in-situ treatment and to understand contaminants transport parameters in fractured rock aquifer. These goals will be attained by means of bio-sparging field tests and tracer tests. Perched aquifer remediation was studied through dual-phase extraction pilot test made on 30 meters thick fractured clay and silty clay horizon.
To define remediation times and contaminants target risk, a transport numerical model will be implemented in the future. This model will be integrated by field tests results and will be useful to plan groundwater site remediation.

T32-15 Poster Puppini, Umberto

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ASSESSING THE THERMAL IMPACT GINVEN BY AN OPEN LOOP GROUND SOURCE SYSTEM AT THE PARENTI THEATRE (MILAN-ITALY)

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Key terms: Groundwater; MODFLOW; heat transport; heat differential; heat pumps

In 2006 Teatro Parenti started a conservative restoration togheter with a full technological renewal, including abstracting groundwater to feed heat pumps and injecting them back to groundwater itself.
A groundwater flow and heat transport model was developed using MODFLOW and MT3D, by means of Groundwater Vistas v. 4.21.
The model is 18.6 km2 wide, three-layered with a finite different grid made by 50 x 50 m wide cells, refined to 2 x 2 m wide around the Teatro Parenti area.
After calibrating the flow model in steady state, some simulations were run to understand the effects of groundwater level changes caused by both pumping and reinjecting Q= ±1.320 m3/d, in two different conditions (P1 - R1 wells working together rather than P1 - R2).
Later on a heat transport model was implemented using MT3D code. The heat transport simulation was developed in transient condition with 398 time step over a 100 years long time testing the effecf of ±6 °C thermal variation, with two different durations (10 and 50 years).
After 50 years with P1and R2 working, the effect in terms of expexted thermal delta was predicted to be higher than ±3°C within the property area boundaries, the ray of temperature differential dispersion was 25 meters long from R1 and the value predicted at the abstraction well (P1) resulted less than ± 0,01 °C.

T32-16 Poster Segoni, Samuele

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APPLICATION OF RIVERBED HIGH-RESOLUTION MAPPING TECHNIQUES IN THE ARNO RIVER (FLORENCE, ITALY)

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Key terms: hydraulic risk; GIS; geodatabase; urban planning; hydraulic policy

Since Roman times, the evolution of the Arno river in the province of Florence has always been strongly connected with human activity. During history's course, full exploitation of the land resources brought heavy modifications to fluvial and morphological elements (swamp reclamation, river bed rectifications, building of weirs in order to use the power of water for proto-industrial assets).
Today, the local society and economy still appear linked with the Arno river and, to a variable extent, are also exposed to hydraulic risk. Thence the relevance of making use of exhaustive maps concerning risk and elements at risk.
However at present, no reliable effort has been made to effectively map whole regional catchments with the accuracy needed for detailed assessments. Moreover, the existent data from different local administrations are sparse and never interconnected.
In this paper, the first results of the "PLANTARIO project" (in which the local Provincia di Firenze administration and the Earth Sciences Department of University of Florence are involved) are presented. The PLANTARIO project consists in the creation of a GIS-related database containing all the natural, urban, hydrological and morphological elements close to the main rivers within the Florence urban and suburban area.
The project aims to provide local public administrations with an helpful tool for managing hydrological risk, hydraulic policy and urban planning.
The geodatabase includes artificial and natural elements such as railways, roads, buildings, assets, bridges, administrative boundaries, hydraulic works, drainage outlets, dikes, hydromorphological elements (such as bars or eroding banks) and so on. All the elements was georeferenced and provided with useful alphanumerical descriptions.
Part of the elements included were preexistent data from different public administration offices and have been made homogeneous to be entered in a single database.
The greatest part of the data were newly acquired from the interpretation of aerial photographs or by direct surveys from both of the Arno river's banks. The spatial location of the elements is very accurate (less than 5cm altimetric error and about 1cm planimetric error) since an extensive high-resolution GPS mapping survey has been carried out over the entire course of the Arno river within the Florence province. Covering such a wide territory with such a fine accuracy took up almost a whole year. The survey also aimed to evaluate and include in the database the present condition of all elements, in order to plan ordinary and extraordinary maintenance works.
A first concrete application has already resulted from the use of the mapped elements: all twenty of the mapped weirs (along with the connected structures) have been analyzed in order to identify the weirs and the contiguous buildings suitable to be renovated for tourist or didactic purposes or eventually converted to the generation of hydroelectric energy for local use.

T32-17 Poster Canepa, Paola

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RELATIONSHIP BETWEEN INPUT AND OUTPUT OF WATER BALANCE IN LOMBARDY PLAIN FROM TICINO RIVER TO OGLIO RIVER

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Key terms: WATER BALANCE; LOMBARDY; RICLIC

During the last years, natural events related to hydrogeologic cycle have been increasing because in Lombardy rains less frequently but more heavy. It's necessary to know the relationship between water balance input and output in order to manage water resources in sustainable way. To pursue this aim, data, measured by subsurface and surface water Monitoring Networks, must be collected and used.
RICLIC (Regional Impact of Climatic Change in Lombardy Water Resources: Modelling and Applications), one of the several scientific working projects in Lombardy, evaluates climatic impacts on water resources. In this project different Scientific Research Autorithies (Università Milano-Bicocca, Università di Milano e Università di Pavia) and Public Monitoring Autorithies (ARPA Lombardia) are involved.
Rainfall data (daily data from 1951 to 2003 recorded by 44 manual and mechanic weather stations and daily data from 1990 to 2005 recorded by 50 automatic weather stations), hydrometric data (daily data from 1979 to 2005 recorded by 21 manual and mechanic hydrometric stations and daily data from 1998 to 2005 recorded by 50 automatic hydrometric stations), discharge data (daily average discharge data from 1920 to 2005 recorded by 13 stations) and piezometric data (10 measures every month from 1959 to 1998 recorded in 8 wells in the plain) have been collected in Lombardy plain from Ticino to Oglio, digitalized and organized . All these data have been provided by ARPA Lombardia that took the place of Servizio Idrografico e Mareografico Nazionale. Data sets have been compared with each other: their temporal trend and spatial distribution have been analyzed in order to underline possible relationships between them.
In this work, surface water behaviours caused by heavy rainfalls (e.g. February and November 2002, November 2003, May 2004, etc.) are analyzed for relating the rainfall to the water surface level response. The heavy rainfall and its effects are observed in the all study area, but in different time and in different way. For example, in many provinces the 2002 autumn rainfall was abundant and therefore the hydrometric levels increased very much. On the contrary, in the 2003 spring and summer it rained very scarcely and so during the 2003 summer hydrometric levels were very low; but few very rainy days, during the 2003 autumn, were enough to restore the standard average hydrometric levels.
The aim of this work is to develop the relationship between these features both in time and in space, to understand when and how different hydrologic basins reply to climatic events.
The research has been developed in the RICLIC Project (Regional Impact of Climatic Change in Lombardy Water Resources: Modelling and Applications), financed by Università degli Studi di Milano-Bicocca, Fondazione Lombardia Ambiente (FLA) and Agenzia Regionale per la Protezione dell'Ambiente (ARPA) of Lombardy Region

T32-18 Poster Rossetto, Rudy

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EVALUATION OF THE IMPACT OF THE VIALE GUIDONI (FLORENCE, ITALY) TRAM TUNNEL ON GROUNDWATER FLOW REGIME BY MEANS OF NUMERICAL MODELLING.

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Key terms: Groundwater flow numerical modelling; MODFLOW-2000; Underground construction

During the design phase of the n. 2 section of the Viale Guidoni (Florence, Italy) tram tunnel, a groundwater flow numerical model was set up in order to evaluate the impact of the planned construction on groundwater flow regime. Simulations were run in unsteady state by means of the finite-difference code MODFLOW-2000.
The planned n. 2 section of the Viale Guidoni tram tunnel is about 800 m long and it passes through a suburban area, where industrial plants are present south of the designed tunnel. Based on investigation prior tunnel construction and literature data, a representative conceptual model of the study area was defined. Three hydrostratigraphic units were identified; namely they are (from top to bottom): 1) a silty-sandy unit, whose hydraulic conductivity was set to 10^{-6} m/s; 2) a sand and gravel unit (the aquifer s.s.), whose hydraulic conductivity ranges from 10^{-3} to 10^{-5} m/s; 3) a silty-clayey unit, defining the impervious layer of the hydrogeological system. The flow regime was investigated in the area by multi-temporal analysis of previous potentiometric surface maps.
A finite-difference groundwater flow numerical model using the code MODFLOW-2000 was then set up. All the available data were stored in a suitable GIS; using deterministic and stochastic interpolators the geometry of the study area was built. The domain of the model covered an area 1000x1400 m large, and cell discretization ranged from 20x20m to 5x5 m cells. The underground conditions at the site were represented by means of four layers. A potentiometric surface prior construction of the tunnel, acting as reference condition, was simulated and compared first with observed data. Then, the tunnel was implemented in the model, acting as a flow barrier from ground floor to the base of the aquifer. Hence, we simulated the change of groundwater flow regime due to tunnel construction in unsteady state. Simulations were run over a period of 20 years and results analysed after 36.5, 182.5, 365, 730, 1460, 3650, and 7300 days. Observation wells were implemented in the model in order to evaluate the raising and lowering of the potentiometric surface north and south of the planned tunnel.
The results of the simulations show that, without mitigation, groundwater lowering would be experienced south of the tunnel in the order of about 1.6 m. On the other hand, north of the tunnel, we evaluate groundwater raising in the