

基于 Geodatabase 的北京城市污水规划辅助系统的开发与应用

龙 瀛 贾海峰

提要 第三代空间数据模型 (Geodatabase) 以 ArcInfo 作为应用平台,充分利用 ArcInfo 平台的空间分析功能和 Geodatabase 关系数据库的属性查询功能辅助城市污水系统规划。系统在北京城市污水处理厂合理布局规划上得到应用,其在自动化程度和方案生成效率等方面,已经被证明优于传统的城市规划工程平台 CAD。

关键词 Geodatabase 地理信息系统 污水处理厂 规划 北京市

0 引言

城市污水处理厂规划是一个涉及面很广的问题。规划方案的选择,直接影响污水处理厂的投资、运行及养护的经济性,以及城市环境保护、污水和污泥资源再利用等诸多方面^[1]。

目前污水处理厂规划主流平台为 CAD, CAD 附带属性数据库,但这种属性数据库不支持空间分析功能,辅助规划的自动化程度不高^[2]。而基于 GIS 的数据库,不仅可以方便地表达污水系统规划方案,还可以辅助生成规划方案并对不同方案进行经济等方面的分析计算。鉴于 GIS 第三代空间数据模型 Geodatabase 在数据管理、可扩展、用户可定制和无缝存储等方面具有前两代数据模型 CAD 和 Coverage 无法比拟的优势^[3],可以提高城市污水系统规划的效率。

北京市最近的一次污水处理与排除规划制定于 1992 年。由于工业结构调整、水价上涨、节水和污水回用等因素的影响,亟需对原有污水处理厂规划作全面验证和修订。受北京市规划委员会委托,清华大学环境科学与工程系与北京市城市规划院合作,对北京市污水处理厂的合理布局及规模进行研究。在该研究中,笔者开发了一套基于 Geodatabase 的北京市污水处理规划辅助地理信息系统,实现了城市污水系统的辅助规划。

1 系统构建

本规划辅助系统的构建流程见图 1,包括需求分析、系统设计、数据预处理、建立 Geodatabase 和系统运行与维护五个阶段。

在需求分析阶段,主要确定原始资料需求、系统

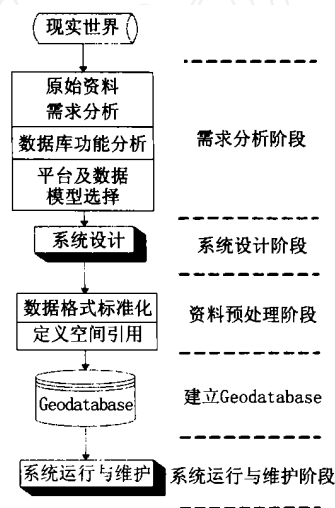


图 1 数据库系统构建流程

功能、平台以及数据模型等;在系统设计阶段,主要进行本规划辅助系统的原型概念化设计、逻辑结构设计和物理结构设计;在资料预处理阶段,主要是对原始资料进行预处理,同时标准化数据格式并定义其空间引用;在建立 Geodatabase 阶段,主要任务是进行 Geodatabase 的模式设计、模式建立、定义关系并加载数据^[2],从而完成该系统的初步设计。在系统运行与维护阶段,根据用户需求不断完善该系统,使其更好地辅助城市污水系统的规划。

本系统图层主要分为四类——基础图层集、污水规划图层集、中水规划图层集和属性表集。具体每个图层集包括的图层见图 2。

该系统的开发,采用美国环境系统研究所开发的 GIS 专业软件 ArcInfo 8.1 作为 Geodatabase 应用平台,利用 Microsoft Access XP 作为存储 Geo-

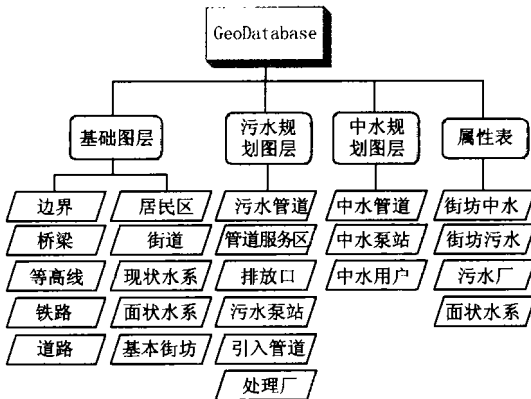


图2 Geodatabase 结构示意图

database 数据的关系数据库。

2 系统功能

利用本规划辅助系统,可以对城市污水量和回用量进行计算,可以辅助污水处理厂厂址选择,辅助确定污水处理厂服务区并计算其规模,辅助污水管道和中水管道布置,对系统经济因素进行计算,对各规划方案进行表达。系统功能框图见图3。

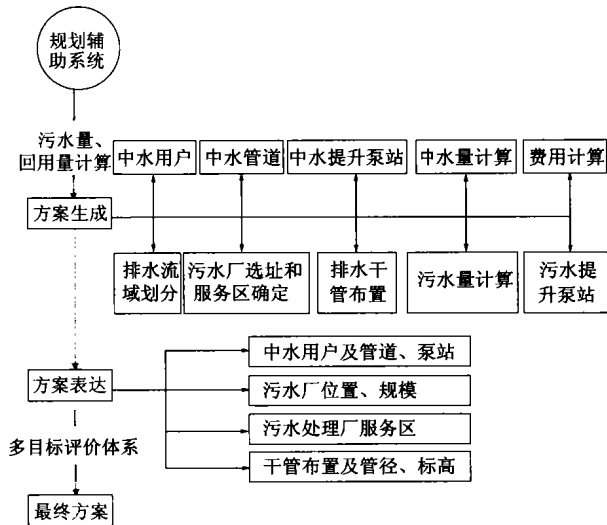


图3 系统功能示意

3 规划方案的辅助确定和分析

在北京市污水处理厂的合理布局研究项目中,辅助确定规划方案生成的步骤见图4。

(1)初步划分污水处理厂服务区。根据城市地形综合图层初步确定污水处理厂服务区,用 Polygon 对象表示各个污水处理厂的服务区。

(2)确定街坊图层的服务区从属字段见图5。利

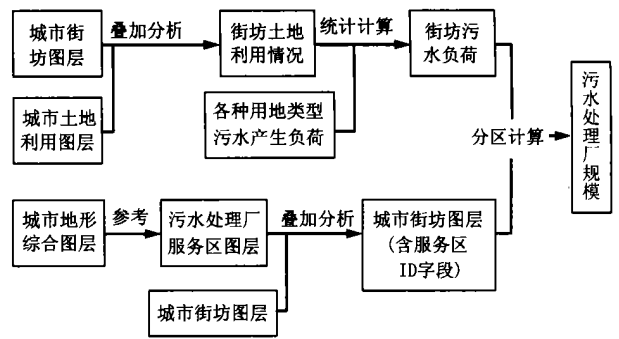


图4 污水处理厂服务区与规模确定方法

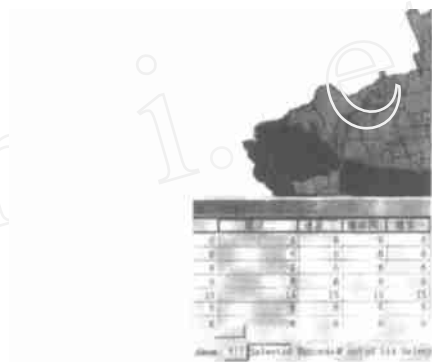


图5 系统前台 ArcInfo 设定街坊图层服务区从属字段

用第一步获得的以 Polygon 对象表示的污水处理厂初步服务区图层和城市街坊图层进行叠加分析,不同污水处理厂的服务区用不同的 ID 表示,这样每个街坊相应规划方案字段就可被设置为所从属的污水处理厂服务区 Polygon 对象的 ID 值。

(3)后台通过属性查询分析功能计算水量。在获得每个街坊单元污水产生量的基础上,在后台基于 Geodatabase 数据模型的 Access 数据库中利用关系查询功能获得每个污水处理厂服务区污水负荷即为相应污水处理厂的规模。以北京市污水处理厂布局规划方案中的通凉(通惠河-凉水河)流域方案一为例,其 Access 数据库查询模块为:

```
SELECT Trim(WW_PLANT. Name) AS 污水厂名称, Sum(BLOCK. Q)/10 000 AS 总水量, Sum(BLOCK. Shape_Area)/1 000 000 AS 服务区面积, Sum(P_WW_BLOCK. 居住建筑量) AS 居住建筑量, Sum(P_WW_BLOCK. 公建建筑量) AS 公建建筑量, Sum(P_WW_BLOCK. 工业面积) AS 工业面积, Sum(P_WW_BLOCK. 居住水量)/10 000 AS 居住水量, Sum(P_WW_BLOCK. 公建水量)/10 000 AS 公
```

建水量, $\text{Sum}(P_WW_BLOCK. \text{工业水量}) / 10\ 000$
 $AS \text{ 工业水量}, 2\ 158.42 * (\text{Sum}(BLOCK. Q) / 10\ 000)^{0.86}$
 $AS \text{ 基建费用}, 361.9 * (\text{Sum}(BLOCK. Q) / 10\ 000)^{0.72}$
 $AS \text{ 运行费用}.$

FROM WW_PLANT, BLOCK INNER JOIN P_ WW_BLOCK ON BLOCK.TEXT_ = P_ WW_BLOCK.BLOCKId.

WHERE (((BLOCK. 通凉一) = [WW_PLANT].[ID]) AND ((WW_PLANT. 通凉一) = 1)).

GROUP BY WW_PLANT. Name.

ORDER BY Sum(BLOCK. Q) / 10 000 DESC.

相应的数据查询结果见表1,其中给出了通凉流域第一个规划方案的不同污水处理厂规模及其相应的基建费用和运行费用。

表1 通凉流域方案一查询结果

污水厂名称	高碑店	小红门
总水量/ 万 m ³ / d	95.6	90.2
服务区面积/ km ²	244.8	254.3
居住建筑量/ 10 km ²	7 595.2	9 290.6
公建建筑量/ km ²	4 953.3	4 485
工业面积/ km ²	15.6	9.2
居住水量/ 万 m ³ / d	33.7	41.2
公建水量/ 万 m ³ / d	46.8	42.4
工业水量/ 万 m ³ / d	10.5	6.2
基建费用/ 万元	109 006	103 627
运行费用/ 万元/a	9 652.1	9 251.7

(4) 规划管道及泵站。在获得合乎要求的污水处理厂服务区规划的基础上,规划该方案的管道和泵站图层。

(5) 依照第(1)~(5)步完成其他规划方案。在本项目中,北京市区每个流域一般初步给出2~4个规划方案。图6给出了通凉流域的两个规划方案对比图。

(6) 方案经济计算。把费用函数集成到 Geodatabase 数据库,直接对管道、泵站、污水处理厂的固定投资和运行费用进行计算(在表1中已有所体现)。

(7) 方案综合评估。在进行其他目标的属性分析基础上,利用 SMART 方法进行多目标决策并对各个方案进行综合评估,给出最优规划方案。



图6 通凉流域污水处理厂规划方案对比

4 结语

本系统尝试应用 GIS 技术辅助实现城市污水系统规划方案的提出、分析和表达,并达到了很好的效果,较原有规划平台 CAD 系统有了一定的突破,同时采用 Geodatabase 这种数据模型,可以更方便地对数据进行管理,充分利用关系数据库强大的关系查询功能,更接近现实世界来建模,提高规划工作效率,进而提高规划成果的准确性和合理性。在我国现阶段,城市排水管网、污水处理厂和中水系统的兴建与改造工作正在逐步开展,同时随着 Geodatabase 数据模型的日趋完善,这种城市污水系统规划解决方案将有广阔的应用前景。

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作者通讯处:100084 北京市清华大学环境科学与工程系
 系统分析研究所

电话:(010)62785610

收稿日期:2002-11-15

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Water System Design for Epidemic Hospital Building Dai Yulin et al (54)

Abstract : The close-infection of the medical crew and contamination spreading are very concerned in water system design for building of serious epidemic clinic. For improvements of design, the vacuum sewer system, hospital refuse incineration, ozone pre-desinfection and avoidance of air release pipe in the sewer are considered.

Automatic Fire Control Systems for Exhibition and Conference Center Zhu Dongyi (62)

Abstract : The exhibition and conference building is very fire risk-bearing due to that it has large area with high height and is crowded with people. The situations of fire system design for two projects, the New International Exhibition Center in Shanghai and the Taizhou Exhibition and Conference Center in Zhejiang Province are presented. The author suggests the consultation be made with the local fire control authority and wide-reaching experiences be used for references in design.

Automatic Fire Control System Design for Building with Special Purpose Pan Zhenqin (65)

Abstract : Some attentions in design of automatic fire control system applied for buildings with wide space, large-span length and low story height like computing room for large or medium-sized computers are pointed out in this paper. The issues related to the application of new developed nozzles or fire control chemicals under the guideline of currently actual design norms are discussed.

Valves in Water Supplying Network Wang Yaowen (70)

Abstract : For water supply enterprises a lot of items have to be taken into consideration in choice of valves used in water supplying network. These include the water supply safety, technical advancement, liquid tightness, real check-out, reliability of quality, smooth operation, reasonable prices, after sale service, consistent order and delivering and establishment of a check and recheck procedure. Meanwhile some main points related to valve application are discussed in practices.

Technological Design of High-Capacity Chlorine Dioxide Generator Fu Sheng et al (72)

Abstract : In designed chlorine dioxide generator of high-capacity MCW-B the reaction liquid is directly heated by countercurrent vapor in continuous multi-tray reactor with high heat transfer efficiency. This unit is reliable and safe with advances of low expenses, high-capacity, high yield and sophisticated automation.

Intelligent Control of Coagulant Dosing Bai Hua et al (81)

Abstract : Two artificial intelligent (AI) based methods are recommended to control the chemical dosing in coagulating treatment of water. To multi-parameter based chemical feeding system, the artificial neuronet (NN) is recommended for optimized coagulant dosing. For the pulsating transperence based single parameter chemical feeding system we recommend the fuzzy logic control method to transact automatic online correction of preset working point to acclimate different water quality. The application of AI control for chemical dosing under condition of routine water turbidity has been achieved.

Development and Application of Geodatabase based Auxiliary Urban Wastewater Planning System Long Ying et al (84)

Abstract : This system was developed on the basis of the 3rd generation spatial data model Geodatabase, and the ArcInfo was applied as its application platform. Both the spatial analysis function of ArcInfo and the attribute query function of relational database are sufficiently utilized in this system. As the assistant platform, this system has multi functions related to urban wastewater planning in Beijing, such as the partitioning drainage watershed, defining service region and estimating the capability of wastewater treatment plants, laying the wastewater and reclaimed water pipelines, calculating the amount of gray water reusing, computing cost of different planning scenarios, and displaying different scenarios etc. In the project, the system is proved to be more automatic and efficient than that of CAD data model, which is the traditional urban engineering plan platform. It is believed that such system would be a new means to solve the urban engineering plan issues, and it will have a broad foreground.

On Technical Terms Sewage and Wastewater Zhang Zhonghe (90)

Abstract : Recent years in Chinese literature the term feishui (wastewater) was frequently used to replace the term wushui (sewage or contaminated water) just like the alternation of terms wastewater and sewage in North American literature. It is very discussable from views of glossarial system of Chinese language and so called conjunction to international rules. Beside these also some problems appeared in lexicography and translation of foreign bibliographies.