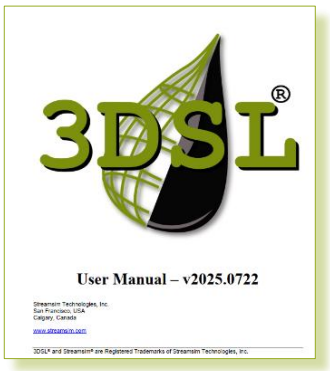
ResConsult and Streamsim Technologies joining forces to deliver solutions for companies operating mature conventional floods in Brazil.

Surveillance & Simulation by Streamlines

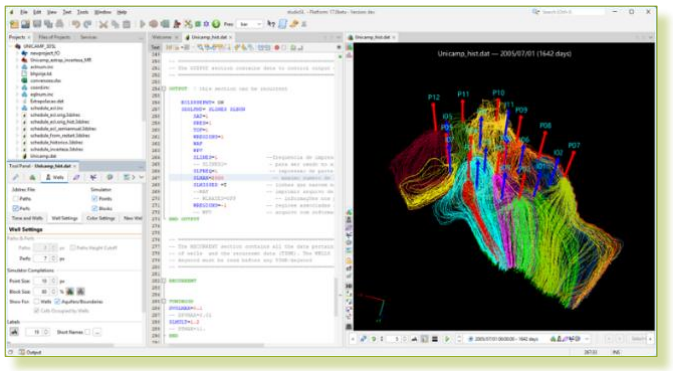
Overview

Streamsim® Technologies (www.streamsim.com) is the developer of unique tools for reservoir modeling:

- **3DSL®:** a flow simulator based on **streamlines**.
- **StudioSL™:** a platform for data preparation, visualization, and simulation management (**3DSL** or other commercial simulators), with *workflows* for reservoir management strategies (floodOPT™), assisted history adjustment (HM), optimizations and uncertainty analysis (EVOLVE®).



3DSL®



StudioSL

3DSL

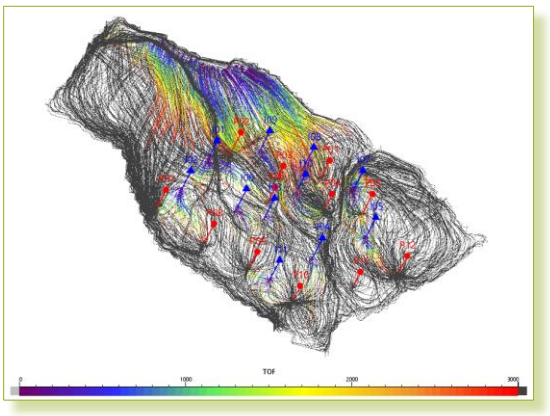
3DSL allows the definition of multiple formulations, including mixable first-contact fluid model, *Black Oil* model, chemical models (polymer injection, tracers, etc.) and dual-porosity.

Streamline simulation uses an IMPES-like approach: it first solves for pressure, then computes saturations along streamlines, which are subsequently mapped back onto the underlying static grid.

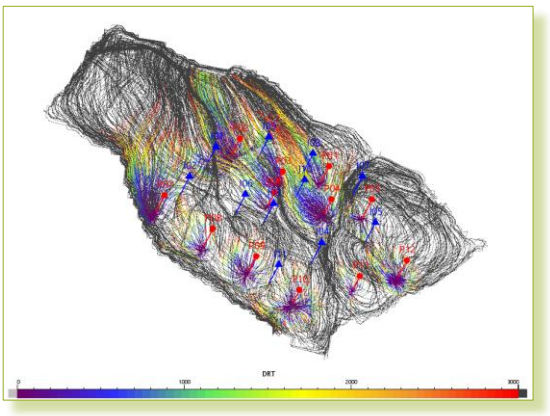
If a surveillance model is used, saturations are calculated using a material balance approach on control volumes defined by streamlines of injector-producer pairs.

Streamlines connect injection wells or boundaries to producing wells and can be intuitively visualized in **StudioSL,** which translates into a powerful tool for understanding fluid dynamics in the reservoir.

The color scale can represent properties such as saturation or identification of volumes associated with producers and/or injectors. An especially useful property for understanding flow is **"Time of Flight" (TOF)** or **"Drainage Time (DRT)".** TOF is the time it takes for a neutral particle to leave an injection point and reach a specific position on the current line while DRT is the time it takes for a neutral particle to reach a producing point from a position on the current line.



Time of Flight (days)

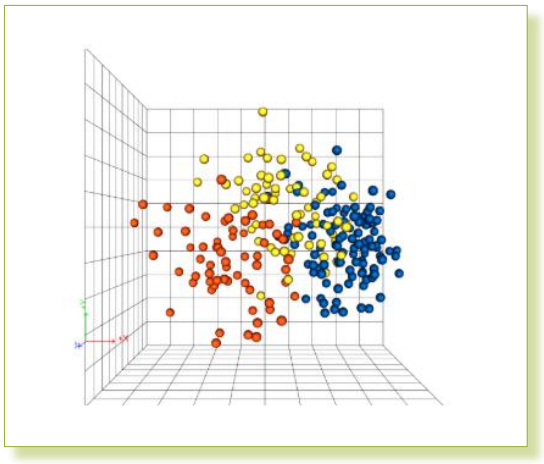


Drainage Time (days)

StudioSL

StudioSL allows for the intuitive creation of multiple *workflows*:

- Assembly of simulation models to run with **3DSL.**
- Surveillance models (reservoir management) — data-driven technology which uses streamlines to quantify dynamic patterns between injection wells and producers.
- Sweep optimization by realigning flow patterns between wells, through the adjustment of injected and produced flow rates.
- Aid model calibration, using streamlines to identify and modify rock properties in regions that affect the behavior of each well.
- EVOLVE® — Set of processes based on multiple rounds for analyzing parameter sensitivity, evaluating uncertainties in forecasts, and adjusting history using MDS (*Multidimensional Scale*) techniques.

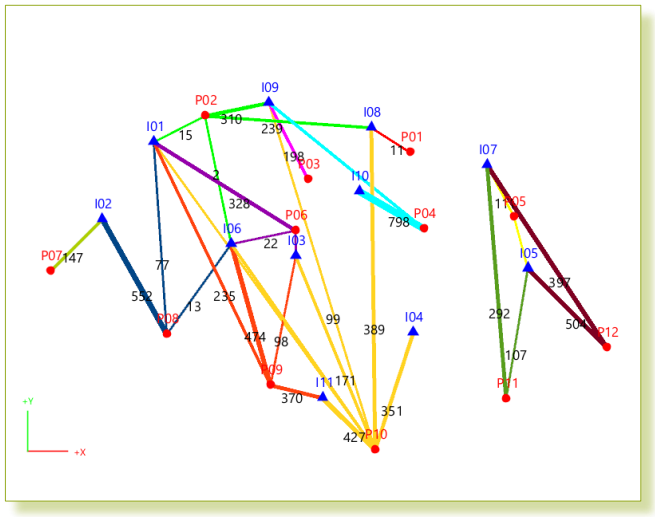


Classification into *clusters* in the MDS.

Application to Mature Fields

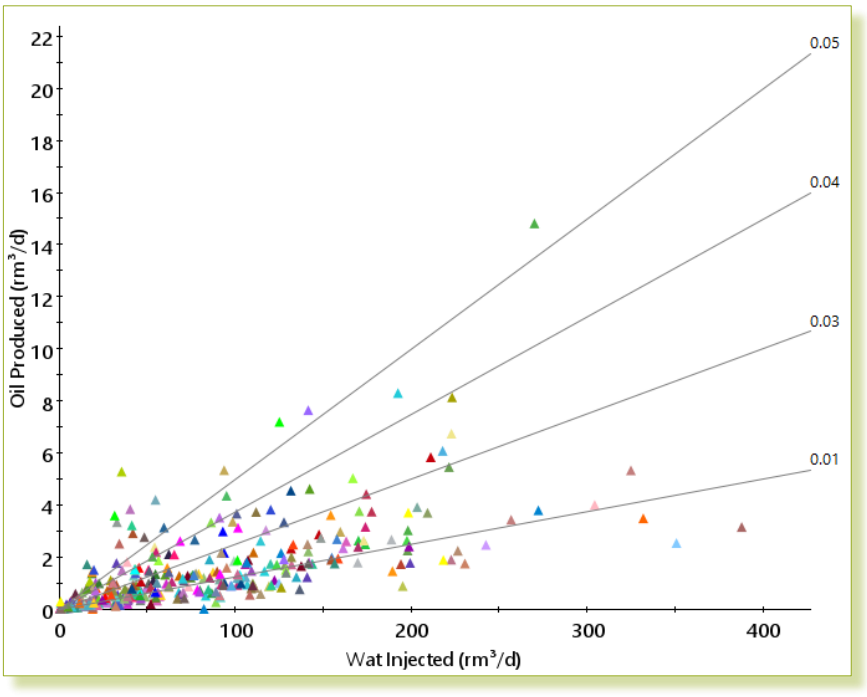
Streamsim's **workflows** are especially useful in reservoir management for **mature fields with large amounts of wells and long production history**.

Using total rates or total volumes (for multiple time steps) of the streamlines, it is possible to calculate dynamic Well Allocation Factors (WAF) at injection wells — defined as the fractions of the injected rate directed to each associated producing well. Similarly, one can calculate the WAF of oil flows in the producing wells. **StudioSL** represents these WAFs very intuitively in Flow Pattern maps (**FPMap**), where the bar thicknesses are proportional to the flow rates of the connections. WAFs and the FPMap will change in time as streamlines change due to changing well conditions.



Flow Pattern Map with Oil Allocation Factors.

As the real water cut in each production well is known, it is possible to estimate the efficiency of each connection between injector and producer (ratio between oil flow produced and flow injected) and also the efficiency of each injector. For mature fields with many wells, being able to identify good patterns and bad patterns based on their efficiency is a unique advantage of using streamlines. **Streamsim** has developed FloodOPT workflow in StudioSL that is a methodology to calculate multipliers to apply to the total voidage rates of injector and producer wells and thereby increase the average efficiency of the field. As a result, **oil production and sweep efficiency can be increased, decline reduced and injected fluid recycling minimized**. The proposed rates can also give clues to which wells are candidates for interventions (re-perforation or conversion) or even for closing.



Injection Efficiency Plot. Each point represents an injector well, placed in function of its own injected rate and the oil rate associated with it.

In Surveillance modes, the streamlines are drawn based on the injection history and total fluid production, but without calculating the movement of the phases. However, the trajectory of the streamlines and the relationships established between injection wells and producers remain correct. From this firm, it is possible to improve the management of the reservoirs, **without the need for the long process of adjusting the history.** If time is short or production records are

incomplete, a preliminary study using only recent data can still be performed, though results may be less precise.

It is also possible, in Surveillance mode, to **map the oil *in place* (ROIP)**, through material balance applied to the paths between the wells, and to **make reliable forecasts of oil, water and gas production for a period of several years**.