APPLICATION OF MIKE-11 WITHIN A DECISION SUPPORT SYSTEM FOR WATERSHED MANAGEMENT

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PRE-SEMINAR DRAFT VERSION

A Decision Support System (DSS) for the optimization of irrigation water supply, minimization of flooding and maximization of hydropower was developed by **HEXA S.A.** [4] for the Department of Irrigation, in Mendoza, Argentina. Although the DSS was designed with the Mendoza requirements in mind, it was designed to be generic enough to allow its use on other watersheds with a minimum of customizing. In its current version, it will be applied to 5 watersheds, and has already been extensively tested on one of them. The version may be applied to any number of reservoirs, hydro or irrigation diversion devices, and a demand of water for irrigation for different crops, may be tabulated or calculated on-line with a programmable routine.

The DSS is composed of several modules:

- A graphical user interface (GUI);
- a Database management system
- a River Flow Forecasting model (Mike-11)
- an Extended Streamflow Predictor (ESP)
- a risk-aversion optimization model
- a long-range average performance optimization model
- a short-term average performance optimization model
- a simulation model,
- and testing protocols for the forecasting-simulation and control of all the modules, operating alone or sequentially..

Mike-11 is used both for the short-term and long-term forecasting of flows to be input to the optimization models. Since short-term precipitation forecasts are not available yet for the region, Mike-11 was expanded to produce extended streamflow predictions (ESP).

The **ESP** is a technique developed by G.H. Leavesley et alt. for the U.S. National Weather Service that produces a number of precipitation-runoff series that covers some possible precipitation scenarios, based on present conditions of soil humidity, freatic level, flow recent history, etc..This principles where developed for HEXA by Morten Runge, from DHI, and is sometimes called **MIKE-BATCH** in our screens.

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The **Risk-Aversion Model**, to be used once a year, uses a heuristic technique to develop maximum and minimum reservoir operation limits that guarantee the meeting of irrigation and flood protection goals with a high degree of certainty.

Those limits are passed to the **Long-Term Optimization Model**, which uses a moving optimization horizon varying from one to two years, using weekly or decadic time steps. This program is executed once a week,(or each **decade**[5] of the month) with updated long-term runoff forecasts.

The reservoir releases recommended by the long-term optimization model are passed as constraints to the **Short-term optimization model**. This model is executed daily and produces the daily reservoir release recommendations.

Both the long-term and short-term optimization models were developed using stochastic dual dynamic programming (SDDP).This technique permits the optimization of systems of many reservoirs, allowing a very flexible framework for river network configuration, planning and operation studies, etc.

The user interacts with the model by means of a Graphical User Interface (GUI), developed by HEXA in Oracle 2000, both for the UNIX and Windows NT versions. The results of the models are presented by means of graphs and tables, and include time series of all the model results, Pareto curves depicting the tradeoffs among competing objectives: Irrigation Demand satisfaction, vs. Flooding Risk, vs. Energy Production and probability distributions of all the important variables.

We will present in more detail, the relevant modules of the Decision Support System.

THE HYDROLOGICAL MODEL.

Usual procedure for forecasting inflows to reservoirs, energy and irrigation schemes, is to use different flavors of stochastic models, such as Auto Regregresive Models as ARMA, autoregresive lag-one as AR(1) etc., as algorithms representing the probability distribution of the stochastic variable, river discharge, e.g.

In this simulation and optimization for the Decision Support System, HEXA preferred to develop a Conceptual (deterministic) Model, given the fact that in the new Mendoza system has been integrated quality hydrological information, initiated in 1909, and supplemented in the future with a new net of 100 hydro-meteorological remote stations, including snow, rain, discharge, etc. sensors. Continuous monitoring, forecasting and simulation is already working properly, implemented by a national manufacturer, ICSA, and collected in 8 DIGITAL Alpha Stations, and different high capacity PCs., with A/D converters, transmiteres, hot stand-by, back to back configuration, etc.

THE DATA BASE

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[5] **decade: day 1 to 10; 11 to 20; 21 to (end of month)**

Historical and fresh information is loaded to a Data Base designed by HEXA Consulting, that is presented in another paper in this same DHI Seminar.
(See M. Barchilón and M. Chrabalowski: A Data Base for the Hydro-Meteorological Net in Mendoza, Argentina).

Today, this Data Base contains:

- 2 millon data lines of historical records, (a data line includes e.g., date, location, river, time, variable (temperature, humidity), sensor, topological posicion in the basin, origin and characterization of the data (measured in real time, historical, obtained by regresion, alarms, remarks and comments).

- A Data-Log (“Libro de Bitácora”), registereng forecasted, decision and real operation data).

- The continuous flow of fresh, remote information, classified, with ear marking of evident outliers, with one-hour sampling rate. Snow stations are sensed and saved each 6 hours.

- Durable (¿permanent?) hard memory devices, CD-Roms, tape back up, and house-keeping information of the System.

THE PREDICTIVE MODEL

HEXA choose MIKE11-FF to be used for forecasting the inflow to the Multi-Purpose reservoir El Carrizal regulating the flows for irrigation and power generation at Tunuyan Basin. The forecast simulations includes simulation of snow accumulation and melt in the High Andes as well as routing of the melted water through dry plains to the reservoir accounting for interchange with groundwater and irrigation schemes located upstream the Reservoir.

SHORT HYDROLOGICAL DESCRIPTION

Previous to any Deterministic (conceptual) Modelling, HEXA has made a clasical study of the Hydrology of the Tunuyan Basin.

Beginning with the historical data gathering, newspaper reports, very sparse numerical hydro and meteo info, visits and site measurements, glacier analysis, geo-morphology, etc., that has been gathered and reported by HEXA. (M. S. Barchilón et. Alt: The Tunuyan River: “The characterization of the Basin” Report, August 1987).

This included the search and depuration of a final Report with 90 years of quite good hydrologic information of the whole Province, with Regressive Analysis of Data (1909-1998), GIS of the area, educated apprisal of the historical and erratic operation in management of irrigation schemes and power-plants, etc.

For the Tunuyan River Catchment, and main tributaries, a Data Collection from 1961 to present contained homogeneous information on sensible parameters for the Model.

A very multidisciplinary work was done, with cold participation of some Public Officers at the start, but with enthousiastic reception of the final result. Present resume, accounts for some short description of end-results.

The **Upper Tunuyan Basin** upstream of the El Carrizal reservoir has an area of approx. 13,600 km² and consists of two parts with distinctly different hydrological characteristics.

43% of the basin is located in the Argentinean High Andes Mountains with altitudes between 2,000 and 7,000 m.a.s.l. This part of the basin receives abundant precipitation which accumulates as snow during the winter season (April-September) and melts during October-March giving rise to peak discharges in the rivers in January. The precipitation is largest in the western parts of the area close to the Chilean border and decreases towards north and east. Rainfall in the mountain areas is reported to be negligible, but no measurements exist.

The foothills and plains between the reservoir and the mountains constitute the rest of the basin. The precipitation in this area is very sparse and occurs as scattered events with high intensity and limited spatial extension.

The whole basin is characterized by coarse soils with high infiltration capacities and sparse vegetation. In the foothill area significant infiltration losses take place from the streams draining the mountain areas. Many of the smaller streams dry out a certain distance from the mountains and emerge as springs further downstream where the terrain flattens.

Downstream of the mountains a part of the river water is extracted for irrigation. The irrigation systems are assumed to have an efficiency of 30-40% and the majority of the losses to infiltrate. The infiltration loss will contribute to the river flows further downstream.

Hydrological data

The most important catchment, which generates more than two thirds of the total flow contribution to the reservoir is gauged at the Valle de Uco Station. The discharge (flow) measurements are of good quality and covers the period from 1960 to 1996. The records from the smaller mountain catchments are much shorter and not with the same quality.

Some records could be extended by correlation with nearby Rivers, like Mendoza River, snow measurements in Chile, etc.

Unfortunately precipitation data from higher altitudes has only been available in the form of snow water equivalents from a few stations close to the model area. Of these stations only one has data for the whole 1960-96 period. The first 29 years of the records consist of only one observation per year while the remaining part is continuous snow pillow data.

Temperature data at higher altitudes have not been available and the simulation of snowmelt and accumulation has therefore been based on temperatures from a station at 2700 m.a.s.l. – a rather low altitude, considering that the runoff generating parts of the basin reach nearly 7000 m. Thus, the available hydro-meteorological data has constitutes quite a weak basis for precipitation-runoff modelling.

SETUP AND CALIBRATION OF MIKE11

As already said, the Mike11 was chosen as the forecasting tool for all the basins (Rivers Mendoza, Tunuyan, Atuel, Diamante, Malargue). Full calibration was made for the Tunuyan Basin.

The MIKE11 modules used in the project are:

- The NAM rainfall-runoff module, with the extended altitude differentiated snow model. The model uses an advanced degree-day approach to simulate the snow accumulation and melting.
- The HD module simulating the channel flows on the plains and interchange with groundwater and irrigation systems.
- The FF flow forecasting module, for automatic updating of the flows.
- A special BATCH version of MIKE11-FF has been developed under this project. This version carries out multible forecasts for the same or proceeding times of forecasts using in each simulation different model input for the forecast period. The module was developed for long term forecast using the extended streamflow prediction method, but has also shown very powerful for testing short-term forecast accuracy under realistic conditions.

The hydrological model simulates the runoff from seven different catchments (see fig. 1). The first five of these are located in the high mountain areas and generate nearly all the runoff. The sixth catchment simulates the runoff from rare thunder showers over plains between the mountains and the reservoir, while the last one is a fictive catchment used to simulate the effect of the irrigation schemes on the river flows.

Each of the mountain catchments in the model are subdivided in 7-10 equidistant (500m) altitude zones for which independent simulation of the accumulation and melting of snow are carried out. The delineation of these altitude zones and their areas have been determined using Arc-View GIS.

The snow accumulation measurements have been converted to series of precipitation and correction factors applied adjusting for the bias in the series introduced by the change in instrumentation. A simple lapse rate of 0.5 (deg.C/100 m) has been introduced to generate temperatures up to 5000 m. Since further decrease of the temperature above 500m showed to prevent any snow melt above this altitude the temperatures calculated for the 5000m altitude have been used also for higher altitudes.

Considering the sparse hydrological data available it has been possible to arrive at good calibration of the model particularly with respect to low flow simulation which is of particular interest in this case. Results from the most important catchment are shown figure 2. Furthermore, it has been possible obtain a consistent model accuracy for the whole 1960-1996 period. This is an important aspect because the final system is being used for both short-term and long-term (annual) forecasts with the latter ones being based on the full historical records using the ESP, extended streamflow prediction method.

When entering the plains part of the flow in the river channels infiltrates into the river beds and is routed as groundwater further downstream to locations with high groundwater tables where it re-surfaces and joins the rivers. The phenomenon, which causes a slow routing of the infiltrated part of the flow, is being simulated by MIKE11's build-in water loss routine. The real balance of this flow was checked against the real differences in flow between Valle de Uco and Carrizal.

Test of Forecast Accuracy

Although river bed infiltration and uncertain irrigation extractions and returns reduces the accuracy of the model results downstream of the mountains, the largest source of uncertainty in the forecast situation is still the snow melt simulation. Hence, the reliable discharge series from the main flow generating catchment offers an excellent opportunity to improve the forecasts by application of the model's automatic updating facility, which ensures that the simulated flow at time of forecast corresponds to the observations. However, in such a case the forecasting accuracy can not be assessed alone from the calibration results, but has to be determined from series of realistic test forecasts.

In a forecast situation hydro-meteorological data are known only up to the time of forecast, while the model input for the period after time of forecast is normally based on local meteorological forecasts.

On the request of the project supervisors sets of test forecasts were carried out on the basis of the historical time series using two different assumptions on model input after time of forecast. One set representing 'perfect' knowledge, i.e. using the (sparse) historical data as model input after time of forecast, and one set using imperfect knowledge represented by the following assumptions of the meteorological conditions after time of forecast:

- No precipitation
- Potential evapotranspiration equal to the long-term average for the month
- Constant temperatures equal to the ones measured (and extrapolated) at the time of forecast.

Each set of forecasts includes 114 single forecasts of the average flow during the ten days following the time of forecast. Each forecast is offset ten days from the previous one and the times of forecasts cover the period from May 1 1993 to June 4 1996. The forecast accuracy is illustrated on figure 3.

From the result statistics shown in table 1 it is noticed that:

- the use of the automatic updating procedure improves the forecast accuracy significantly and
- the meteorological short-term prognoses are likely to have only minor influence on the accuracy of the flow forecasts in this special case where rainfall is negligible and the flows are dominated by melting of snow falling several months earlier.

Table .1 Statistics of test forecasts May 1 1993 – June 4 1996 of average flow over ten days at the Valle de Uco station

No.	Knowledge level in forecasting period	Use of automatic updating	Coefficient of determination (R^2)	Root Mean Square Error	Coefficient of Variation
1	'Perfect'	Yes	0.937	4.775	0.165
2	Imperfect	Yes	0.925	5.133	0.177
3	'Perfect'	No	0.856	8.389	0.230
4	Imperfect	No	0.859	8.377	0.389

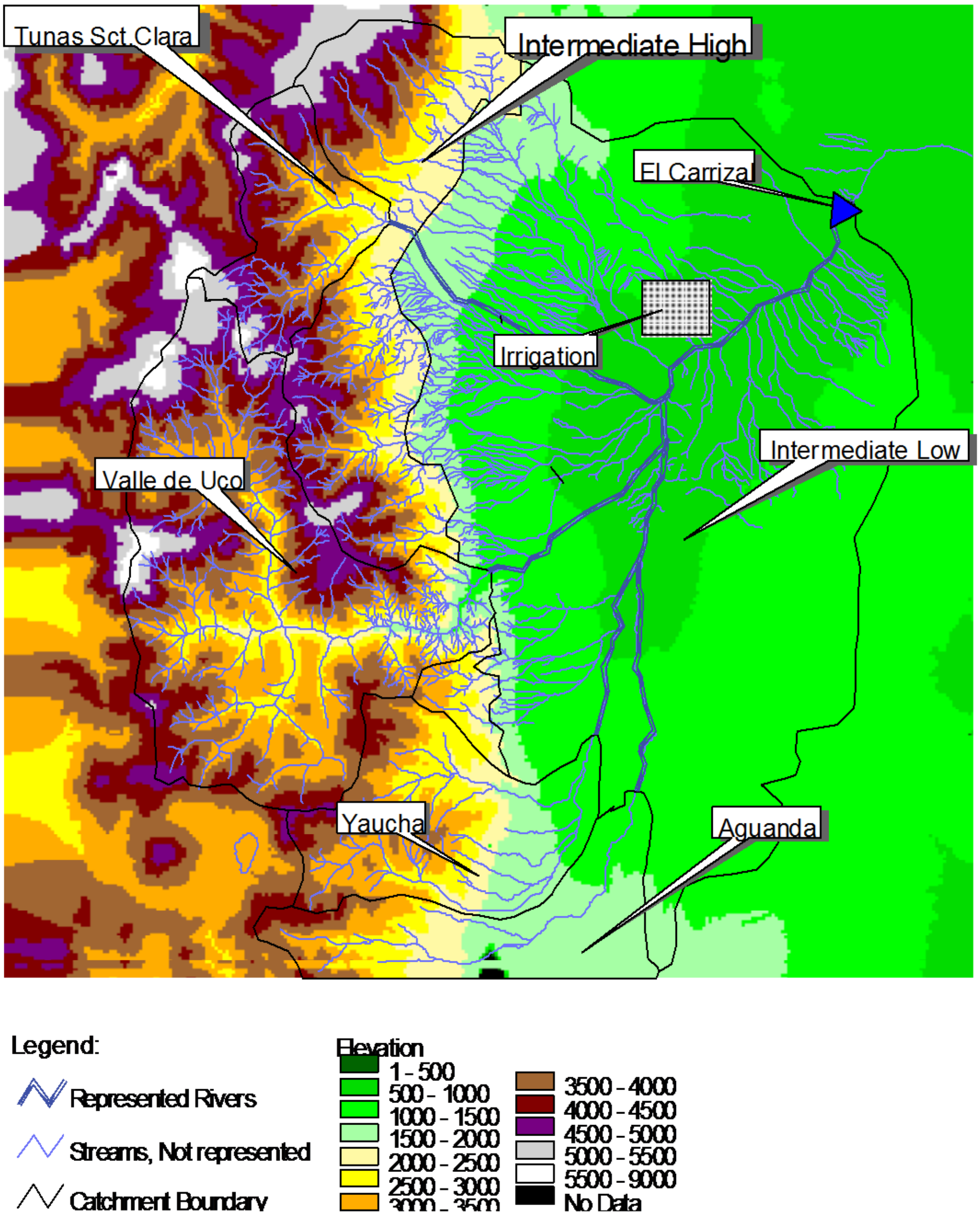


Figure 1 Catchments and altitude zones represented in the hydrological model

Following graphic presentations, taken from the GUI interfase, will give a sound idea of real result of the MIKE11 performance.

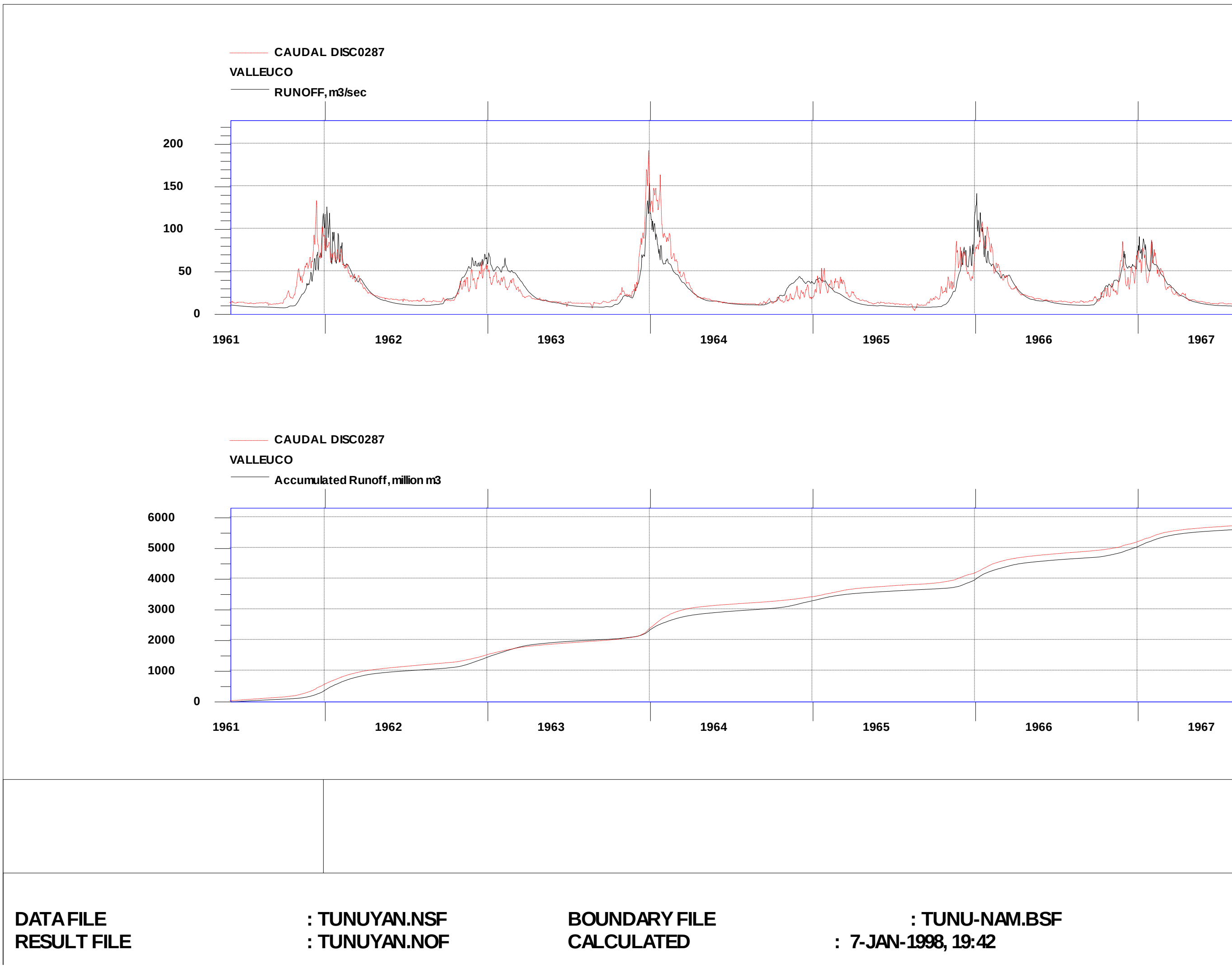


Figure 2 Simulated and observed hydrographs at Valle de UCO with flow accumulation, validation period

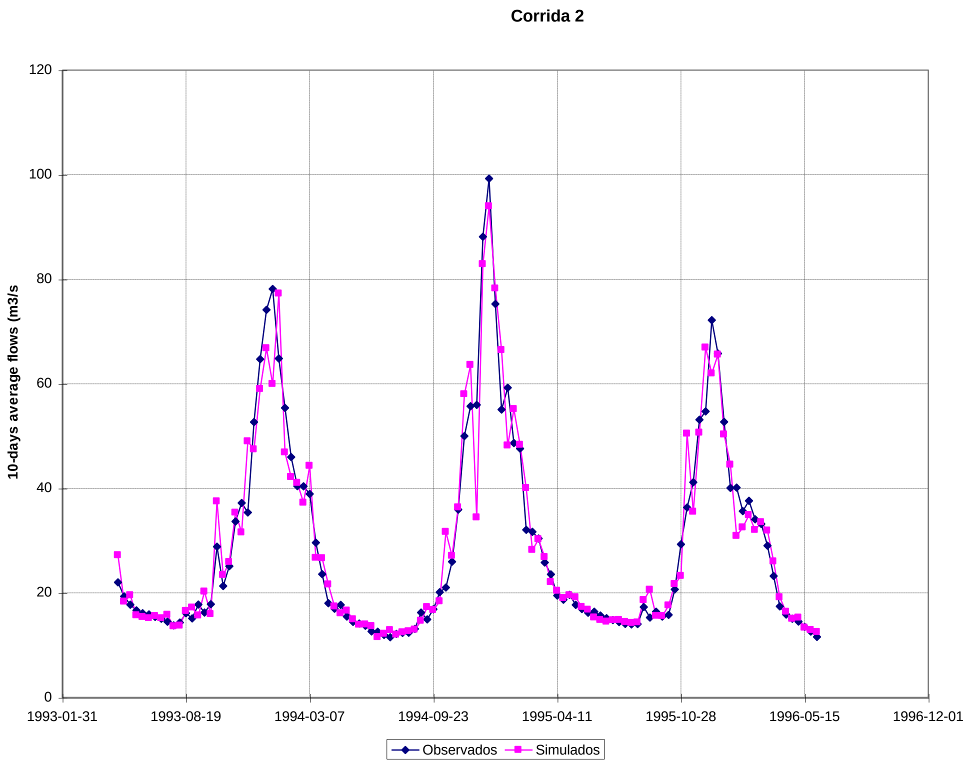


Figure 3 10-days flow forecasts for the Valle de Uco Station using imperfect knowledge on the forecasting period.

After this short Briefing on the **Calibration and Results of the Forecasting Model**, let´s give attention to the rest of the Decision Support System Modules.

RISK AVERSION MODEL

The Risk Aversion Model will define the upper and lower limits for the reservoir(s) that will assure both contradictory interest from the Water Authority:

- Give good satisfaction of irrigation
- Give protection to life and crops against floods.

Satisfy water demand for irrigation, is strongly dependent on the type of crops, temperature and season (time of the year), may be in oposition with protection against floods. As example, to try to initiate the irrigation season with a full-filled reservoir at the beginning of the irrigation season, will assure a good irrigation, (October- march for grapes, in Mendoza), and in fact this used to be the natural move from the water managers.

But leaving the reservoir without empty volume, a flood from the snow melting or a sudden rainfall in december, will not be dampened (laminated), resulting in distressing flooding downstream from the dam. In Carrizal Reservoir, for instance, a discharge higher than 100 m3/s will result in river-side properties covered with water during the coincident “vendimia” (vintage, grape collection) season . A discharge from the valves, spillway or turbines combined, higher than 150 m3/s, will mean bridges and dikes   destroyed, etc. Historically, floods of 250 m3/s has been measured, downstream after the construction of the dam, with strong human and economic damages.

The trade-off indicators, for this two environmental-economic and risk mitigation impact evaluation will be characterized by two simple parameters:

Alpha = real supply for crops / crop optimal demand for the decade, and

Beta   = real combined discharge / maximum accepted flow

It's evident that neither the flood protection will be total, or the water irrigation demand will be always achieved, but the trade-off will be presented to the Dam Manager as a Pareto Curve. This well known graph gives indication of the optimal point Alpha-Beta or the regions where is not possible to give better satisfaction to demand (*Alpha*), without reducing the risk protection (*Beta*), etc.

LONG TERM OPTIMIZATION MODEL

This LONG TERM OPTIMIZATION MODULE, allows the user to select a set of values Alpha and Beta, pre-calculated by the Risk Aversion Model.

This Model has two succesive trade-off:

1 – water demand satisfaction vs. Energy supply, expressed in $ or Gwh.
2 – Remainnig water volume in the reservoir at the end of the irrigation year (June)

The first trade-off is represented by a weighting factor, Lambda.

Lambda = 0 will represent 100 % priority to irrigation;
Lambda = 1, will indicate priority to energy production.

Please note that even with Lambda = 1, this second Module (Long Term Optimization) must obey the bounds guaranteed by the risk Aversion Module, and the Model uses its flexibility for operating the dam, maximizing the energy sales.

At the end of the optimization process, the model will produce a curve or table, giving the recommended volumes to be released each week (or decade), fulfilling the requirements of Final Volume at the reservoir, and Lambda. The model will give this values without exceeding the flood protection discharge requested.

SHORT TERM OPTIMIZATION MODEL

This Module weight the trade-off between energy sales and the flood accepted discharge. As the Long Term Model results has given the allowable water volume for the decade (or week), as constraints, is necessary for the Irrigation Manager to make daily allocation of irrigation water, trying to maximize energy sales: Energy price is suggested or presumed for the near future. This Short Term Model is executed daily, and produces the daily reservoir releases recommendations, attending the long term irrigation demand, optimizing for the near future the options between energy sales and flood protection.

The responsible parameter for the trade-off is defined as Lambda:

Lambda **= energy sales / flood protection**

in normalized units, after maximum acceptable values

.

So, after the successive application of the models, the Decision Maker will have a sound proposal for immediate release of water, through irrigation valves, and turbines and spill of excedents.

Planning and Operational Strategies

Please note than this description may induce the feeling of rigid commands and restrictions from the Decision Support System. Anyhow, some of this restrictions, or bounds, as energy production or final volume at the reservoir, are softer limitation than irrigation satisfaction, (at least in an arid zone as Mendoza) and may be violated: the Model will signal this trespassing and leave to the Operator the final Decision Making.

If the Decision Maker is planning in advance, (Whith the Planning **Scheme) he will have different options (for the** Operational **Stage), adopting an educated risk for, say, ending the irrigation -year with very low reserve for the following year.**

This Planning Stage**, also accessible through the initial screens of the GUI, use identical modules than the Operational Sequence of commands, differing only on the archives and permanency of the information.**

A special device, the Log-Book or "Libro de Bitácora", **as in old ships, keeps trace of programmed route and final, real operation.**

MATHEMATICAL TOOLS

Multiatribute scenarios of conflicting interest, may be treated in simpler cases, as wind generation vs. thermal generation, introducing the uncertainties, strategies, attributes, benefits or commercial impact of pollution remediation, for instance. commercial software is available today at the computational

capabilities of a PC. and has been subject of research in the 80's. and industrial use in the 90's.

In the case of our real DSS, one side of the problem, the allocation of a hydro-energy, stored in system reservoirs at certain level, creates a link between today operation with future consequences of the decision. Because it is impossible to have a perfect forecast of future inflows to the dam, the operation problem is essentially of stochastic nature.

In the real world, multiple reservoir or hydro plants, on the same river, in chain or parallel, gives extra mathematical difficulties to the problem solving of this integral trade off.

It is not our intention to give a review of the analytical tools, but to indicate some difficulties intrinsic to the problem formulation.

In fact, the present day state of the problem is well known: storage volume, water inflow today, and may be probabilistic distribution of inflow volumes. A Recursive equation will fairly represent in the Control Theory the immediate future, given decision variables and limitations: allowable spill through weirs, upper and lower bounds (flood –demand!)

Dynamic Programming will give solution to the Recursive Equation for one or two reservoirs. But when in the real world, the reservoir must be discretized in spatial subdivision (volume depends on water level and topography), the Vector carrying this space state information added to the stage (time) discretization becomes increasingly complex, and the number of recursive steps exponentially increase with the number of state variables. This problem, known as the *course of dimmensionality*, in Dynamic Programming, may keep the problem computationally unfeasible, even for a small reservoir system.

M.V. Pereira, "*Optimal stochastic operations scheduling of large hydroelectric systems"*, in Electric Power & Energy Systems, July 1989, gives an introduction of the subject and an example of the progression of computational steps necessary for solving the Recursive Equation:

1 reservoir with 20 discretization steps, gives 20^2 = 400 possible states,
2 reservoirs with the same 20^4 = 160 000 states,
3 reservoirs with the same 20^6 = 64 000 000 states,
4 reservoirs with the same 20^8 = 25 000 000 000 states,
5 reservoirs with the same 20^{10} = 20 000 000 000 000 states,

Dual Dynamic Programming (DDP) **is the answer to deterministic cases: This technique is described in specialized texts. For a two stage optimization problem of deterministic nature, this method see the Recursive Equation as a two-stages sequential decision process. Vector variables, are described in the first and second stage respectively.**

Stochastic Dual Dynamic Programming: (SDDP)

In our case, strongly hydrology-dependent variables are of stochastic nature

Vectors of random structure, are composed of irrigation and flood variables. For the first: inflow to the dam, water demand; for the former: ouflow volumes, reservoir level). The irrigation demand is represented by a simple linear expression, and the constraints to system operation, (upper and lower bounds on outflow, and the limitations on hydraulic system balance (energy, continuity equation, etc.) are represented also by linearized equations. Numerically speaking, this process is sometimes difficult, as linearizing the Hill-Diagram of a turbine, and some educated, engineering approaches, must be adopted, with polygonal representation of the function (see convergence warning!).

Given a feasible solution to the first stage problem, the operation problem can be represented by a minimization of a linear function, subject to constraints already known at this stage (water available at the reservoir, e.g.) The reservoir storage of the dam is calculated at the end of the first step, where this variable has been part of decision variables), and becomes the initial volume constraint in the second stage.
This sequential decision process may be represented and solved with mathematical tools used in Control Theory. The Stochastic Dual Dynamic Algorithm constructs the future variables: (discharge scheduling, e.g.). through a Recursive Equation solution from the dual information of the linear problem.

Convergence**: This approach with SDDP permits the solution of** many-reservoirs **configuration. In our case, the authors tested with 4-5 reservoirs, two or three irrigation areas, four hydro plants, etc. in different topologies, always with convergent solutions.**

The linear approach for different non-linear functions converge to the global optimum *only* for concave functions. As example, is valid the representation of Cross-Section Area of the reservoir with level, but convergence to optimality cannot be guaranted for some complex topologies in the general case.

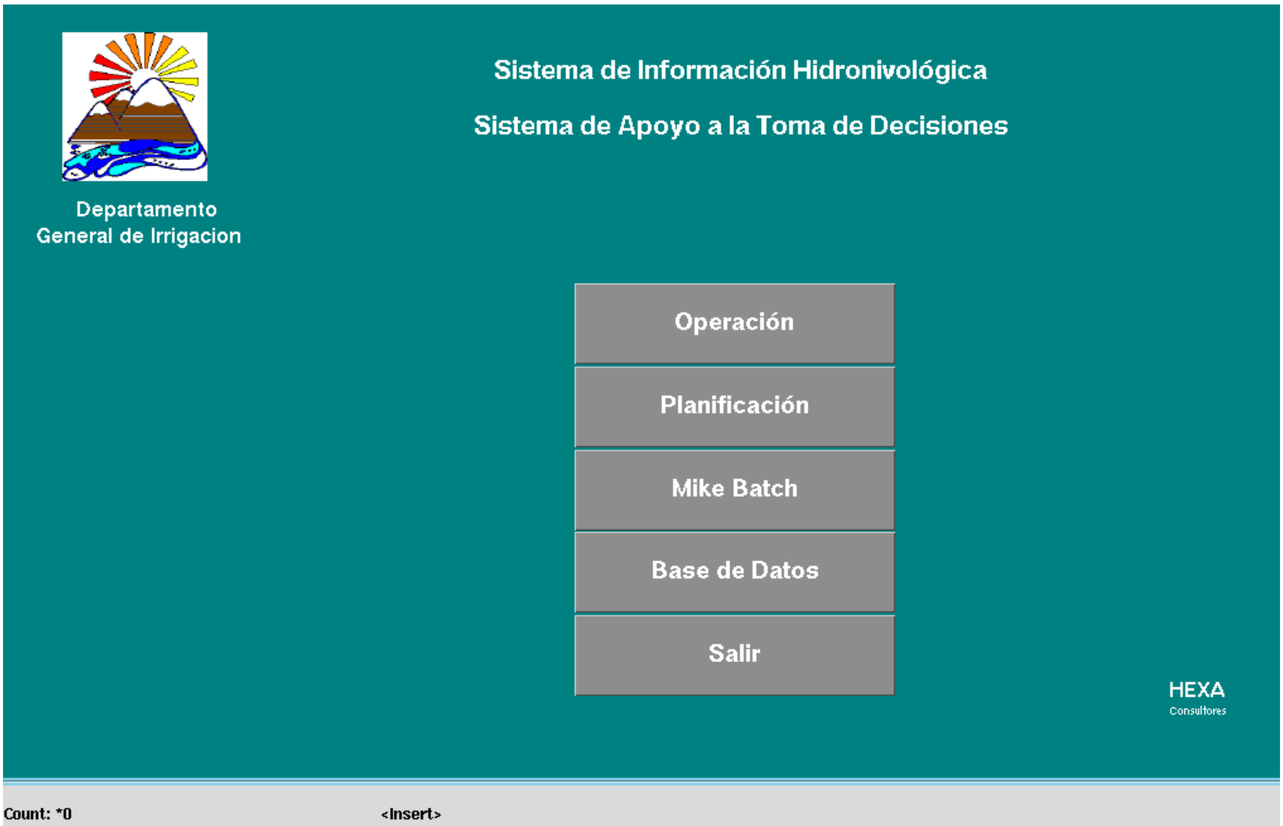
SOME EXAMPLES OF OPERATION OF *HEXA`s DECISION SUPPORT SYSTEM*

To clarify this introduction, we will present some typical operations of the Operational DSS.

For the sake of space and memory , when not necessary, only final graphic representations are included here. The total Graphic User Interfases (GUI) are presented in another paper and only few graphic screens are included.

THE MASTER SCREEN

The Operator of the system found an Master Screen like the following figures:



The first **Master Screen,** view by the Operator, where He/She will interact with DATA BASE (updating, saving, ...), the MIKE11 and the specific fields of the DSS: The Planification and Operation Buttons.

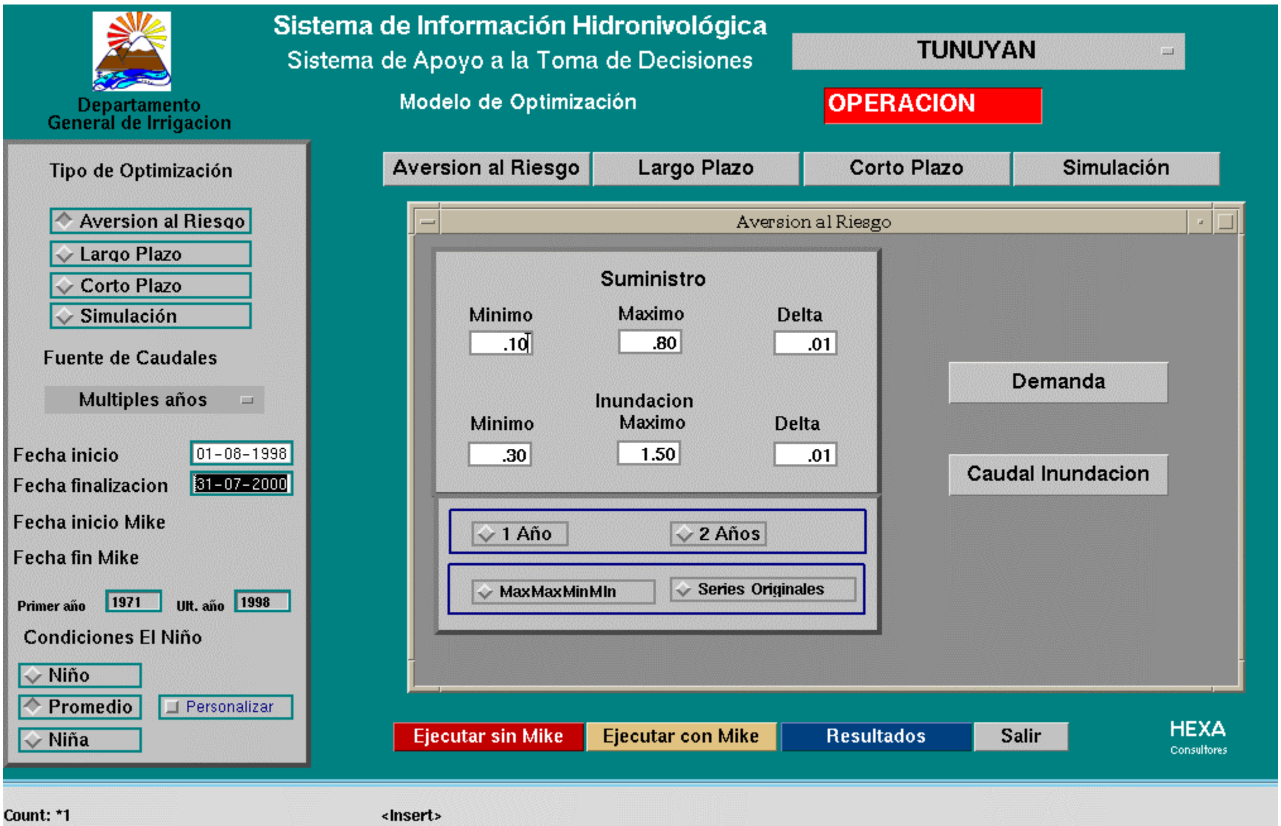
The **Operation** is the gate to fields of **Development** and/or **Optimization** Techniques. In the development (Desarrollo) are tools for creating new reservoirs configurations, different scenarios of hydro schemes, demands, etc.

Both, Operation and Planning, invokes the same simmulation tools, creating different files:

Operation, creates permanent registers of steps and results, in day to day practice.

Planning, creates provisional files to play with "What if...", alternative scenarios, strategic analysis of the consequences of the "Clients" request to the System: Hydro-energy producers, local irrigation managers, political and "fuerzas vivas" (agricultural land owners, industrial managers..) with demands almost in oposition.

As said, the Operator will iniciate the Optimization Operation with a Risk Aversion screen, where input of numerical parameters, for irrigation demand, limits to flood protection, etc., are typed..



Environmental variables: El Niño Year, flood protection alternatives, 1 or 2 year horizon, etc., can be prepared. Also can prepare a simulation with historical flows, or MIKE11 forecasted values for the selected period.

See later the resulting **Risk Aversion Diagram**, showing the bounds of recommended operation, the Pareto resulting curves, and the possibility of optimal or sub-optimal operation point, with the adoption of **alpha** and **beta** parameters.

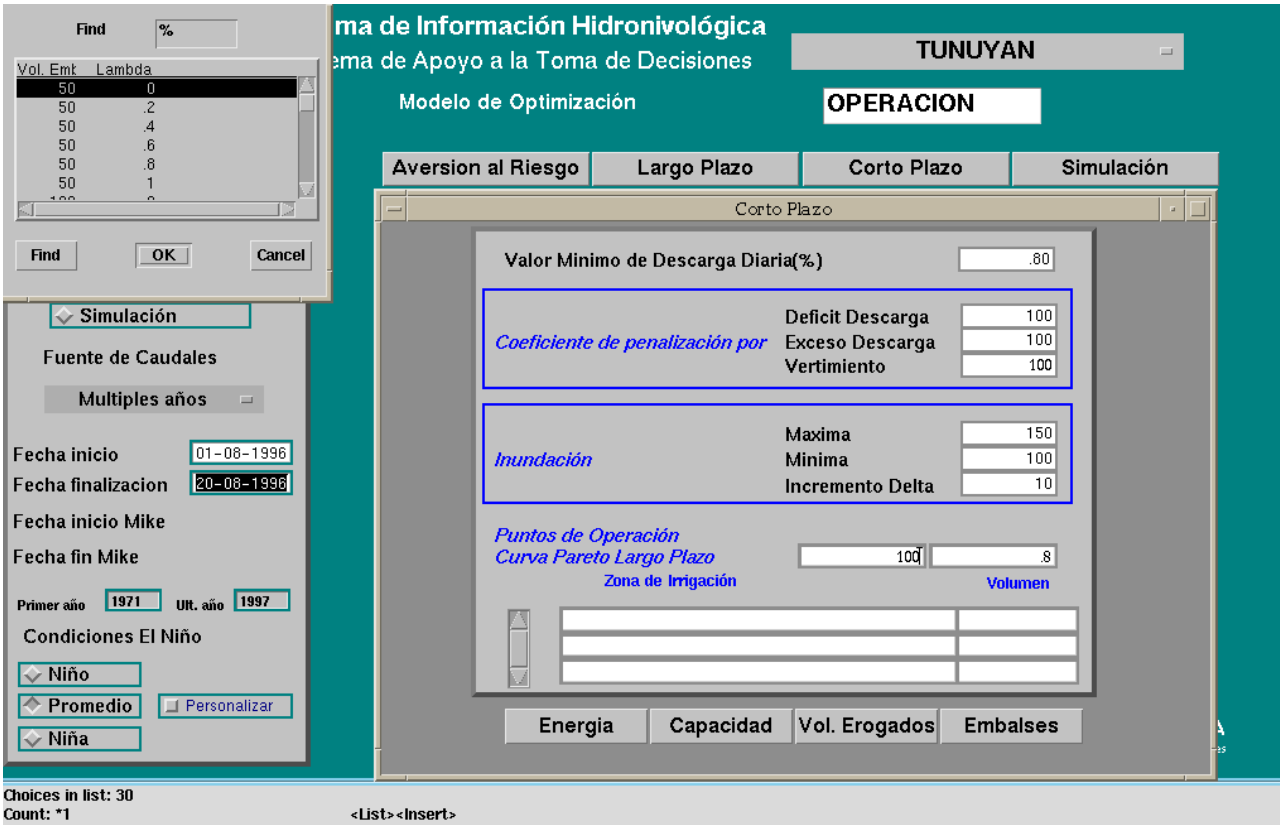
LONG TERM SCREENS

For the first simmulation, the “Largo Plazo” screen is chosen. ...press the Largo Plazo “radio button”,

and the, after full optimization, with possible traces of historical or forecasted discharge values, have a screen with the bounds respecting the risk Aversion Model and the Long Term Decadical Volumes in the Reservoir,

SHORT TERM GUI:

Enter for the selection of short term parameters, penalties, lambda, final volume stage of the dam, etc.



...and day-to day operation will be recommended. See figures.

SOME TYPICAL RESULTS.

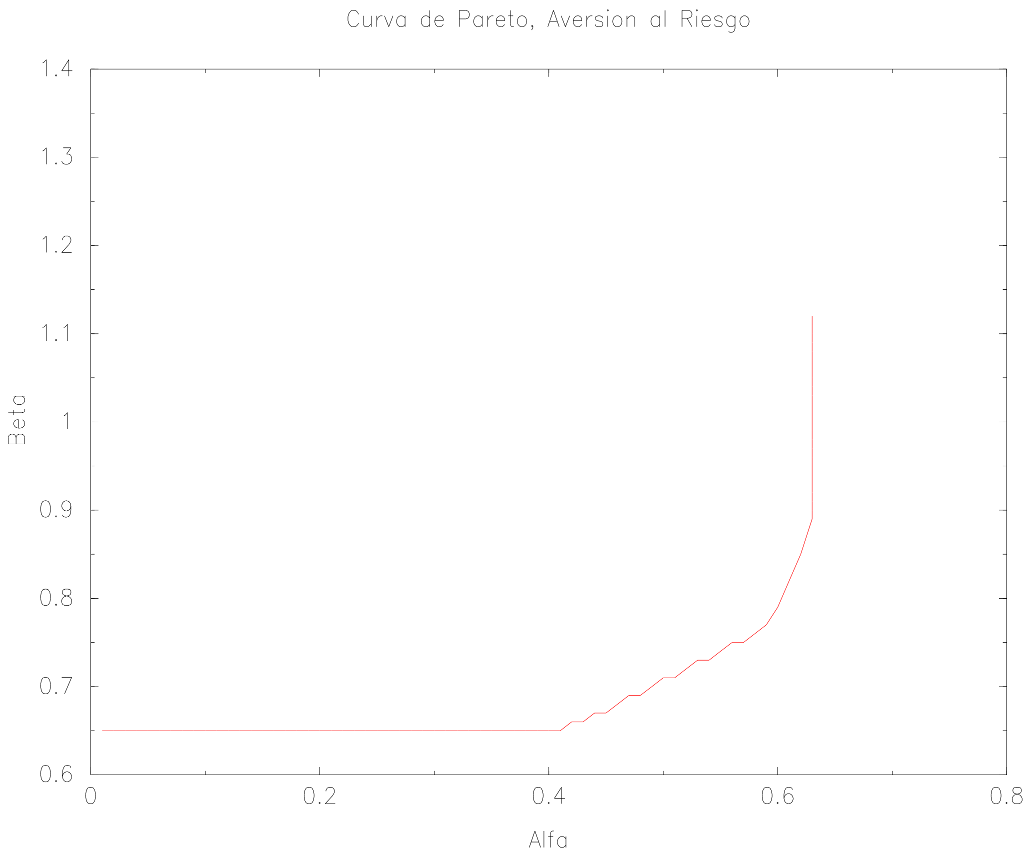
Even when results of the optimization proccess are presented in the form of graphic curves, tables can be presented, pasted to reports, etc.

We present some typical curves in different situations.

RISK AVERSION PARETO RESULTS

Discharge measurement origin: Múltiple Years (Histórical)
inicial: Date: 01/08/1993
final Date: 31/07/1995
Period: 1975 - 1993
ENSO condition:: Niña

RESULTING PARETO DIAGRAM:



Any point may be adopted, but for alpha = 0.65 beta = 0.89, a suboptimal decision will be taken. Higher betas means higher risk of flooding. In such a case, irrigation satisfaction will not increase. (alpha constant).

In the following figure, the bounds for operation are in red: upper for flood protection, lower for irrigation satisfaction. Any policy of operation should give a volume or discharge comprised within the two areas, including the narrow gorge.

DUE TO TIME LIMITATIONS, THIS DRAFT PRELIMINAR PRE-SEMINAR VERSION WILL HAVE AN ANEX DISTRIBUTED DURING THE SEMINAR WITH SERIAL SISTEMATIC EXAMPLES, AND POSTED IN THE HOME PAGE OF HEXA (www.hexa.com) IN SPANISH LENGUAGE AND IN THE DHI HOME PAGE (www.dhi.dk).

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