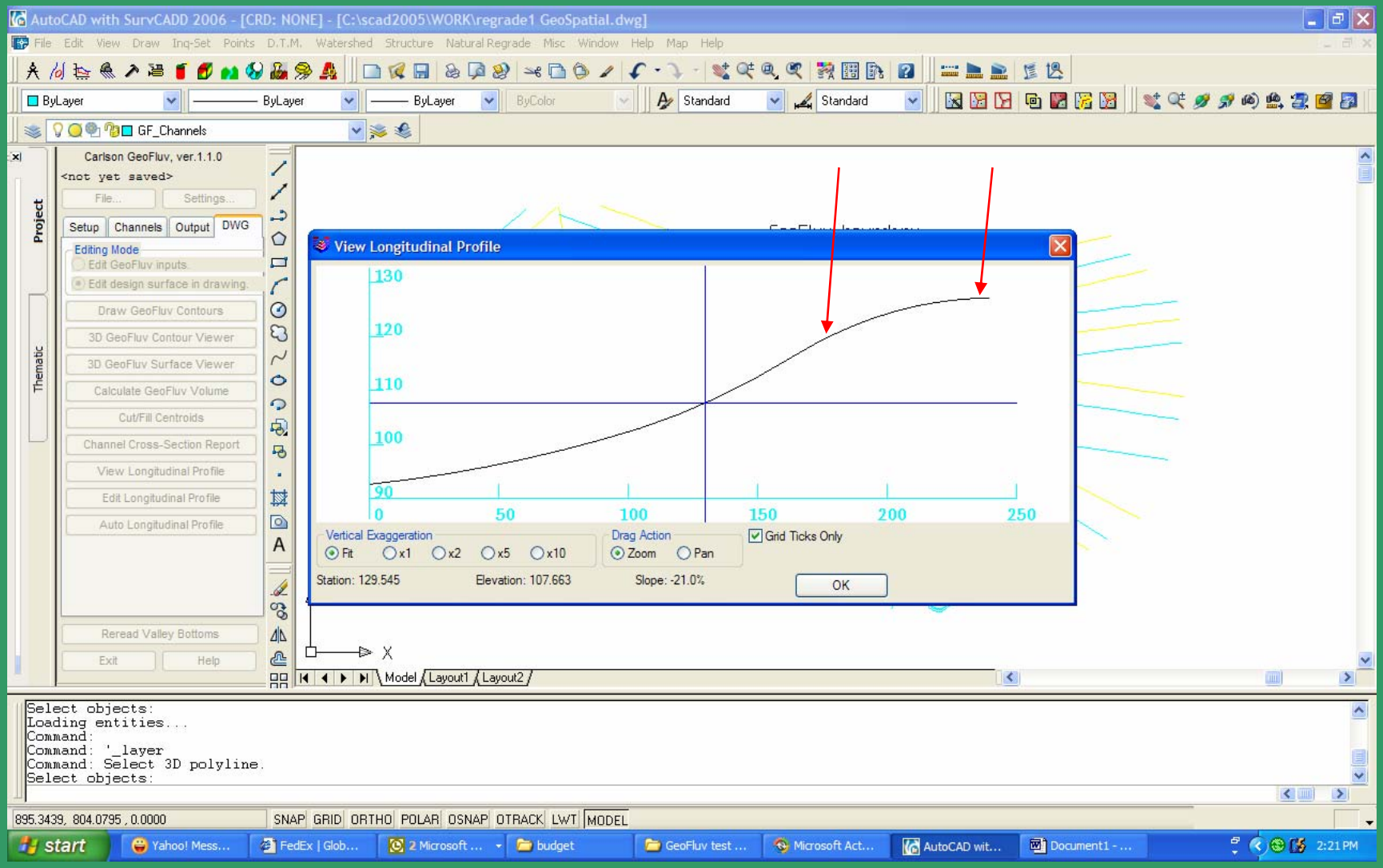
# *Drainage density* appropriate for material and balanced



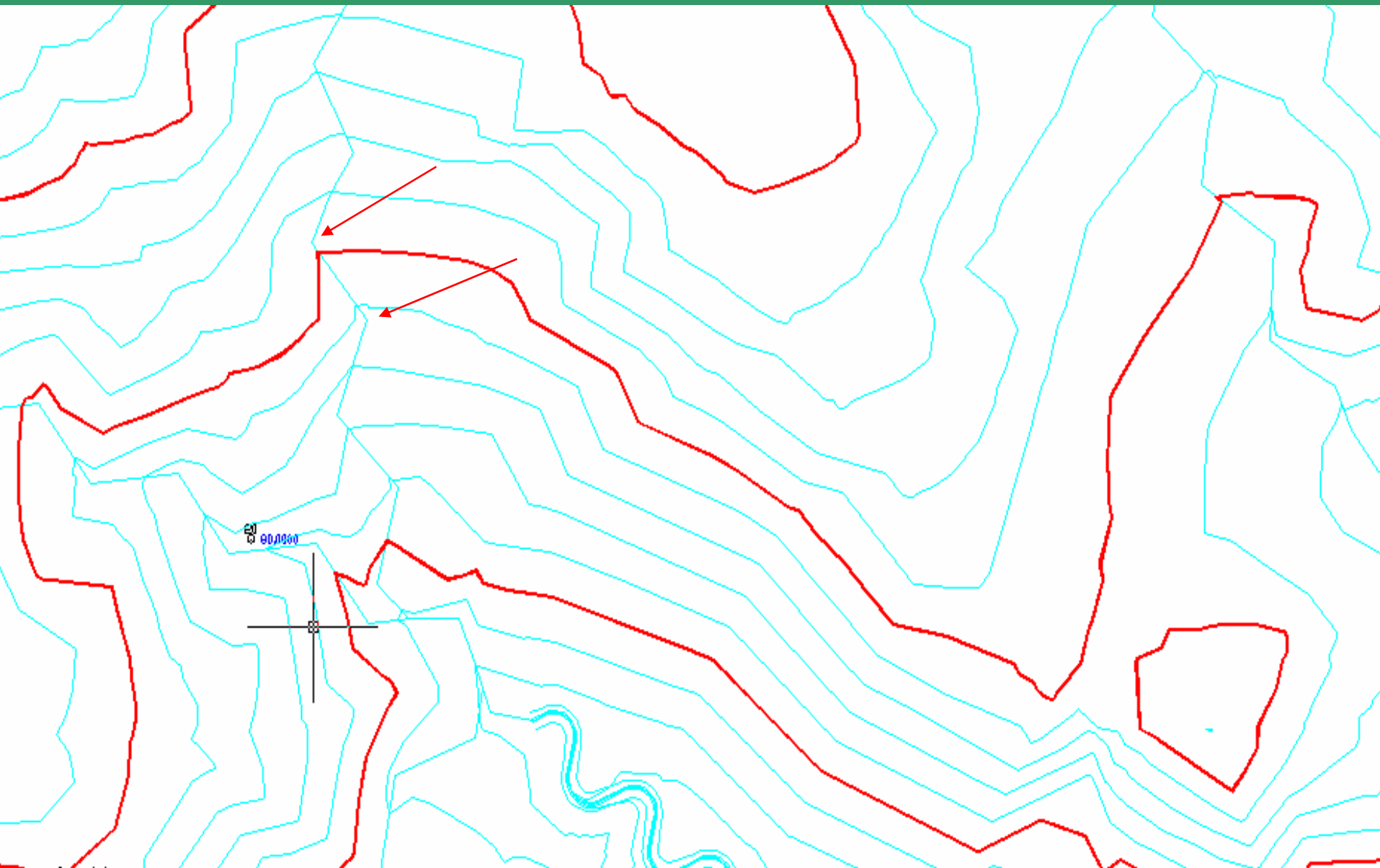
# Drainage density appropriate for material and *balanced*



# Ridge to head-of-channel distance appropriate



# Appropriate ‘A’ channel reach length



# Fluvial Geomorphic Review Item Checklist

- Check point 1a – What is the local base level elevation?
- Check point 1b – What is the design base level elevation?
- Check point 2a – What is the channel slope from the base level downstream?
- Check point 2b – What is the earth material at the base level?
- Check point 2c – What is the slope downstream of the base level?
- Check point 3 – Are the channel longitudinal profiles appropriate for a stable landform?
- Checkpoint 4a – Verify the width to depth ratio (W:D) at several places along channels of these two broad categories (<4% and >4%).
- Checkpoint 4b – Verify that channels >4% and <4% have appropriate sinuosity.
- Checkpoint 4c – Verify that cross sectional areas are adequate and consistent with the desired design velocity.
- Checkpoint 4d - Verify the radius of curvature of the design's meander bends.
- Checkpoint 4e - Verify the meander wavelength of the design's channel meanders.
- Checkpoint 4f - Verify the meander belt width of the design channel.
- Check point 5 – Calculate the drainage density for the design and compare it to the pre-disturbance drainage density and values for stable landforms in the design area.
- Check point 6 – Determine the ridge to head-of-channel distance and compare it to stable landforms in the design area.
- Checkpoint 7a – Determine the sinuosity for channels with valley bottom slopes greater than 4 percent.
- Checkpoint 7b – Determine the 'A' channel reach length for channels with valley bottom slopes greater than 4 percent.

# New feature introduction

# New RIVERMorph link

AutoCAD with SurvCADD 2006 - [CRD: NONE] - [C:\Natural Regrade tutorial\regrade2.dwg]

Carlson GeoFluv, ver.2.0.6

<not yet saved>

Channel "main R1R1" Settings

Geometry | Watershed | RIVERMorph

| | | | | |
|---|---|---|---|---|
| Maximum Water Velocity (ft./s.) | | | | 1.37 |
| Upstream slope % | | | | -12.00 |
| Downstream slope % (Only adjustable on main channel.) | | | | n/a |
| Width-to-Depth | slope > -0.04: | 10.00 | < -0.04: | 12.50 |
| Sinuosity | slope > -0.04: | 1.15 | < -0.04: | 1.48 |

☑ Random scale factors on sinusoidal channel.

Subridge spacing on sinusoidal channel: 3

☑ Specify head elevation.

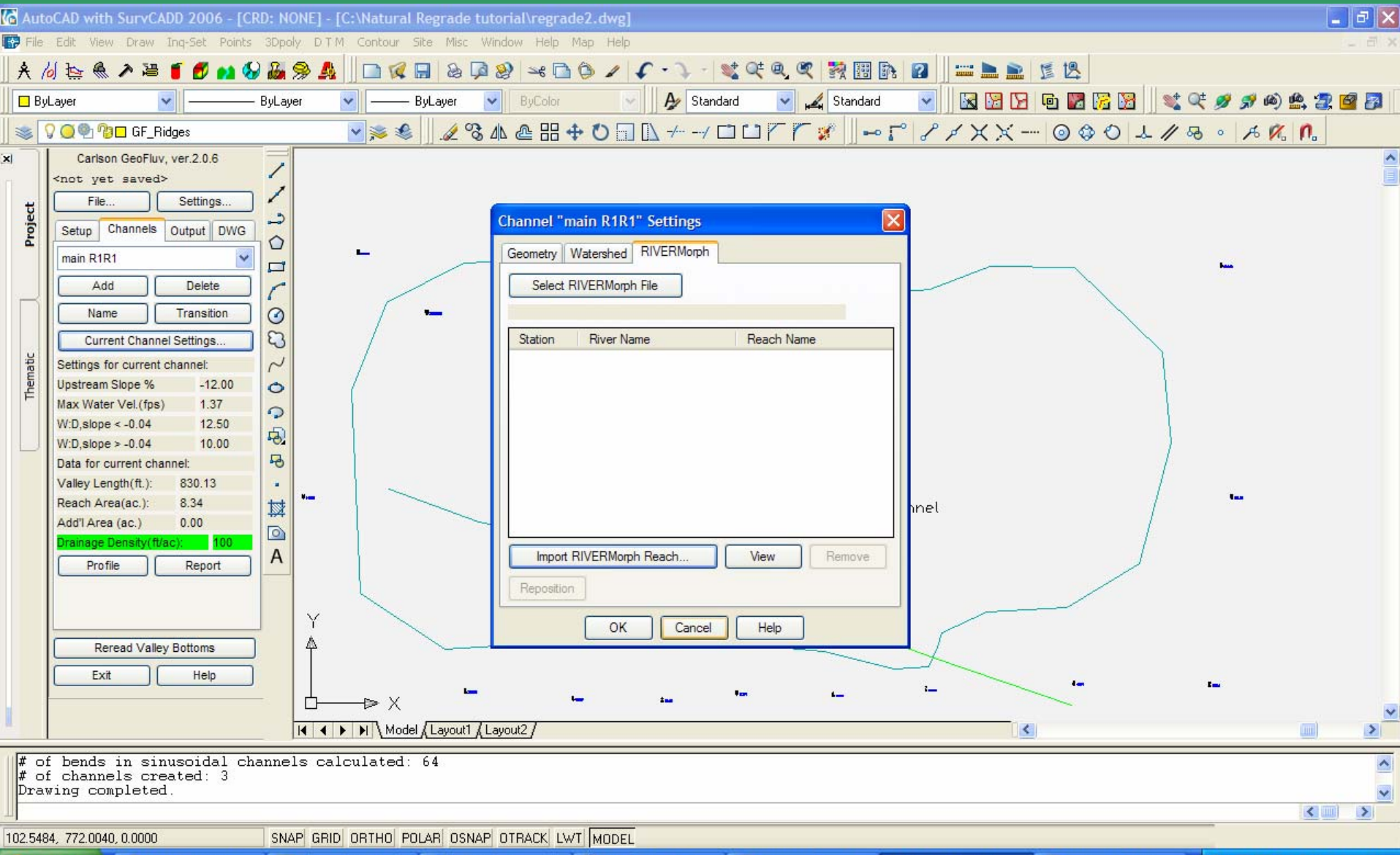
Head elevation (ft.): 142.58 Pick

☐ Specify mouth elevation. Only adjustable on main channel.

Mouth elevation (ft.): 55.15 Pick

OK | Cancel | Help

```
# of bends in sinusoidal channels calculated: 64
# of channels created: 3
Drawing completed.
```

102.5484, 772.0040, 0.0000 SNAP GRID ORTHO POLAR OSNAP OTRACK LWT MODEL

# Data stored in RIVERMorph and 2D design work now comes into *Natural Regrade* to make final 3D design