AD-A036 596 KENNEDY-TUDOR SPOKANE WASH F/G 8/6

METROPOLITAN SPOKANE REGION WATER RESOURCES STUDY. APPENDIX H. --ETC(U)

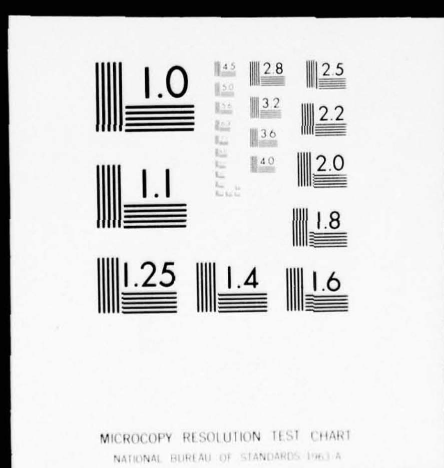
JAN 76

UNCLASSIFIED NL

1 OF 4

ADA036596

1 OF 4
ADA036596



WATER RESOURCES STUDY

Metropolitan Spokane Region

APPENDIX H · VOLUME 2
Plan Formulation and Evaluation

JANUARY 1976

METROPOLITAN SPOKANE REGION
MSRWRS
WATER RESOURCES STUDY

LIST OF REPORTS AND APPENDICES

REPORTS

Summary Report

Technical Report

APPENDIX	TITLE
A	Surface Water
B	Geology and Groundwater
C	Water Use
D	Wastewater Generation and Treatment
E	Environment and Recreation
F	Demographic and Economic Characteristics
G	Planning Criteria
H (Volume 1)	Plan Formulation and Evaluation
H (VOLUME 2)	**PLAN FORMULATION AND EVALUATION**
I	Institutional Analysis
J	Water Quality Simulation Model

(1)

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 701.3

FORMULATION AND EVALUATION OF

SLUDGE DISPOSAL ALTERNATIVES

20 June 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

A

INDEX

TABLE INDEX

FIGURE INDEX

SECTION 701.3
FORMULATION AND EVALUATION OF
SLUDGE DISPOSAL ALTERNATIVES

Scope and Objectives

The initial cost effectiveness screening of alternative wastewater management plans is based on the uniform application of a single representative sludge disposal system. Social, economic and environmental screening of cost effective plans from various alternative categories results in a further reduction of the field of candidates, based on wastewater process and disposal considerations alone. Before proceeding to a detailed evaluation of sludge disposal systems for the final field of wastewater alternatives, it is necessary to demonstrate whether or not the application of alternative sludge disposal systems would effect the initial selection processes. Therefore, the first objective of this section is to formulate a field of sludge disposal alternatives and evaluate their potential impact on the initial screening of wastewater alternatives.

The City of Spokane sewage treatment plant (STP), upgraded and expanded in accordance with DOE directives, is a major element in all alternative wastewater management plans. A complete sludge processing system consisting of anaerobic digestion, vacuum filtration and sanitary landfill is included in the committed plans for upgrade and expansion. Although committed to a specific physical plan, a concurrent study has been prepared to evaluate other sludge disposal alternatives, particularly land application. The concurrent study was prepared by Bovay Engineers Inc. under contract to the State of Washington Department of Ecology (DOE) and applies specifically to the upgraded and expanded City STP. A second objective of this section is to evaluate the results and findings of the DOE study for their application to the candidate wastewater plan alternatives.

The final objective of this section is to formulate and apply alternative sludge disposal systems to the leading wastewater management plans for cost effectiveness and social, economic and environmental evaluation. This process will make maximum use of the DOE study where applicable.

Alternative Sludge Disposal Systems

Consideration of the sludge processing decision tree shown in Figure A together with the constraints discussed in Section 603.3 leads to the formulation of the following candidate plans.

Plan S. This plan consists of sludge stabilization, dewatering and disposal of dewatered cake to sanitary landfill. Subalternatives considered for stabilization include aerobic digestion, anaerobic digestion, chemical treatment, heat treatment and lagooning. Subalternatives considered for dewatering are vacuum filtration, pressure filtration, centrifugation and drying beds.

Anaerobic digestion is selected as the representative stabilization process and heat treatment is selected as a subalternative for second stage or design stage reconsideration. Aerobic digestion is eliminated as not cost effective except in very small sizes. Chemical treatment is eliminated for cost reasons and the fact that it does not provide any reduction of volatiles or volume. Lagoons are judged to be infeasible throughout the study area because of their nuisance potential and space requirements when applied at a plant site.

Vacuum filtration is selected as the representative dewatering process. Centrifugation and pressure filtration are considered equal alternatives on a cost level but the factors affecting choice in performance between vacuum filtration, pressure filtration and centrifugation are so specific to the properties of the sludge that the choice is a design level process. Drying beds are eliminated from this alternative plan which is to represent processes feasible at the treatment plant site due to the space requirements. Drying beds are incorporated in another plan for remote location.

In summary, the basic Plan S consists of anaerobic digestion, vacuum filtration and truck haul to sanitary landfill. Also included are concentration of raw sludges as necessary for optimum use of digestion tank volume and reconcentration and conditioning before vacuum filtration, again to provide optimum utilization. For the subalternative utilizing heat stabilization, a process comparable to Zimpro Intermediate Pressure Oxidation is selected.

The basic Plan S is equal to the committed facilities in the expanded and upgraded City STP and is representative of the comparable alternative in the DOE study (Bovay 1975).

A potential subalternative for disposal of the dried sludge cake is application to agricultural lands or greenbelts. In the case of agricultural lands there has not yet developed a fertilizer cost situation in which the agriculturalist will seek out and use sludge at his own application expense. A first step would probably consist of making the sludge available as a stockpile in agricultural areas, which would have a higher haul cost than landfill but would eliminate the landfill operation, judged a trade off. In the case of greenbelts, the owner agency is the same public who pay for wastewater treatment and disposal. Therefore, the haul and application costs are essentially public costs, again a probable trade-off to landfill disposal. From a cost standpoint these subalternatives are judged to be adequately represented by the basic sanitary landfill disposal. These subalternatives have their place of recognition in environmental considerations and possible implementation at a later date. The sanitary landfill method would be a necessary fall-back position when total production is not taken by these potential beneficial uses.

Plans T-1 and T-2. These plans utilize the agricultural land application of stabilized liquid sludge. Plan T-1 provides for application to dry land agriculture and Plan T-2 provides for application to irrigated agriculture. These two land application systems correspond to the systems explored in Bovay (1975).

Stabilization subalternatives considered comprise the same field discussed above under Plan S and for the reasons given above anaerobic digestion is selected as the representative process.

Subalternatives considered for transport of the liquid sludge to areas of application are truck haul and pipeline. These subalternatives must be kept open since the cost effectiveness is a function of the combination of distance and quantity.

There are a number of subalternatives to be considered for the process of distribution and application on the agricultural land. These, like the transport subalternatives are affected by distance and quantity as well as by whether applied to dry farmed or irrigated land and must be kept open for analysis on an individual basis.

The climate which produces a long season of frozen grounds and the specific cropping practices place constraints on the times at which liquid sludge can be applied to the soil. These constraints in combination with the large volumes of daily sludge production produce a requirement for large volumes of storage, volumes not feasibly provided at treatment plant sites. Therefore, large volume storage at remote sites is a required process element together with appurtenances to withdraw from storage for application.

The elements of Plans T-1 and T-2 cannot be described specifically for all applications due to the number of open subalternatives. In general terms a typical Plan T consists of the following elements:

1. Anaerobic digestion
2. Transport from the treatment to application site
    a. By pump stations and pipeline
    b. By tank truck
3. Seasonal storage at the application site is lined earth ponds complete with dredge for withdrawal.

4. Application facilities

   a. Distribution
      (1) Pump and pipelines
      (2) Tank truck
      (3) Mixed with irrigation waters
   b. Spreading
      (1) Piped sprinklers
      (2) Vehicular spray or injector
      (3) Mixed with irrigation waters

The criteria to be met in detailed formulation of sludge land application plans are contained in EPA draft supplement to Federal Guidelines issued November 1974 titled "Acceptable Methods for Utilization or Disposal of Sludges."

Plan U. This plan provides for air drying of stabilized sludge with disposal of the dried cake to sanitary landfill. Subalternatives considered for stabilization are as discussed for Plan S above with anaerobic digestion selected as representative. Subalternatives considered for transport of liquid stabilized sludge to the drying bed site are pipeline and truck haul.

Climate again provides a constraint on the air drying season with open beds. Subalternatives considered are enclosed beds for year around operation (at greatly reduced winter rates despite shelter) and open beds for seasonal operation with between season storage. Open beds of much lower cost are selected as representative.

Plan U typically consists of the following process elements:

1. Anaerobic digestion

2. Transport of liquid sludge to drying site

   a. Pump station and pipeline
   b. Tank truck

3. Seasonal storage in lined earth pond with dredge withdrawal.

4. Open air drying beds, underdrained. (Underdrainage returned to the treatment plant by parallel pipe transport or return truck trip.)

5. Load and transport dried sludge to sanitary landfill.

The drying beds would be located typically near a remote sanitary landfill.

The agricultural or greenbelt application subalternatives discussed under Plan S are equally applicable to Plan U. The same conclusion is reached that the basic sanitary landfill subalternative adequately represents the costs for both but that recognition should be given to potential environmental differences.

Plans V-1 and V-2. These plans provide for incineration of sludge to an ash residual which is disposed to sanitary landfill. All incineration subalternatives require pretreatment by mechanical dewatering to reduce fuel requirements to feasible levels. Subalternatives considered for the pretreatment are centrifuge dewatering of raw sludge and vacuum filtration dewatering of digested sludge. The former is significantly more cost effective but the latter is included to represent the plan analyzed in the DOE Study (Bovay 1975).

Subalternatives considered for the incineration process itself are multiple hearth and fluidized bed. The final selection is considered a design level analysis. Multiple hearth incineration is selected as representative because more extensive cost data are available.

Plan V-1 consists of raw sludge conditioning, dewatering by centrifugation, multiple-hearth incineration and ash disposal by sanitary landfill.

Plan V-2 consists of anaerobic digestion, vacuum filter dewatering, multiple-hearth incineration and ash disposal by sanitary landfill.

Plan W. This plan provides for production of a sludge dried and sterilized suitable for marketing to the general public. The finished product has 5.5 percent moisture and contains about 5.3 percent nitrogen and 3.9 percent phosphorus (EPA Tech Trans Sludge). The process usually consists of dewatering raw sludge by centrifugation or vacuum filtration and flash drying in a special equipment similar to C-E Raymond. As utilized in the DOE Study for the City STP a sub-alternative process is used which includes digestion, vacuum filtration and flash drying. No net return on the product is credited. It is assumed that the dried product would be furnished at no cost to others for enrichment with fertilizer chemical, packaging and marketing.

Plan X. This plan provides for wet oxidation of conditioned raw sludge with centrifuge separation of the inert residual and truck haul to sanitary landfill. The wet oxidation process is assumed to be equal to Zimpro High Pressure Oxidation which produces a 70% oxidation.

Effect of Sludge Alternatives on Initial Screening of Wastewater Plans

Wastewater Candidate Plans. Initial screening of alternative wastewater management plans results in reduction of an initial field of 57 plans, not counting "no action" plans to a field of nine as follows:

Plan	Plan Element
A	(C+NS)-sw, SV-sw
B	C-sw, NS-li, SV-sw
C	(C+NS+SW)sw
D	(C+NS)-sw/lp, SV-sw/lp
E	(C+NS)-li-sw, SV-li
F	(C+NS)-li, SV-li
G	(NS+SV)-li, C-sw/lp
H	C-sw, N-sw, SV-sw
I	(C+NS)-swt, SV-swt

In addition, there are two "no action" plans, one in which Spokane Valley (SV) takes no action and remains with on site disposal and one in which North Spokane (NS) takes no action and continues with on site disposal. The no action plans do not lead to the introduction of plan elements not already included above.

Further screening results in a focus on Plan A and its variants as the leading contender. The variants are the "no action" alternative for the SV component and the possible future upgrading to meet interpreted 1985 standard by conversion to Plan D with infiltration-percolation land application in lieu of surface water disposal.

All of the foregoing screening is based on the application of the same solids processing system to all alternatives, namely anaerobic digestion, vacuum filtration and sanitary landfill. It is necessary therefore first to determine if consideration of alternative sludge disposal plans would significantly affect these initial screening operations.

Note that the nine wastewater candidates listed above involve only four different potential treatment plants, the City STP, North Spokane, Spokane Valley and joint North Spokane-Spokane Valley. The latter is a lagoon treatment plant which does not have a yearly sludge disposal problem, thus reducing the sites for consideration to three.

Possible Effect on Relative Cost. In order for sludge alternatives to possibly effect the relative total cost of wastewater plans as compared with use of a single sludge management plan, a situation must arise where a lower cost sludge alternative can apply to some wastewater plans and not to others. Consideration of a matrix composed of wastewater plan elements and sludge alternatives indicates only one situation where such a potential arises. This situation arises in connection with land application where wastewater plans utilizing irrigation can provide lower sludge land application.

Specifically, the cost of providing sludge application to land in conjunction with (C+NS)-sw or (C+NS)-lp would cost more than if provided in conjunction with (C+NS)-li. The reason for this is that part of the cost of application of sludge to the land is already covered in the cost of irrigation distribution. This potential saving, however, could not begin to offset the large total cost difference between wastewater plans (C+NS)-sw or (C+NS)-lp and (C+NS)-li. Therefore, this condition would not affect the relative cost effectiveness ranking of these wastewater alternatives.

It is concluded that consideration of sludge alternatives with wastewater alternatives would not significantly affect total cost effectiveness ranking of wastewater plans.

This consideration does not affect ranking of Spokane Valley alternatives for the same reasons and more specifically because SV-1i uses lagoon treatment.

Possible Effect on Social, Economic and Environmental Values. In a manner similar to that regarding cost effectiveness, sludge alternatives can effect the overall ranking of wastewater plans if, in various combinations, there were different mutual effects on the acceptability of either element. For example, this might occur if a particular sludge alternative when combined with a particular wastewater alternative affected its environmental acceptability, but in combination with another wastewater plan had no effect or the opposite effect.

A canvass of a matrix of wastewater and sludge alternatives indicates that there are no synergistic effects except, again, in the case of combining sludge land application with wastewater application. Since sludge land application can be combined on the same area with wastewater land irrigation, the impacts of the two actions are not additive in the same sense that sludge land application is when combined with a surface water or percolation disposal. Therefore, negative impacts of the sludge and wastewater land application would, in combination, tend to be no worse than either element alone. If land application of sludge proves to be desirable this would tend to raise the environmental ranking of wastewater disposal to irrigation relative to its ranking without regard to sludge disposal.

Combined Cost and Environmental Effects. For both cost and environmental concerns, the combination of sludge land disposal with wastewater land disposal tends to raise the relative ranking of both elements. The overwhelming cost disadvantage of irrigation disposal to land for this study area is so great that these combined effects are judged to be inadequate to affect overall wastewater plan ranking.

Therefore, considering the possible effect of alternative sludge plans, Plan A remains the most favorably ranked wastewater management plan.

Sludge Facilities in City Treatment Plant

As for wastewater management alternatives, the sludge processing elements of the committed expansion and upgrading of the City treatment plant are regarded as existing and as comprising sunk costs in cost effectiveness analysis. The committed expansion and upgrading provides anaerobic digestion and vacuum filtration facilities for 40 mgd capacity sized to handle sludge produced by year around phosphorus removal accomplished by alum precipitation in the secondary in addition to the normal primary and waste activated sludges.

Bovay (1975) describes the sludge facilities being incorporated in the proposed enlargement as follows:

1. Gravity thickeners for primary sludge
2. Flotation thickeners for waste activated sludge
3. Three anaerobic digesters at 275,000 cubic feet each.
4. Six vacuum filters, each 12 feet diameter by 16 feet long

5. Four trucks for sludge cake haul to landfill.

All elements which utilize the City STP share the situation where complete anaerobic digestion and vacuum filtration facilities are provided as a sunk cost.

Concurrent Sludge Disposal Study

Introduction. The study prepared by Bovay Engineers, Inc. for the State of Washington Department of Ecology bears the title "Report on Feasibility Study of Wastewater Solids Application to Land for Spokane, Washington" and was completed in May 1975. The Bovay report is most significant to the formulation and evaluation of sludge alternatives herein. For this reason its findings, criteria and methodology are abstracted briefly below and more extensively in Appendix I.

Scope. The DOE study (Bovay 1975) analyzes the economics and environmental impact of the application of liquid stabilized sludge to dry and irrigated agriculture from the proposed enlarged and upgraded City of Spokane sewage treatment plant (STP). The economic elements of the study are for the STP operating at its design capacity of 40 mgd and with year-around 85 percent phosphorus removal. Disposal sites are considered in an area up to 30 miles from the STP. Following a detailed analysis of site specific land application alternatives, the highest ranked is compared with three non-land application alternatives.

Summary of Conclusions. The DOE study concludes that land application is feasible but more costly than vacuum filtration and sanitary landfill. The proposed enlargement and upgrading, now under construction, includes facilities for vacuum filtration and sanitary landfill. A recommendation is made that additional on-site agronomic studies be made to establish firm criteria for land application before full scale operation is actually undertaken. There is no recommendation either to continue with the planned vacuum filtration and sanitary landfill or to change to agricultural land application. Presumably, the recommendation is to continue with vacuum filtration and sanitary landfill while making additional tests for land application and monitoring progress in the field nationally. It is pointed out that the present unfavorable cost for agricultural land application may change as future increases in chemical and energy prices raise the cost of vacuum filtration and future increases in fertilizer costs make the nutrient value of sludge more attractive to the farmer.

The DOE study indicates that the most favorable agricultural land application system and location will have total costs of $123 per ton of dry solids as compared with $90 per ton for vacuum filtration and sanitary landfill. This comparison is based on including all costs for both systems; that is, the proposed facilities now under construction are not regarded as sunk costs.

Application to dry land agriculture is identified as more cost effective than to irrigated agriculture and the region extending from Indian Prairie west to Reardan is determined to be the most favorable location from both cost and environmental impact considerations. At design loading conditions, the area required is estimated at from 6,000 to 8,000 acres for dry and 2,000 to 3,000 acres for irrigated application. The criteria limiting application rate is the ability of the crop to assimilate the nitrogen content of the sludge. Life of the application sites receiving sludge is estimated on the basis of the cation exchange capacity of the soil to fix toxicants. The estimates range from 57 years for dry farmed to 168 years irrigated land.

Analysis of three non-land application alternatives determined that digestion-vacuum filtration-landfill at $90 per ton of dry solids was more cost effective than vacuum filtration-incineration at $133 per ton or vacuum filtration-drying at $163 per ton.

The basic economic analysis of land application alternatives does not take credit for the value of commercial fertilizer displaced by nitrogen in the applied sludge. A separate calculation for the most favorable site under dry farming conditions concludes that the disposal cost per ton would be reduced from $123 to $116.[1] This calculation is based on a current price of $0.22 per pound of nitrogen available in commercial ammonia fertilizers.

EPA Guidelines

The DOE study, Bovay (1975), makes reference to EPA Guidelines for sludge disposal dated August 1974. A further revision to these

---

[1]This calculation on per ton basis does not appear in Bovay (1975); it is shown in annual cost form at $1,398,500 for 12,045 tons per year.

guidelines is dated November 1974. There are several changes and additions. One is in the limitation criteria for heavy metals which is changed from a zinc equivalent of 5 percent to 10 percent which would increase the site lives calculated by Bovay (1975). Otherwise, the revised guidelines would have negligible impact on the basic conclusions of the DOE study.

Significance of the DOE Study to Wastewater Plan Alternatives

As indicated in the foregoing abstract, the DOE Study provides a cost effectiveness and environmental ranking of land application sludge alternatives and a cost effectiveness ranking of certain non-land sludge alternatives for the City STP operating at 40 mgd. These results are directly applicable to all wastewater alternatives which utilize the City STP in general and are specific to those plans which combine the flows of North Spokane and the City to the City STP. The forecast flow of the combined North Spokane and City wastewaters is 40 mgd at the last year of the planning period, year 2000. All of the nine candidate wastewater plan alternatives utilize the City STP and six of the nine, including the most favored Plan A, call for combining North Spokane and City flows.

The cost effectiveness and environmental screening in the DOE Study of alternative land application sites for sludge is directly applicable. The conclusion that Site 6 is the most suitable site from both cost and environmental considerations is adopted herein as the representative land application site for all plans which utilize the City STP.

The cost effectiveness comparisons in the DOE study for the optimum sludge land application alternative with three other sludge management alternatives is applicable and adopted herein for integration with other possible alternatives. The DOE study does not provide an environmental screening of sludge alternatives other than that comparing land application sites. This study, therefore, takes the cost effectiveness comparison from the DOE study for four* plans and considers the need for or the relative place of additional plans and develops an environmental screening for all sludge alternatives applied to the City STP.

Cost Effectiveness of Sludge Plans for City STP

The results of the cost comparison developed in the DOE study are summarized in Table 1. Comparison of Table 1 with the alternative sludge disposal systems developed in a previous paragraph indicates that the DOE study includes all except the following:

Plan	Description
U	Digestion, air drying at a remote site, and disposal to sanitary landfill
V-1	Centrifugation and incineration
X	Wet oxidation

*Considering the dry farm and irrigated land application plans as subalternatives.

For the situation where the digestion and vacuum filtration facilities are a sunk cost, Plans V-1 and X are known to be more costly than Plan S, digestion, vacuum filtration and sanitary landfill, without formal analysis. It is not useful to consider Plan V-1 as a subalternative to Plan V-2 when anaerobic digestion and vacuum filtration are provided as sunk costs. Plan V-2 provides adequate representation of the incineration alternative. It is useful to consider Plan X regardless of its obvious cost disadvantage because it represents an alternative with significantly different environmental impacts. For the purpose of environmental evaluation, Plan X is assigned cost ranking equal to incineration, its competition for maximum reduction. This reflects the environmental differences between the two alternatives unobscured by cost differences.

Plan U is generally not considered practical for plants over 10 mgd let alone 40 mgd. A brief analysis to determine its cost relative to Plan S is made to confirm the validity of eliminating it from further consideration. It can be shown that the cost of drying beds and conveyance exceed the cost of vacuum filtration operation and maintenance costs.

Consideration of the summarized cost effectiveness data in Table 1 shows the strongly favorable position of Plan S relative to the second place alternative Plan T-1. It should be kept in mind that the figures shown for Plan S as taken from the DOE study do not consider the vacuum filtration equipment committed to construction as a sunk cost. From the viewpoint of this study where these committed facilities are a sunk cost the position of Plan S is reinforced further.

Basis for Economic, Social and Environmental Evaluation

A basis for evaluation of wastewater management plans is developed in Section 401.3. The evaluation of sludge management plans as an adjunct to wastewater management plans follows this general format with modifications as outlined below. These modifications are to focus on and give greatest emphasis to those concerns most critically affected by sludge alternatives as compared with wastewater management.

In addition to cost, the primary areas of impact for sludge management alternatives are as follows:

1. Health, general
2. Groundwater quality
3. Surface water quality
4. Health aspects of air quality
5. Aesthetic aspects of air quality
6. Thermal energy
7. Electrical energy
8. Chemical consumption
9. Salvage of resources
10. Effect on wastewater quality
11. Reliability

On the other hand, sludge management alternatives in general have small or negligible impact in the following categories:

1. Employment
2. Community income
3. Tax income
4. Indirect economic concerns
5. Living patterns and lifestyle
6. Recreation
7. Dislocations

Matrices following the above indicated shift in emphasis are developed as shown in the tables summarizing the ranking of sludge plans applied to the City STP and the Spokane Valley STP. Refer to Tables 2 to 8 and 10 to 15. The narrative evaluations contained in Appendices II and III follow the same format as the summary tables and provide the basis for the developed rankings.

Economic, Social and Environmental Evaluation of Sludge Plans for City STP

Plans Considered. The plans to be evaluated include five plans formulated by the DOE study plus one plan not included in the DOE study. The candidate plans are as follows:

Plan Identifier	Description
S	Anaerobic digestion, vacuum filtration and final disposal to sanitary landfill. (The system included in the committed plans for enlargement and upgrading)
T-1	Anaerobic digestion, dry farm land application at Indian Prairie (Site 6 per DOE study)
T-2	Anaerobic digestion, irrigated land application at Indian Prairie
V	Anaerobic digestion, vacuum filtration, incineration, landfill of ash
W	Anaerobic digestion, vacuum filtration, drying and marketing by others
X	Concentration of raw sludge, high pressure wet oxidation (70 percent), vacuum filter separation of solids, final disposal to landfill.

Schematic diagrams of these alternative processes are shown in Figures B through G. All except Plan X are as formulated in the DOE study. Note that Plans T-1 and T-2 are in themselves the product of an in-depth selection process in the DOE study to determine the optimum site from both cost effectiveness and environmental standpoints. Refer to the DOE study (Bovay 1975) for details of the evaluations leading to selection of Site 6.

Plan X is added as an alternative to the regular combustion process of Plan V since it has the unique capability of providing maximum reduction but with less threat to air pollution than incineration.

Plans V and W are analyzed in the form presented in the DOE study. It should be recognized that the potential subalternatives which bypass the anaerobic digestion step would have a different cost effectiveness ranking and fuel use ranking. Since, for this study, the anaerobic digestion facilities are a sunk cost, the DOE study formulation results in a ranking compatible with the criteria for this study and is adopted for analysis.

Narrative Evaluation. Initial ranking of sludge plans associated with the City STP is shown for each concern in Table 2. These rankings are derived from the complete narrative evaluation contained in Appendix II. The evaluations are relative and the ranking is in order of desirability, from 1 for the most desirable to larger numbers for the least desirable. Where there is judged to be no significant difference in rank, plans are ranked together with the same ranking number.

Weighted Evaluations. To transform the simple ranking by concerns into a meaningful basis for evaluation, a system of weighting is applied. The division of the total list of concerns into two groups and the application and processing of weighting factors follows the format developed for evaluation of wastewater plans. A brief description of the format and system is repeated here to make this section self-contained.

As a first step to quantifying an overall evaluation, the characteristics and concerns are separated into two groups, a first level containing those items judged to be of greatest importance and a second group containing those of lesser importance, designated Group 1 and Group 2 concerns, respectively. For each concern in each group the rankings are first transformed into values to quantitatively indicate relative performance of each plan. The highest ranked alternative is assigned a value of one and all others are assigned fractional values in proportion to their estimated performance relative to the highest ranked. Where there is a quantitative basis such as cost or energy use, the fractions are actually computed. Where there is no quantitative basis, judgment is used. Where the spread between alternative performance is judged to be small, the ranking reflects this as well as the opposite condition where the differences in performance are large. The basis for these judgments are covered in the narrative evaluations.

The greatest impact of the bias of the evaluator arises in assigning relative weights to the various concerns in each group and between the two groups. In order to demonstrate the effects of such bias and recognize it in the evaluation process, a range of rankings is applied. For Group 1, four ranking plans, each totaling 100, are selected: heavily weighted toward cost, moderately weighted toward cost, moderately weighted toward environmental concerns and heavily weighted toward environmental concerns. For Group 2, a single balanced weighting is selected.

The selected weightings for Group 1 and Group 2 concerns are interacted with the relative ranking of each candidate plan to arrive at weighted rankings. This process is shown in Tables 3 through 6 for Group 1 and in Table 7 for Group 2.

To arrive at a total evaluation based on consideration of Group 1 and 2 concerns combined it is necessary to again make a weighting selection for their combination. Two relative weightings are selected for application, one which gives Group 1 three times the weight of Group 2 and one which gives Group 1 nine times the weight of Group 2. The results of the combining of group results into an overall weighted ranking is shown in Table 8.

Analysis and Conclusions. Plan S, digestion, vacuum filtration and sanitary landfill, is found to have the highest ranking for all weightings of Group 1 concerns. It should be recognized that the costs used in this analysis are from the DOE study which does not consider as sunk costs the vacuum filtration facilities being incorporated into the current upgrade and expansion of the City STP. Since Plan S relies on vacuum filtration, its favored position would be greatly enhanced by consideration of the vacuum filtration facilities as a sunk cost.

Since the economic, environmental and social concerns most strongly affected by sludge disposal are in Group 1, the ranking of alternatives in Group 2 is not definitive in itself, but only in combination with Group 1. This can be seen in the resultant high ranking of the maximum reduction alternatives, Plans V, W and X. The weak points of Plans V, W and X including cost, energy consumption and air pollution potential are all in Group 1, whereas their strong points such as minimum disruptive potential and very small land use are in Group 2. The reverse is true of the land application alternatives whose strong points such as energy use and reclamation of resources are in Group 1 whereas their weak points of disruptive potential and land use are in Group 2.

When Group 1 and Group 2 concerns are combined in various weighting combinations on Table 8, Plan S is found to have the highest ranking in all cases. Since cost forms an important part in the ranking of Plan S, it is significant to refer to the weighting combination which most strongly favors social and environmental concerns for interpretation relative to the other plans.

The line on Table 8 with 75 percent weight to Group 1 heavily weighted to environmental illustrates this situation. The maximum reduction plans are found to rank second after Plan S and the land application plans lowest. Note that Plan W which includes resource recovery is the highest ranking of the maximum reduction plans. Plan X has the lowest rank among the maximum reduction alternatives despite being assigned a cost ranking equal to Plan V. This indicates overall environmental rank lower than Plan V. The relatively low ranking of the land application plans is due in part to the very high costs for this specific locality which requires long pipelines, high lifts and low application rates over a short season.

The conclusion seems clear that Plan S is the best alternative for immediate implementation even without consideration of the fact that, for this study, the facilities are a sunk cost. Plan S not only has merit in itself but is a stepping stone and back-up position to other alternatives. If a land application plan is developed, the digestion facilities of Plan S are an essential element and the vacuum filters provide an alternative operation for reliability. Similarly if a maximum reduction alternative is developed, both the digestion and vacuum filtration facilities are usable elements in some and an alternative to give reliability for all.

The primary benefit to be derived from land application alternatives is resource recovery. It is not a way to "get-rid-of" sludge with the least unfavorable environmental impacts. The DOE study points out that the importance of resource recovery is probably subject to a significant increase in the near future as the availability and cost of fertilizer changes. For this reason a reevaluation should be made as these economic forces change. Meanwhile, there are many technical and cost problems to be solved and this study concurs with the DOE study in recommending that a continuing program be undertaken to develop data specific to the Spokane area while continually monitoring the progress in this field throughout the country. Since there are many technical uncertainties at this time, the cost estimates currently made for land application must reflect these uncertainties. Therefore, the conclusions drawn at this time must not be regarded as fixed but should be reviewed and updated as more refined data become available.

The apparent second place position of the maximum reduction alternatives is also subject to change. The increase in energy costs are likely to lower their ranking while the same economic forces are raising the ranking of land application. The only reason for going to one of the maximum reduction plans from Plan S would be because either the space for or distance to wet cake disposal sites became prohibitive. The critical air pollution situation in Spokane is a strong negative factor against any incineration process. Even with the best emission control technology there would be strong public pressure against any addition to the air pollution load while others are being pressured to reduce their input. For these same reasons it seems unlikely in the near future that the City would consider incineration of their solid wastes, either as an energy recovery measure or a bulk reduction measure. In the event that solid waste incineration should be considered, the disposal of sewage sludge in the same facility becomes an attractive alternative for reconsideration.

Sludge Alternatives for the Spokane Valley Element of Plan A

Wastewater alternative Plan A provides a separate biological secondary treatment plant for Spokane Valley located in the vicinity of the east end of Felts Field for surface water disposal. The plant would be constructed in one stage at 10 mgd capacity to serve from 1980 to 2000. Alternative sludge management plans in combination with this specific wastewater management plan are formulated from the generalized list previously developed. Basic sludge quantities for the Spokane Valley service area used in formulation of sludge alternatives are for a wastewater treatment plant with biological secondary treatment and seasonal phosphorus removal.

In addition to the alternatives for solids processing facilities to serve the Spokane Valley alone, there is the possibility of combining Spokane Valley solids with those of the City and North Spokane at the City STP. The solids processing facilities being incorporated into the City STP are sized for sludge quantities associated with a nominal wastewater capacity of 40 mgd. The combined forecast flow for the City plus North Spokane at year 2000 is 40 mgd which would indicate full utilization of solids facilities by these service areas and none to spare for Spokane Valley with forecast flow of 10 mgd by year 2000. Forecasts of sludge production are notably difficult and uncertain enough to suggest the possibility that actual experience may permit processing of a 25 percent overrun of the nominal capacity. This possibility is the basis for exploring the feasibility of conveying Spokane Valley solids to the City STP for processing and disposal. This alternative is developed following analysis of systems to serve Spokane Valley separately.

Solids processing plans formulated to serve the Spokane Valley are shown schematically in Figures H through M and are summarized below:

Plan Identification	Description
S	Anaerobic digestion, vacuum filtration, sanitary landfill
T	Anaerobic digestion, vacuum filtration, land application to dry farm
U	Anaerobic digestion, air drying, sanitary landfill
V-1	Centrifugation of raw sludge, multiple-hearth incineration
V-2	Anaerobic digestion, vacuum filtration multiple-hearth incineration
X	Wet Oxidation (70% reduction), centrifuge separation of solids
Y	Deliver raw sludge to City STP for processing and disposal

The above plans are representative of certain subalternatives, also considered, which are not listed separately. Plan S is also representative of the subalternatives utilizing low pressure and intermediate pressure wet oxidation in lieu of anaerobic digestion. In view of the unfavorable cost of sludge application to irrigated land relative to dry land developed in the DOE report for the City, the latter is not applied here. Land application to dry farmed areas per Plan T is selected to most favorably represent this alternative.

Plan U is for air drying at a site remote from the treatment facility and the populated area. Consideration is included as a subalternative of possible use of truck haul in lieu of pipeline transport of the liquid sludge. The cost effectiveness appears to favor pipelines but the combination of quantity and distance are near the break even point. Pipeline conveyance is selected as representative of the optimum method.

Plan W is not included for formal analysis for Spokane Valley. Although sludge drying for marketing has been practiced for flows as low as 10 mgd, see Irving (1965) regarding Schenectady, N. Y., it has not been favored for smaller communities. The relation of this alternative to others is demonstrated above for the City.

Plan V-1, incineration of raw sludge, is introduced to contrast costs with that of incineration of digested sludge, Plan V-2. This relationship is not previously developed for the City.

Plan Y is developed to represent the subalternatives by which raw sludge from the Spokane Valley could be conveyed to the City STP for processing and disposal. Three conveyance subalternatives are considered: (1) tank truck haul, (2) conveyance in the City sewage collection system which extends to Felts Field and (3) pump stations and force mains. Although conveyance in the City sewers would be the lowest cost it is eliminated at this time because it would be an intolerable addition to the present overflow problem. If it were not for the overflow problem, the conveyance of sludge mixed with raw sewage in this manner is feasible. (The City of Glendale, California returns raw sludge from a secondary treatment plant to a City of

Los Angeles trunk sewer for processing and disposal.) A substudy indicates that pipeline conveyance is slightly more cost effective than tank truck haul. Therefore, pipeline conveyance is selected as representative of Plan Y. (An example of an existing system using this arrangement is the City of San Francisco where sludge from the Bay Street plant is conveyed by pipeline to the Islais Creek plant for processing and disposal.) Parallel lines are provided for maintenance and continuity of service.

Cost Effectiveness of Sludge Plans for Spokane Valley

Cost effectiveness results of the above described alternative plans are summarized in Table 9. Note that these results are expressed in terms of present worth for the twenty year planning period 1980 to 2000 consistent with the methodology developed for this study in Section 401.1. (The previously discussed cost effectiveness analysis for the City is in terms of average annual cost as they are expressed in the DOE study.)

Plans S and Y are found to be most cost effective. Plan Y is lower in cost but the difference between the costs is not great enough to show a conclusive advantage to either considering the accuracy of estimating and the following considerations. The operation and maintenance costs for Plan Y include estimated charges that would be made by the City of Spokane for processing and disposal of the raw sludge based on a modification and interpretation of the proposed schedule of user charges and industrial cost recovery developed in

Bovay (1974). These charges were not developed for this specialized use and therefore probably do not represent an equitable basis that both parties would arrive at based on negotiations for the specific conditions. They are adopted as representative for the purpose of this study. It is assumed that the phosphorus component of the charge would not be applicable since the Spokane Valley plant would have already borne the expense of precipitation and was delivering the separated phosphorus directly to the City solids processing system without the material passing through the wastewater elements of the City STP. The capital recovery charge is adjusted to reflect recovery of the City's share of the cost rather than the federal grant recovery. This is based on the assumption that the Spokane Valley would share in the use of state or federal grant funds without charge but would be expected to reimburse the City for their share. The user and capital recovery charges represent the majority of the operation and maintenance costs shown for Plan Y so that any significant changes made in the basis for charging would significantly affect the total cost.

The most significant reservation concerning Plan Y is the possibility that the solids processing capacity at the City STP may not be enough to include Spokane Valley without additions. Also of significant concern is the disruptive impact during construction caused by work in city streets for pipelines.

The system next lowest in total cost after Plans S and Y is Plan V-1, which provides for incineration of raw sludge solids. The reliability weakness of this system is considered under the screening for other than cost concerns. Plan V-2, which is in effect Plan S plus incineration and therefore high in reliability, is next in cost effectiveness.

The distances for conveyance to the nearest suitable sites for Plans T and U are prime contributors to their position of relatively low cost effectiveness. The smaller flows involved for Spokane Valley cause a larger relative impact by conveyance than experienced in City alternative plans. Incremental pipeline capacity increases at a higher rate than the corresponding incremental increase in cost.

The wet air oxidation process to 70 percent reduction has the highest cost. This process had its earliest applications in the 70 percent reduction configuation as competition to incineration for maximum reduction without the same air pollution threat. Due to the cost consideration and the operating problems at the extreme high pressures (1700 psi) it is no longer being favored in this application. As pointed out under formulation, the lower percent reduction versions of this process are considered as subalternatives to anaerobic digestion at design level.

Economic, Social and Environmental Evaluation of Sludge Plans for Spokane Valley

Narrative Evaluation. Initial rankings in each concern of sludge plans for the Spokane Valley are shown in Table 10. These rankings are derived from the complete narrative evaluation included in Appendix III. The initial evaluations are relative and are in the order of desirability, from 1 for the most desirable to larger numbers for the less desirable. Plan Y is not included in the evaluation because its impact in large part becomes dependent upon the plan selected for the City STP. This special case is discussed relative to the other plans in the analysis and conclusion paragraph below.

Weighted Evaluations. The weighted evaluations developed in Tables 11 through 16 follow the same methodology described above under the corresponding paragraph for City STP alternatives. Tables 11 through 14 show four weightings of Group 1 concerns. Table 15 shows a balanced weighting of Group 2 concerns. Final combined weightings of Group 1 and Group 2 concerns are shown in Table 16.

Analysis and Conclusions. This initial discussion is exclusive of Plan Y. After a preliminary conclusion is reached exclusive of Plan Y, the most favored plan is compared with Plan Y to reach a final conclusion.

Table 16 shows that Plan S is the most favored for all weightings of Group 1 concerns. The next plans in order are the two incineration plans, again at all weightings.

As was the case for City STP sludge alternatives, the maximum reduction plans are found to be most favored considering Group 2 concerns. The same reasons apply here as were discussed under the City STP alternatives.

With Groups 1 and 2 combined to give greatest weight to social and environmental concerns, as depicted by 75 percent weight to line D and 25 percent to line E, Plan S remains the most favored with Plan V-1 a close second. The land application Plan T and air drying Plan U remain as the least favored. The weight given to reliability and threat of air pollution, the weak points of Plan V-1, are evidently not sufficient to counteract the second place cost position and certain favorable environmental impacts. Heavier emphasis on cost, increases the favorable position of Plan S.

Since the most favored plan for the City STP is Plan S and the most favored plan for Spokane Valley is Plan S, the introduction of Plan Y means that the Plan S activities at the Spokane Valley facilities would be transferred to and combined with those at the City STP. The negative environmental impacts of Plan S are of the same character for both sides. Combining them to one site would undoubtedly reduce the overall negative impacts, representing a plus value for Plan Y. The most prominent negative value inherent in Plan Y is the temporary disruption that would be caused by pipeline construction through city streets.

Another plus value for Plan Y is that having all sludge processing concentrated at one location would facilitate the adoption of new and innovative technology. For example, the feasibility of land application appears to be more favorable for the City STP than for Spokane Valley due to the advantages of size. The plus factors for Plan Y are judged to outweigh the disadvantage of temporary disruption during construction. This and the fact that Plan Y offers the possibility of cost savings and maximum utilization of existing facilities, are evaluated as the basis for giving Plan Y a favorable combined ranking. The uncertainty regarding available capacity in the City STP solids facilities is the factor which precludes recommendation of this alternative as the basic plan.

Plan S is selected as the basic recommended solids processing system for the Spokane Valley for its favorable cost and environmental ranking. If at design stage, more data are available on the capacity utilization of the City STP facilities, Plan Y should be reopened for review and consideration.

Alternatives for North Spokane

Plan H, one of the wastewater candidate plans open for further consideration, has possibilities of benefiting from consideration of Plan Y in lieu of a sludge plan to serve a North Spokane wastewater plan separately. A comparison of the cost of raw sludge conveyance plus cost recovery and user charges indicates that it is as cost effective or better than separate facilities such as Plan S. In the case of Plan Y applied to North Spokane, there is not the disadvantage of uncertainty of available capacity at the City STP or of disruptive construction through City streets since most of the route is in undeveloped areas and outside the City. A disadvantage of Plan Y applied to North Spokane is the very high pumping lifts involved which are unusual for conveying sludge and may be subject to some unforeseen technical difficulties.

Non-Structural Measures Affecting Sludge Quantity and Quality

In recent years home and restaurant and other commercial and individual garbage grinders have added significantly to the quantity of sludge being added to wastewater. The municipal sewer system is in effect taking over by water conveyance a small part of the total solid waste disposal problem of the community. There have been moves in certain communities to encroach still further into the field of solid waste disposal by allowing other solids to be added to the water conveyance system. The high costs of solids processing associated with wastewater treatment as compared with collection, conveyance and disposal of dry materials does not favor adding unnecessarily to the solids burden of municipal sewage. Not only is this method of solid waste disposal not cost effective, it usually precludes any salvage and reuse of resources. It is recommended that these unnecessary solids additions be prohibited by restricting the permitted use of garbage grinders to residential use and only in association with food preparation for commercial and institutional use.

In order to keep the option of land disposal open and useable for extended periods, if not indefinately, it is necessary to take non-structural measures to protect the quality of sludge from heavy metals which can poison the soil by accumulation. Wherever possible, sources of heavy metals in the wastewater should be identified so that they can be prevented from becoming inextricably mixed with the community wastewater flow. Quantities of heavy metal that do not pose a problem to receiving waters can, by accumulation over many years, render land poisoned. Removal or treatment at the source of heavy metals is one method. Finding alternative chemicals to provide the same function is another. One method that has been used by some communities where small quantitites of objectionable materials have been identified, is to provide for tank truck haul of these liquid wastes to a special treatment unit located on the STP site for separate processing and separate disposal of sludges. Although these methods involve structural measures, they are, with respect to the primary sludge processing stream, non-structural diversions of objectionable materials. The identification of these sources is a continuing process and is recommended as a tool for protection of sludge quality.

No Action Plans

In general, once committed to collection and treatment of sewage, there is no such thing as "no action" with respect to sludge disposal. Even septic tanks and primary lagoons require some action sonner or later unless the abandonment of the facility be considered "no action". Specifically, for the City STP the committed sludge facilities, equal to Plan S, is the "no action" plan with respect to this study. Specifically, for Spokane Valley, where the present method of wastewater disposal is septic tanks, the "no action" method is continuance of the present practice of allowing each owner to decide when and if his septic tank should be pumped and then relying on independent pumping companies to provide the service. These alternatives are considered in the foregoing discussion and are reiterated to identify them as being synonymous with the "no action" alternative.

TABLE 1

COST EFFECTIVE ANALYSIS OF SLUDGE MANAGEMENT ALTERNATIVES FOR CITY STP (Source: Bovay 1975)

Sludge Alternative	Description	Average Annual Cost[1] Thousand Dollars Capital	O&M	Total
S	Anaerobic digestion, vacuum filtration, sanitary landfill	458	626	1,084
T-1	Anaerobic digestion, dry farm land application[2]	1,058	433	1,491
T-2	Anaerobic digestion, irrigated land application[2] [3]	1,449	624	2,073
V	Anaerobic digestion, vacuum filtration, incineration, landfill	601	895	1,596
W	Anaerobic digestion, vacuum filtration, drying, marketing	733	1,114	1,848
(X	Wet oxidation) (4)			

(1) Costs do not include either capital or O&M costs for anaerobic digestion which is common to all alternatives as formulated in Bovay (1975).
(2) Land application costs are for Site 6 as described in Bovay (1975).
(3) Costs for Site 4 are lower than Site 6 but by an insignificant amount.
(4) Not included in the referenced source

TABLE 2

INITIAL RANKING OF SLUDGE PLANS
ASSOCIATED WITH CITY STP

CHARACTERISTICS AND CONCERNS	Ranking of Candidate Plans					
	S	T-1	T-2	V	W	X
1. COST EFFECTIVENESS	1	2	3	4	5	6
2. DIRECT ECONOMIC CONCERNS						
a. Lowest requirement for capital	1	4	5	2	3	6
b. Lowest O&M cost	2	1	2	3	4	5
c. Minimum loss of employment	1	3	2	1	1	1
d. Minimum loss of tax revenue	3	5	4	2	1	2
3. INDIRECT ECONOMIC CONCERNS (General negligible relative impact)						
4. TRANSIENT ECONOMIC CONCERNS						
a. Maximum employment during construction	4	1	2	3	3	3
b. Maximum increase in local manufacture and supply during construction	4	2	1	3	3	3
c. Minimum disruption of circulation and business during construction	1	3	2	1	1	1
5. SOCIAL CONCERNS FOR COMMUNITY						
a. Minimum potential for unfavorable health impact	2	4	3	1	1	1
b. Minimum disruption of community living	2	4	3	1	1	1
c. Minimum constraints on land use	2	4	3	1	1	1
6. SOCIAL CONCERNS FOR INDIVIDUAL						
a. Minimum dislocation of individuals	1	3	2	1	1	1
7. CONCERNS FOR GROUNDWATER						
a. Maximum protection of groundwater	2	3	3	1	1	1
8. CONCERNS FOR SURFACE WATER						
a. Maximum protection of surface water	2	4	3	1	1	1

TABLE 2 (Continued)

INITIAL RANKING OF SLUDGE PLANS
ASSOCIATED WITH CITY STP

CHARACTERISTICS AND CONCERNS	Ranking of Candidate Plans S	T-1	T-2	V	W	X
9. CONCERNS FOR LAND USE						
a. Minimum impact on wildlife habitat	3	5	4	2	1	2
b. Minimum undesirable impact on aesthetic quality of landscape	3	5	4	2	1	2
10. CONCERNS FOR AIR QUALITY AND NOISE						
a. Minimum potential for noxious emissions to air	1	2	2	4	5	3
b. Minimum odor nuisance	1	6	5	3	4	2
c. Minimum noise potential	4	1	1	2	3	2
11. CONCERNS FOR ENERGY AND RESOURCES						
a. Minimum electrical energy	2	1	1	3	4	5
b. Minimum thermal energy	1	1	1	3	4	2
c. Minimum use of chemicals	3	1	1	3	3	2
d. Maximum recovery or reuse of resources	3	1	1	3	2	4
12. PERFORMANCE EVALUATION						
a. Minimize degradation of wastewater treatment process	2	1	1	2	2	3
b. Maximum reliability	1	4	5	2	3	6
c. Least offensive end product	4	5	5	1	2	3
13. FLEXIBILITY						
a. Maximum flexibility to meet unanticipated growth	1	3	2	4	5	6
b. Maximum flexibility to meet unanticipated changes in sludge quality	3	1	1	3	3	1
c. Maximum flexibility to meet changes in dispoal criteria	2	4	3	1	1	1
d. Maximum flexibility to incorporate changes in technology	2	1	1	4	3	5

TABLE 3

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS ASSOCIATED WITH CITY STP
HEAVILY WEIGHTED TO COST

			Weighted Ranking of Candidate Plans											
			S		T-1		T-2		V		W		X	
	CONCERN	WEIGHT	Rel (1)	Wtd (2)	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1.	Lowest cost	65	1.000	65.0	.727	47.3	.523	34.0	.679	44.1	.587	38.2	.68	44.2
5a.	Minimum potential for unfavorable health impact	7	.80	5.6	.60	4.2	.70	4.9	1.000	7.0	1.000	7.0	1.000	7.0
7a.	Maximizes protection of groundwater	6	.90	5.4	.75	4.5	.75	4.5	1.000	6.0	1.000	6.0	1.000	6.0
8a.	Maximizes protection of surface waters	5	.95	4.8	.60	3.0	.70	3.5	1.000	5.0	1.000	5.0	1.000	5.0
10a.	Minimum potential for noxious emissions to air	2	1.000	2.0	.85	1.7	.85	1.7	.55	1.1	.50	1.0	.60	1.2
10b.	Minimum potential for odor nuisance	2	1.000	2.0	.20	0.4	.40	0.8	.85	1.7	.80	1.6	.95	1.9
11a.	Minimum use of electrical	2	.90	1.8	1.00	2.0	1.00	2.0	.70	1.4	.65	1.3	.25	0.5
11b.	and thermal energy	2	1.00	2.0	1.00	2.0	1.00	2.0	.60	1.2	.45	0.9	.75	1.5
11c.	Minimum use of chemicals	1.5	.60	0.9	1.00	1.5	1.00	1.5	.60	0.9	.60	0.9	.90	1.4
11d.	Maximum recovery of resources	4.5	.20	0.9	1.00	4.5	1.00	4.5	.20	0.9	.80	3.6	.10	0.4
12a.	Minimum degradation of wastewater process	1.5	.80	1.2	1.00	1.5	1.00	1.5	.80	1.2	.80	1.2	.70	1.0
12b.	Maximum reliability	1.5	1.00	1.5	.70	1.0	.65	1.0	.90	1.4	.85	1.3	.20	0.3
	TOTALS	100		93.1		73.6		61.9		71.9		68.0		70.4

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 4

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS ASSOCIATED WITH CITY STP
MODERATELY WEIGHTED TO COST

			Weighted Ranking of Candidate Plans											
			S		T-1		T-2		V		W		X	
	CONCERN	WEIGHT	Rel (1)	Wtd (2)	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1.	Lowest cost	50	1.000	50	.727	36.4	.523	26.2	.679	34.0	.587	29.4	.68	34.0
5a.	Minimum potential for unfavorable health impact	10	.80	8.0	.60	6.0	.70	7.0	1.000	10.0	1.000	10.0	1.000	10.0
7a.	Maximizes protection of groundwater	8.5	.90	7.6	.75	6.4	.75	6.4	1.000	8.5	1.000	8.5	1.000	8.5
8a.	Maximizes protection of surface waters	7.0	.95	6.6	.60	4.2	.70	4.9	1.000	7.0	1.000	7.0	1.000	7.0
10a.	Minimum potential for noxious emissions to air	3	1.000	3.0	.85	2.6	.85	2.6	.55	1.6	.50	1.5	.60	1.8
10b.	Minimum potential for odor nuisance	3	1.000	3.0	.20	0.6	.40	1.2	.85	2.6	.80	2.4	.95	2.8
11a.	Minimum use of electrical	3	.90	2.7	1.00	3.0	1.00	3.0	.70	2.1	.65	2.0	.25	0.8
11b.	and thermal energy	3	1.00	3.0	1.00	3.0	1.00	3.0	.60	1.8	.45	1.4	.75	2.2
11c.	Minimum use of chemicals	2	.60	1.2	1.00	2.0	1.00	2.0	.60	1.2	.60	1.2	.90	1.8
11d.	Maximum recovery of resources	6.5	.20	1.3	1.00	6.5	1.00	6.5	.20	1.3	.80	5.2	.10	0.6
12a.	Minimum degradation of wastewater process	2.0	.80	1.6	1.00	2.0	1.00	2.0	.80	1.6	.80	1.6	.70	1.4
12b.	Maximum reliability	2.0	1.00	2.0	.70	1.4	.65	1.3	.90	1.8	.85	1.7	.20	0.4
	TOTALS	100		90.0		74.1		66.1		73.5		71.9		71.3

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 5

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS ASSOCIATED WITH CITY STP
MODERATELY WEIGHTED TO ENVIRONMENTAL

		Weighted Ranking of Candidate Plans											
		S		T-1		T-2		V		W		X	
CONCERN	WEIGHT	Rel[1]	Wtd[2]	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1. Lowest cost	30	1.000	30	.727	21.8	.523	15.7	.679	20.4	.587	17.6	.68	20.4
5a. Minimum potential for unfavorable health impact	14	.80	11.2	.60	8.4	.70	9.8	1.000	14.0	1.000	14.0	1.000	14.0
7a. Maximizes protection of groundwater	12	.90	10.8	.75	9.0	.75	9.0	1.000	12.0	1.000	12.0	1.000	12.0
8a. Maximizes protection of surface waters	10	.95	9.5	.60	6.0	.70	7.0	1.000	10.0	1.000	10.0	1.000	10.0
10a. Minimum potential for noxious emissions to air	4	1.000	4.0	.85	3.4	.85	3.4	.55	2.2	.50	2.0	.60	2.4
10b. Minimum potential for odor nuisance	4	1.000	4.0	.20	0.8	.40	1.6	.85	3.4	.80	3.2	.95	3.8
11a. Minimum use of electrical	4	.90	3.6	1.00	4.0	1.00	4.0	.70	2.8	.65	2.6	.25	1.0
11b. and thermal energy	4	1.00	4.0	1.00	4.0	1.00	4.0	.60	2.4	.45	1.8	.75	3.0
11c. Minimum use of chemicals	3	.60	1.8	1.00	3.0	1.00	3.0	.60	1.8	.60	1.8	.90	2.7
11d. Maximum recovery of resources	9	.20	1.8	1.00	9.0	1.00	9.0	.20	1.8	.80	7.2	.10	0.9
12a. Minimum degradation of wastewater process	3	.80	2.4	1.00	3.0	1.00	3.0	.80	2.4	.80	2.4	.70	2.1
12b. Maximum reliability	3	1.00	3.0	.70	2.1	.65	2.0	.90	2.7	.85	2.6	.20	0.6
TOTALS	100		86.1		74.5		71.5		75.9		77.2		72.9

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern **weight**.

TABLE 6

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS ASSOCIATED WITH CITY STP
HEAVILY WEIGHTED TO ENVIRONMENTAL

		Weighted Ranking of Candidate Plans											
		S		T-1		T-2		V		W		X	
CONCERN	WEIGHT	Rel[1]	Wtd[2]	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1. Lowest cost	20	1.000	20	.727	14.5	.523	10.5	.679	13.6	.587	11.7	.68	13.6
5a. Minimum potential for unfavorable health impact	16	.80	12.8	.60	9.6	.70	11.2	1.000	16.0	1.000	16.0	1.000	16.0
7a. Maximizes protection of groundwater	14	.90	12.6	.75	10.5	.75	10.5	1.000	14.0	1.000	14.0	1.000	14.0
8a. Maximizes protection of surface waters	11	.95	10.4	.60	6.6	.70	7.7	1.000	11.0	1.000	11.0	1.000	11.0
10a. Minimum potential for noxious emissions to air	5	1.000	5.0	.85	4.2	.85	4.2	.55	2.8	.50	2.5	.60	3.0
10b. Minimum potential for odor nuisance	5	1.000	5.0	.20	1.0	.40	2.0	.85	4.2	.80	4.0	.95	4.8
11a. Minimum use of electrical	5	.90	4.5	1.00	5.0	1.00	5.0	.70	3.5	.65	3.2	.25	1.2
11b. and thermal energy	5	1.00	5.0	1.00	5.0	1.00	5.0	.60	3.0	.45	2.2	.75	3.8
11c. Minimum use of chemicals	3	.60	1.8	1.00	3.0	1.00	3.0	.60	1.8	.60	1.8	.90	2.7
11d. Maximum recovery of resources	10	.20	2.0	1.00	10.0	1.00	10.0	.20	2.0	.80	8.0	.10	1.0
12a. Minimum degradation of wastewater process	3	.80	2.4	1.00	3.0	1.00	3.0	.80	2.4	.80	2.4	.70	2.1
12b. Maximum reliability	3	1.00	3.0	.70	2.1	.65	2.0	.90	2.7	.85	2.6	.20	0.6
TOTALS	100		84.5		74.5		74.1		77.0		79.4		73.8

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 7

RANKING OF GROUP 2 CONCERNS
SLUDGE PLANS ASSOCIATED WITH CITY STP
BALANCED WEIGHTING

		Weighted Ranking of Candidate Plans											
		S		T-1		T-2		V		W		X	
CONCERN	WEIGHT	Rel (1)	Wtd (2)	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
2c. Minimum loss of employment	8	1.00	8.0	.80	6.4	.90	7.2	1.00	8.0	1.00	8.0	1.00	8.0
2d. Minimum loss of tax revenue	6	.90	5.4	.60	3.6	.75	4.5	.95	5.7	1.00	6.0	.95	5.7
4a. Maximum employment during construction	5	.12	0.6	1.00	5.0	.90	4.5	.15	0.8	.15	0.8	.15	0.8
4b. Maximum increase in local manufacture and supply during construction	4	.20	0.8	1.00	4.0	.90	3.6	.25	1.0	.25	1.0	.25	1.0
4c. Minimum disruption of circulation and business during construction	5	1.00	5.0	.30	1.5	.60	3.0	1.00	5.0	1.00	5.0	1.00	5.0
5b. Minimum disruption of community living	4	.90	3.6	.50	2.0	.70	2.8	1.00	4.0	1.00	4.0	1.00	4.0
5c. Minimum constraints on land use	8	.95	7.6	.30	2.4	.60	4.8	1.00	8.0	1.00	8.0	1.00	8.0
6a. Minimum dislocation of individuals	6	1.00	6.0	.30	1.8	.60	3.6	1.00	6.0	1.00	6.0	1.00	6.0
9a. Minimum impact on wild-life habitat	8	.90	7.2	.30	2.4	.60	4.8	.95	7.6	1.00	8.0	.95	7.6
9b. Minimum undesirable impact on aesthetic quality of landscape	6	.90	5.4	.30	1.8	.60	3.6	.95	5.7	1.00	6.0	.95	5.7
10c. Minimum noise potential	8	.50	4.0	1.00	8.0	1.00	8.0	.95	7.6	.80	6.4	.95	7.6
12c. Least offensive end product	8	.80	6.4	.10	0.8	.10	0.8	1.00	8.0	.95	7.6	.90	7.2
13a. Maximum flexibility to meet unanticipated growth	6	1.00	6.0	.80	4.8	.90	5.4	.30	1.8	.25	1.5	.20	1.2
13b. Maximum flexibility to meet unanticipated changes in sludge quality	6	.50	3.0	.75	4.5	.75	4.5	.50	3.0	.50	3.0	1.00	6.0
13c. Maximum flexibility to meet changes in disposal criteria	6	.90	5.4	.50	3.0	.60	3.6	1.00	6.0	1.00	6.0	1.00	6.0
13d. Maximum flexibility to incorporate changes in technology	6	.90	5.4	1.00	6.0	1.00	6.0	.80	4.8	.85	5.1	.70	4.2
TOTALS	100		79.8		58.0		70.7		83.0		82.4		84.0

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 8

SUMMARY RANKING OF GROUP 1 AND GROUP 2 CONCERNS
SLUDGE PLANS ASSOCIATED WITH CITY STP

	Alternative Plans					
	S	T-1	T-2	V	W	X
GROUP 1 CONCERNS						
A. Heavily weighted to cost	93.1	73.6	61.9	71.9	68.0	70.4
B. Moderately weighted to cost	90.0	74.1	66.1	73.5	71.9	71.3
C. Moderately weighted to environmental	86.1	74.5	71.5	75.9	77.2	72.9
D. Heavily weighted to environmental	84.5	74.5	74.1	77.0	79.4	73.8
GROUP 2 CONCERNS						
E. Balanced weighting	79.8	58.0	70.7	83.0	82.4	84.0
COMBINED GROUPS						
0.75A + 0.25E	89.8	69.7	64.1	74.7	71.6	73.8
0.75B + 0.25E	87.4	70.1	67.2	75.9	74.5	74.5
0.75C + 0.25E	84.5	70.4	71.3	77.7	78.5	75.7
0.75D + 0.25E	83.3	70.4	73.2	78.5	80.2	76.4
0.90A + 0.10E	91.8	72.0	62.8	73.0	69.4	71.8
0.90B + 0.10E	89.0	72.5	66.6	74.4	73.0	72.6
0.90C + 0.10E	85.5	72.8	71.4	76.6	77.7	74.0
0.90D + 0.10E	84.0	72.8	73.8	77.6	79.7	74.8

TABLE 9

COST EFFECTIVE ANALYSIS OF SLUDGE MANAGEMENT ALTERNATIVES FOR SPOKANE VALLEY ELEMENT OF PLAN A

Sludge Alternative	Description	Present Worth, Million Dollars 1980-2000 Planning Period Capital Cost	O&M Cost	Total Cost
S	Anaerobic digestion, vacuum filtration, sanitary landfill	1.62	2.13	3.75
T	Anaerobic digestion, dry farm land application	3.73	1.73	5.46
U	Anaerobic digestion, air drying, sanitary landfill	3.61	2.30	5.91
V-1	Centrifugation of raw sludge, multiple-hearth incineration	2.31	1.83	4.14
V-2	Anaerobic digestion, vacuum filtration, multiple hearth incineration	3.02	2.23	5.25
X	Wet oxidation (70%), centrifuge separation of solids, sanitary landfill	3.79	2.29	6.08

TABLE 10

INITIAL RANKING OF SLUDGE PLANS
FOR SPOKANE VALLEY (PLAN A)

CHARACTERISTICS AND CONCERNS	Ranking of Candidate Plans					
	S	T	U	V-1	V-2	X
1. COST EFFECTIVENESS	1	4	5	2	3	6
2. DIRECT ECONOMIC CONCERNS						
a. Lowest requirement for capital	1	5	4	2	3	6
b. Lowest O&M cost	3	1	5	2	4	6
c. Minimum loss of employment	1	1	1	1	1	1
d. Minimum loss of tax revenue	2	4	3	1	1	1
3. INDIRECT ECONOMIC CONCERNS (General negligible relative impact)						
4. TRANSIENT ECONOMIC CONCERNS						
a. Maximum employment during construction	2	1	1	2	2	2
b. Maximum increase in local manufacture and supply during construction	2	1	1	2	2	2
c. Minimum disruption of circulation and business during construction	1	3	2	1	1	1
5. SOCIAL CONCERNS FOR COMMUNITY						
a. Minimum potential for unfavorable health impact	2	4	3	1	1	1
b. Minimum disruption of community living	2	4	3	1	1	1
c. Minimum constraints on land use	2	4	3	1	1	1
6. SOCIAL CONCERNS FOR INDIVIDUAL						
a. Minimum dislocation of individuals	2	4	3	1	1	1
7. CONCERNS FOR GROUNDWATER						
a. Maximum protection of groundwater	2	3	4	1	1	1
8. CONCERNS FOR SURFACE WATER						
a. Maximum protection of surface water	2	4	3	1	1	1

TABLE 10 (Continued)

INITIAL RANKING OF SLUDGE PLANS
FOR SPOKANE VALLEY (PLAN A)

CHARACTERISTICS AND CONCERNS	Ranking of candidate plans S	T	U	V-1	V-2	X
9. CONCERNS FOR LAND USE						
a. Minimum impact on wildlife habitat	2	4	3	1	1	1
b. Minimum undesirable impact on aesthetic quality of landscape	2	3	4	1	1	1
c. Minimum interference with other use	2	4	3	1	1	1
10. CONCERNS FOR AIR QUALITY AND NOISE						
a. Minimum potential for noxious emission to air	1	2	2	4	4	3
b. Minimum odor nuisance	1	4	5	2	2	3
c. Minimum noise potential	4	2	3	1	1	1
11. CONCERNS FOR ENERGY AND RESOURCES						
a. Minimum electrical energy	3	2	1	4	4	5
b. Minimum thermal energy	1	1	1	2	3	2
c. Minimum use of chemicals	3	1	1	3	3	2
d. Maximum recovery or reuse of resources	2	1	2	3	3	3
12. PERFORMANCE EVALUATION						
a. Minimize degradation of wastewater treatment process	3	3	1	2	3	4
b. Maximum reliability	1	4	3	5	2	6
c. Least offensive end product	3	4	3	1	1	2
13. FLEXIBILITY						
a. Maximum flexibility to meet unanticipated growth	1	3	2	4	4	4
b. Maximum flexibility to meet unanticipated changes in sludge quality	3	2	1	1	3	1
c. Maximum flexibility to meet changes in disposal criteria	2	3	2	1	1	1
d. Maximum flexibility to incorporate changes in technology	3	1	2	4	5	6

TABLE 11

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS FOR SPOKANE VALLEY
HEAVILY WEIGHTED TO COST

			Weighted Ranking of Candidate Plans										
		S		T		U		V-1		V-2		X	
CONCERNS		WEIGHT	Rel[1]	Wtd[2]	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1.	Lowest cost	65	1.00	65.0	0.69	44.8	0.63	41.0	0.91	59.2	0.71	46.2	0.62	40.3
5a.	Minimum potential for unfavorable health impact	7	.80	5.6	.60	4.2	.70	4.9	1.00	7.0	1.00	7.0	1.00	7.0
7a.	Maximizes protection of groundwater	6	.90	5.4	.75	4.5	.60	3.6	1.00	6.0	1.00	6.0	1.00	6.0
8a.	Maximizes protection of surface waters	5	.95	4.8	.60	3.0	.85	4.2	1.00	5.0	1.00	5.0	1.00	5.0
10a.	Minimum potential for noxious emissions to air	2	1.00	2.0	.85	1.7	.85	1.7	.55	1.1	.55	1.1	.60	1.2
10b.	Minimum potential for odor nuisance	2	1.00	2.0	.20	0.4	.15	0.3	.85	1.7	.85	1.7	.95	1.9
11a.	Minimum use of electrical	2	.85	1.7	.95	1.9	1.00	2.0	.70	1.4	.70	1.4	.25	0.5
11b.	and thermal energy	2	1.00	2.0	1.00	2.0	1.00	2.0	.60	1.2	.60	1.2	.70	1.4
11c.	Minimum use of chemicals	1.5	.60	0.9	1.00	1.5	1.00	1.5	.70	1.0	.60	0.9	.90	1.4
11d.	Maximum recovery of resources	4.5	.20	0.9	1.00	4.5	.20	0.9	.10	0.4	.10	0.4	.10	0.4
12a.	Minimum degradation of wastewater process	1.5	.80	1.2	.80	1.2	1.00	1.5	.90	1.4	.80	1.2	.70	1.0
12b.	Maximum reliability	1.5	1.00	1.5	.75	1.1	.80	1.2	.40	0.6	.90	1.4	.20	0.3
	TOTALS	100		93.0		70.8		64.8		86.0		73.5		66.4

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 12

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS FOR SPOKANE VALLEY
MODERATELY WEIGHTED TO COST

		Weighted Ranking of Candidate Plans											
		S		T		U		V-1		V-2		X	
CONCERN	WEIGHT	Rel[(1)]	Wtd[(2)]	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1. Lowest cost	50	1.00	50.0	0.69	34.5	0.63	31.5	0.91	45.5	0.71	35.5	0.62	31.0
5a. Minimum potential for unfavorable health impact	10	.80	8.0	.60	6.0	.70	7.0	1.00	10.0	1.00	10.0	1.00	10.0
7a. Maximizes protection of groundwater	8.5	.90	7.6	.75	6.4	.60	5.1	1.00	8.5	1.00	8.5	1.00	8.5
8a. Maximizes protection of surface waters	7	.95	6.6	.60	4.2	.85	6.0	1.00	7.0	1.00	7.0	1.00	7.0
10a. Minimum potential for noxious emissions to air	3	1.00	3.0	.85	2.6	.85	2.6	.55	1.6	.55	1.6	.60	1.8
10b. Minimum potential for odor nuisance	3	1.00	3.0	.20	0.6	.15	0.4	.85	2.6	.85	2.6	.95	2.8
11a. Minimum use of electrical	3	.85	2.6	.95	2.8	1.00	3.0	.70	2.1	.70	2.1	.25	0.8
11b. and thermal energy	3	1.00	3.0	1.00	3.0	1.00	3.0	.60	1.8	.60	1.8	.70	2.1
11c. Minimum use of chemicals	2	.60	1.2	1.00	2.0	1.00	2.0	.70	1.4	.60	1.2	.90	1.8
11d. Maximum recovery of resources	6.5	.20	1.3	1.00	6.5	.20	1.3	.10	0.6	.10	0.6	.10	0.6
12a. Minimum degradation of wastewater process	2	.80	1.6	.80	1.6	1.00	2.0	.90	1.8	.80	1.6	.70	1.4
12b. Maximum reliability	2	1.00	2.0	.75	1.5	.80	1.6	.40	0.8	.90	1.8	.20	0.4
TOTALS	100		89.9		71.7		65.5		83.7		74.3		68.2

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 13

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS FOR SPOKANE VALLEY
MODERATELY WEIGHTED TO ENVIRONMENTAL

		Weighted Ranking of Candidate Plans											
		S		T		U		V-1		V-2		X	
CONCERN	WEIGHT	Rel(1)	Wtd(2)	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1. Lowest cost	30	1.00	30.0	0.69	20.7	0.63	18.9	0.91	27.3	0.71	21.3	0.62	18.6
5a. Minimum potential for unfavorable health impact	14	.80	11.2	.60	8.4	.70	9.8	1.00	14.0	1.00	14.0	1.00	14.0
7a. Maximizes protection of groundwater	12	.90	10.8	.75	9.0	.60	7.2	1.00	12.0	1.00	12.0	1.00	12.0
9a. Maximizes protection of surface waters	10	.95	9.5	.60	6.0	.85	8.5	1.00	10.0	1.00	10.0	1.00	10.0
10a. Minimum potential for noxious emissions to air	4	1.00	4.0	.85	3.4	.85	3.4	.55	2.2	.55	2.2	.60	2.4
10b. Minimum potential for odor nuisance	4	1.00	4.0	.20	0.8	.15	0.6	.85	3.4	.85	3.4	.95	3.8
11a. Minimum use of electrical	4	.85	3.4	.95	3.8	1.00	4.0	.70	2.8	.70	2.8	.25	1.0
11b. and thermal energy	4	1.00	4.0	1.00	4.0	1.00	4.0	.60	2.4	.60	2.4	.70	2.8
11c. Minimum use of chemicals	3	.60	1.8	1.00	3.0	1.00	3.0	.70	2.1	.60	1.8	.90	2.7
11d. Maximum recovery of resources	9	.20	1.8	1.00	9.0	.20	1.8	.10	0.9	.10	0.9	.10	0.9
12a. Minimum degradation of wastewater process	3	.80	2.4	.80	2.4	1.00	3.0	.90	2.7	.80	2.4	.70	2.1
12b. Maximum reliability	3	1.00	3.0	.75	2.2	.80	2.4	.40	1.2	.90	2.7	.20	0.6
TOTALS	100		85.9		72.7		66.6		81.0		75.9		70.9

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 14

RANKING OF GROUP 1 CONCERNS
SLUDGE PLANS FOR SPOKANE VALLEY
HEAVILY WEIGHTED TO ENVIRONMENTAL

		Weighted Ranking of Candidate Plans											
		S		T		U		V-1		V-2		X	
CONCERN	WEIGHT	Rel [1]	Wtd [2]	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd	Rel	Wtd
1. Lowest cost	20	1.00	20.0	0.69	13.8	0.63	12.6	0.91	18.2	0.71	14.2	0.62	12.4
5a. Minimum potential for unfavorable health impact	16	.80	12.8	.60	9.6	.70	11.2	1.00	16.0	1.00	16.0	1.00	16.0
7a. Maximizes protection of groundwater	14	.90	12.6	.75	10.5	.60	8.4	1.00	14.0	1.00	14.0	1.00	14.0
8a. Maximizes protection of surface waters	11	.95	10.4	.60	6.6	.85	9.4	1.00	11.0	1.00	11.0	1.00	11.0
10a. Minimum potential for noxious emissions to air	5	1.00	5.0	.85	4.2	.85	4.2	.55	2.8	.55	2.8	.60	3.0
10b. Minimum potential for odor nuisance	5	1.00	5.0	.20	1.0	.15	0.8	.85	4.2	.85	4.2	.95	4.8
11a. Minimum use of electrical	5	.85	4.2	.95	4.8	1.00	5.0	.70	3.5	.70	3.5	.25	1.2
11b. and thermal energy	5	1.00	5.0	1.00	5.0	1.00	5.0	.60	3.0	.60	3.0	.70	3.5
11c. Minimum use of chemicals	3	.60	1.8	1.00	3.0	1.00	3.0	.70	2.1	.60	1.8	.90	2.7
11d. Maximum recovery of resources	10	.20	2.0	1.00	10.0	.20	2.0	.10	1.0	.10	1.0	.10	1.0
12a. Minimum degradation of wastewater process	3	.80	2.4	.80	2.4	1.00	3.0	.90	2.7	.80	2.4	.70	2.1
12b. Maximum reliability	3	1.00	3.0	.75	2.2	.80	2.4	.40	1.2	.90	2.7	.20	0.6
TOTALS	100		84.2		73.1		67.0		79.7		76.6		72.3

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 15

RANKING OF GROUP 2 CONCERNS
SLUDGE PLANS FOR SPOKANE VALLEY
BALANCED WEIGHTING

CONCERN	WEIGHT	Weighted Ranking of Candidate Plans: S Rel [1]	S Wtd [2]	T Rel	T Wtd	U Rel	U Wtd	V-1 Rel	V-1 Wtd	V-2 Rel	V-2 Wtd	X Rel	X Wtd
2c. Minimum loss of employment	8	1.00	8.0	1.00	8.0	1.00	8.0	1.00	8.0	1.00	8.0	1.00	8.0
2d. Minimum loss of tax revenue	6	.90	5.4	.60	3.6	.85	5.1	1.00	6.0	1.00	6.0	1.00	6.0
4a. Maximum employment during construction	5	.20	1.0	1.00	5.0	1.00	5.0	.20	1.0	.20	1.0	.20	1.0
4b. Maximum increase in local manufacture and supply during construction	4	.20	0.8	1.00	4.0	1.00	4.0	.20	0.8	.20	0.8	.20	0.8
4c. Minimum disruption of circulation and business during construction	5	1.00	5.0	.50	2.5	.60	3.0	1.00	5.0	1.00	5.0	1.00	5.0
5b. Minimum disruption of community living	4	.95	3.8	.70	2.8	.80	3.2	1.00	4.0	1.00	4.0	1.00	4.0
5c. Minimum constraints on land use	8	.90	7.2	.60	4.8	.70	5.6	1.00	8.0	1.00	8.0	1.00	8.0
6a. Minimum dislocation of individuals	6	.95	5.7	.70	4.2	.80	4.8	1.00	6.0	1.00	6.0	1.00	6.0
9a. Minimum impact on wildlife habitat	8	.90	7.2	.50	4.0	.75	6.0	1.00	8.0	1.00	8.0	1.00	8.0
9b. Minimum undesirable impact on aesthetic quality of landscape	6	.85	5.1	.75	4.5	.50	3.0	1.00	6.0	1.00	6.0	1.00	6.0
10c. Minimum noise potential	8	.50	4.0	.85	6.8	.70	5.6	1.00	8.0	1.00	8.0	1.00	8.0
12c. Least offensive end product	8	.80	6.4	.10	0.8	.70	5.6	1.00	8.0	1.00	6.0	.90	8.0
13a. Maximum flexibility to meet unanticipated growth	6	1.00	6.0	.80	4.8	.85	5.1	.30	1.8	.30	1.8	.30	1.8
13b. Maximum flexibility to meet unanticipated changes in sludge quality	6	.50	3.0	.75	4.5	1.00	6.0	1.00	6.0	.50	3.0	1.00	6.0
13c. Maximum flexibility to meet changes in disposal criteria	6	.90	5.4	.50	3.0	.90	5.4	1.00	6.0	1.00	6.0	1.00	6.0
13d. Maximum flexibility to incorporate changes in technology	6	.85	5.1	1.00	6.0	.90	5.4	.80	4.8	.75	4.5	.70	4.2
TOTALS	100		79.1		69.3		80.8		87.4		84.1		86.8

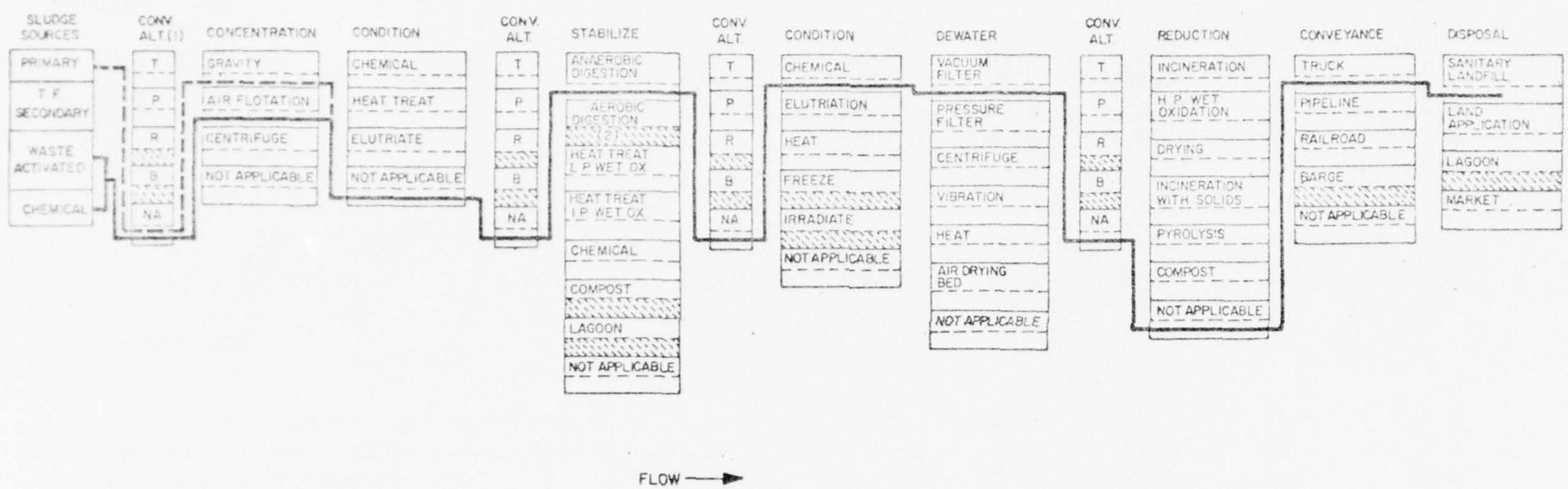
(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

TABLE 16

SUMMARY RANKING OF GROUP 1 AND GROUP 2 CONCERNS
SLUDGE PLANS FOR SPOKANE VALLEY

	Alternative Plans					
	S	T	U	V-1	V-2	X
GROUP 1 CONCERNS						
A. Heavily weighted to cost	93.0	70.8	64.8	86.0	73.5	66.4
B. Moderately weighted to cost	89.9	71.7	65.5	83.7	74.3	68.2
C. Moderately weighted to environmental	85.9	72.7	66.6	81.0	75.9	70.9
D. Heavily weighted to environmental	84.2	73.1	67.0	79.7	76.6	72.3
GROUP 2 CONCERNS						
E. Balanced weighting	79.1	69.3	80.8	87.4	84.1	86.8
COMBINED GROUPS						
0.75A + 0.25E	89.5	70.4	68.8	86.4	76.2	71.5
0.75B + 0.25E	87.2	71.1	69.3	84.6	76.8	72.8
0.75C + 0.25E	84.2	71.8	70.2	82.6	78.0	74.9
0.75D + 0.25E	82.9	72.2	70.4	81.6	78.5	75.9
0.90A + 0.10E	91.6	70.6	66.4	86.1	74.6	68.4
0.90B + 0.10E	88.8	71.5	67.0	84.1	75.3	70.1
0.90C + 0.10E	85.2	72.4	68.0	81.6	76.7	72.5
0.90D + 0.10E	83.7	72.7	68.4	80.5	77.4	73.8

ALTERNATIVE PROCESSES BY FUNCTION



NOTES:

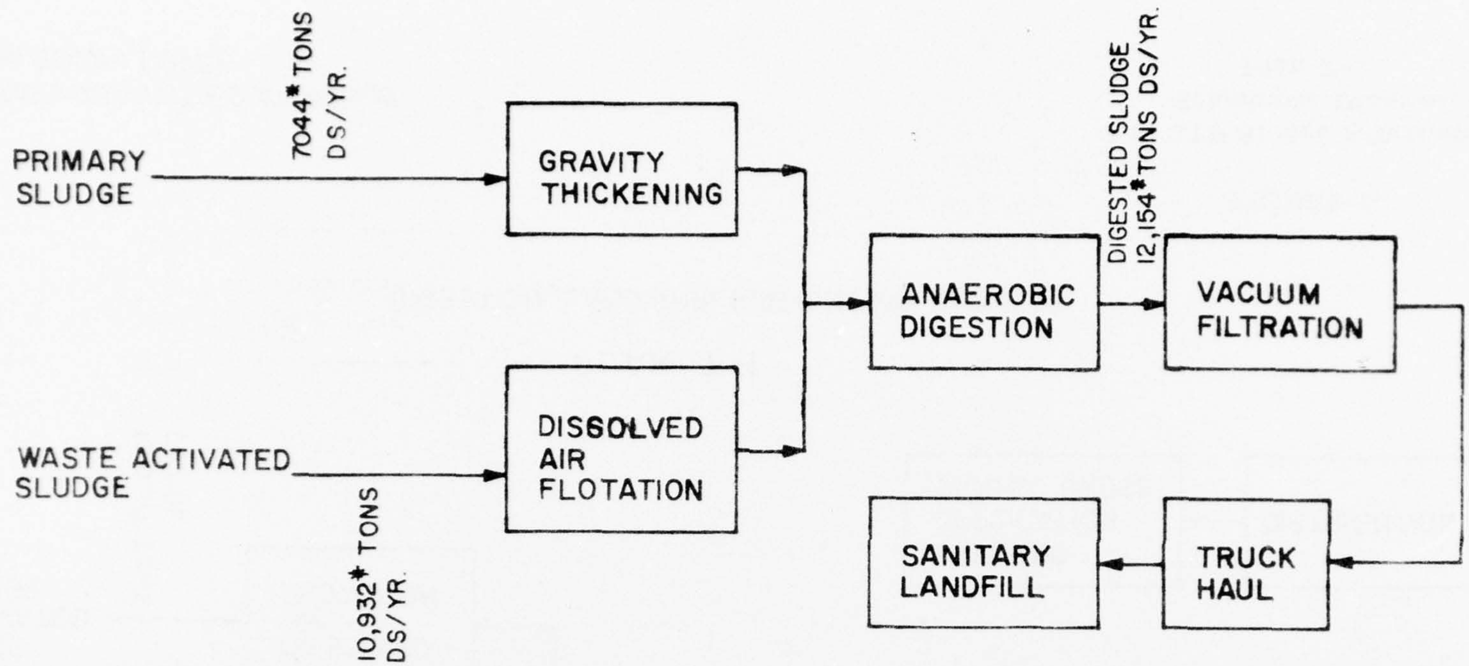
(1) CONV. ALT. indicates alternatives sequence of conveyance

(2) Cross hatching indicates alternative not applicable to this study

(3) Path illustrates decisions for Plan S as proposed for City STP by Bovay (1975)

FIGURE A

SOLIDS PROCESSING DECISION TREE



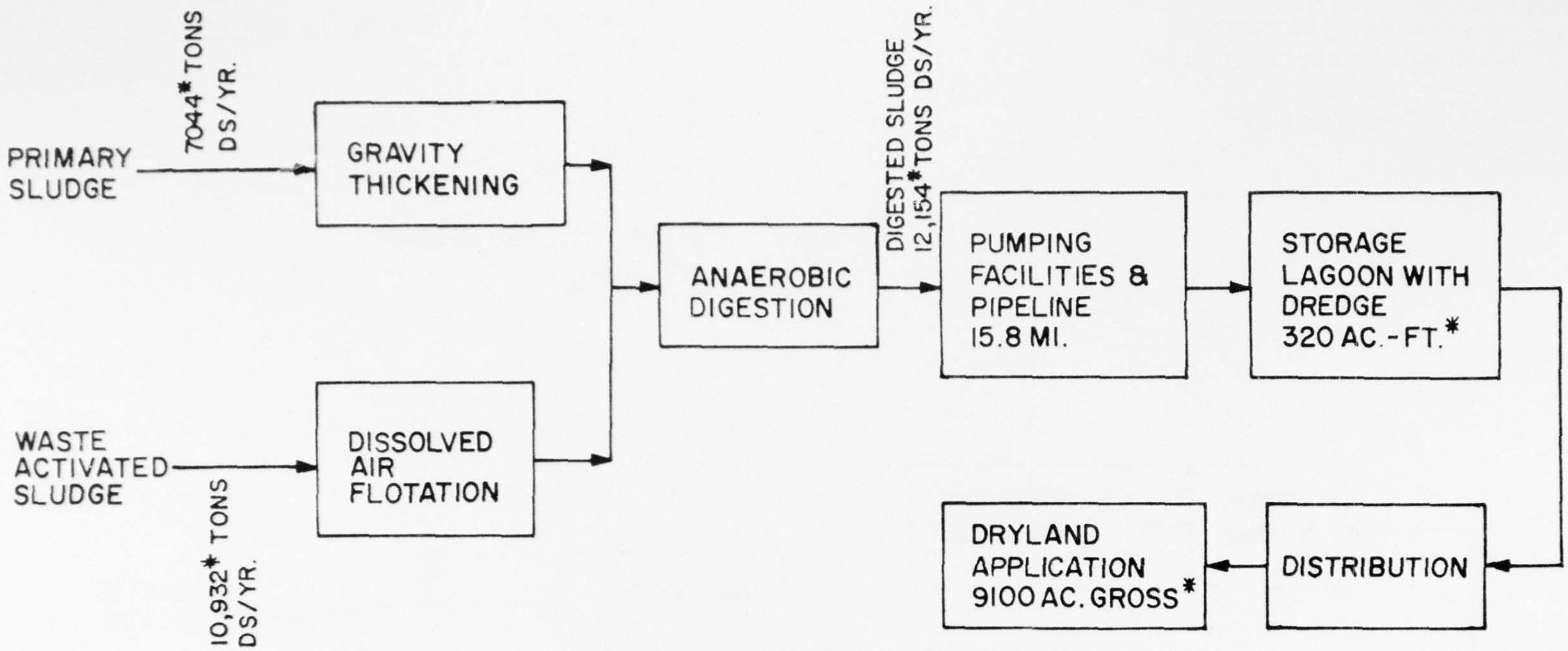
PLAN S

DIGESTION, FILTRATION, LANDFILL

* DESIGN QUANTITIES AT 40 mgd from BOVAY (1975)

FIGURE B

City STP Sludge Alternatives
Schematic Diagram
Plan S



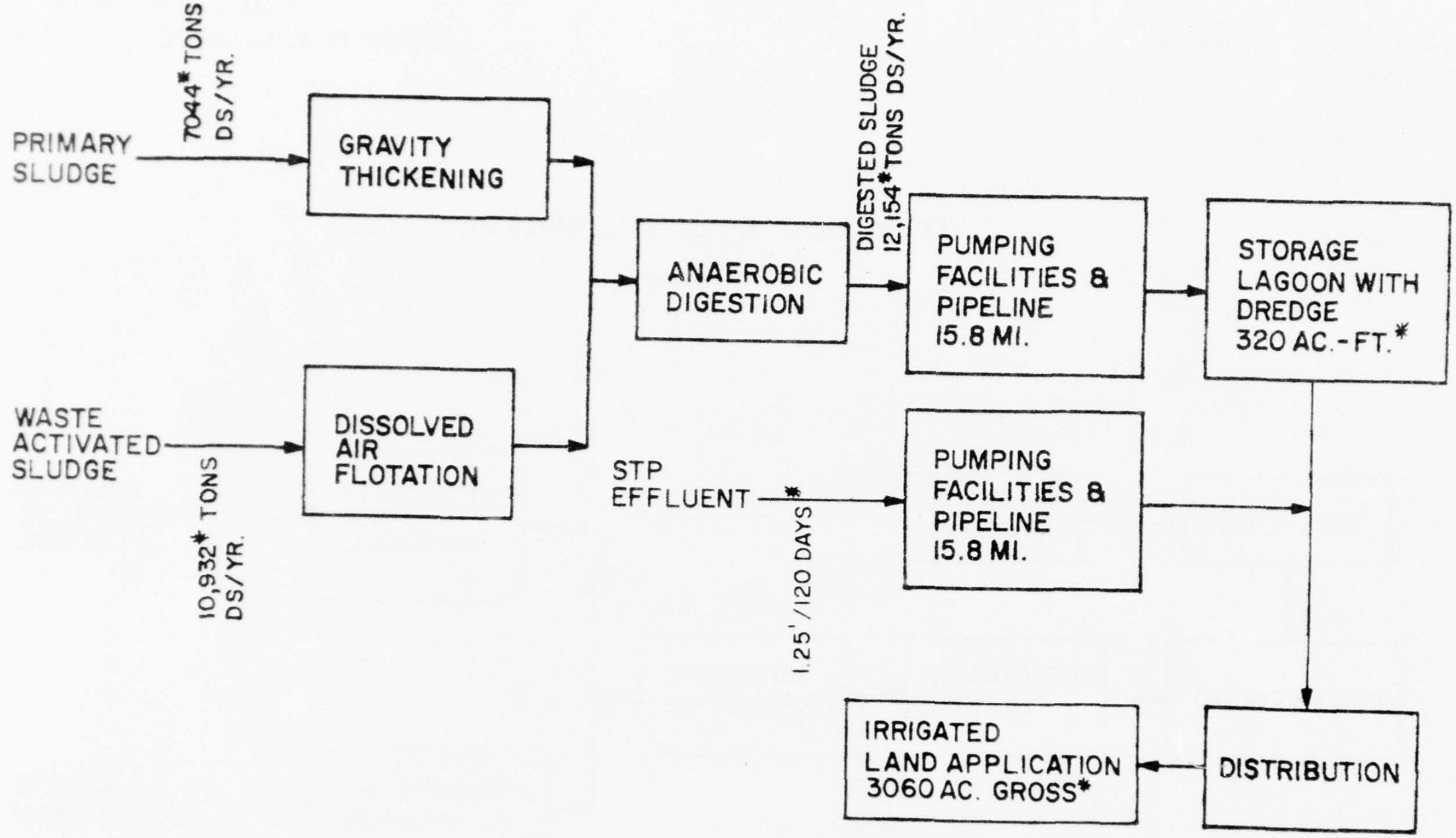
PLAN T-1

DIGESTION, LAND APPLICATION (DRY FARMED)

FIGURE C

City STP Sludge Alternatives
Schematic Diagram
Plan T-1

* *DESIGN QUANTITIES AT 40 mgd from BOVAY (1975)*



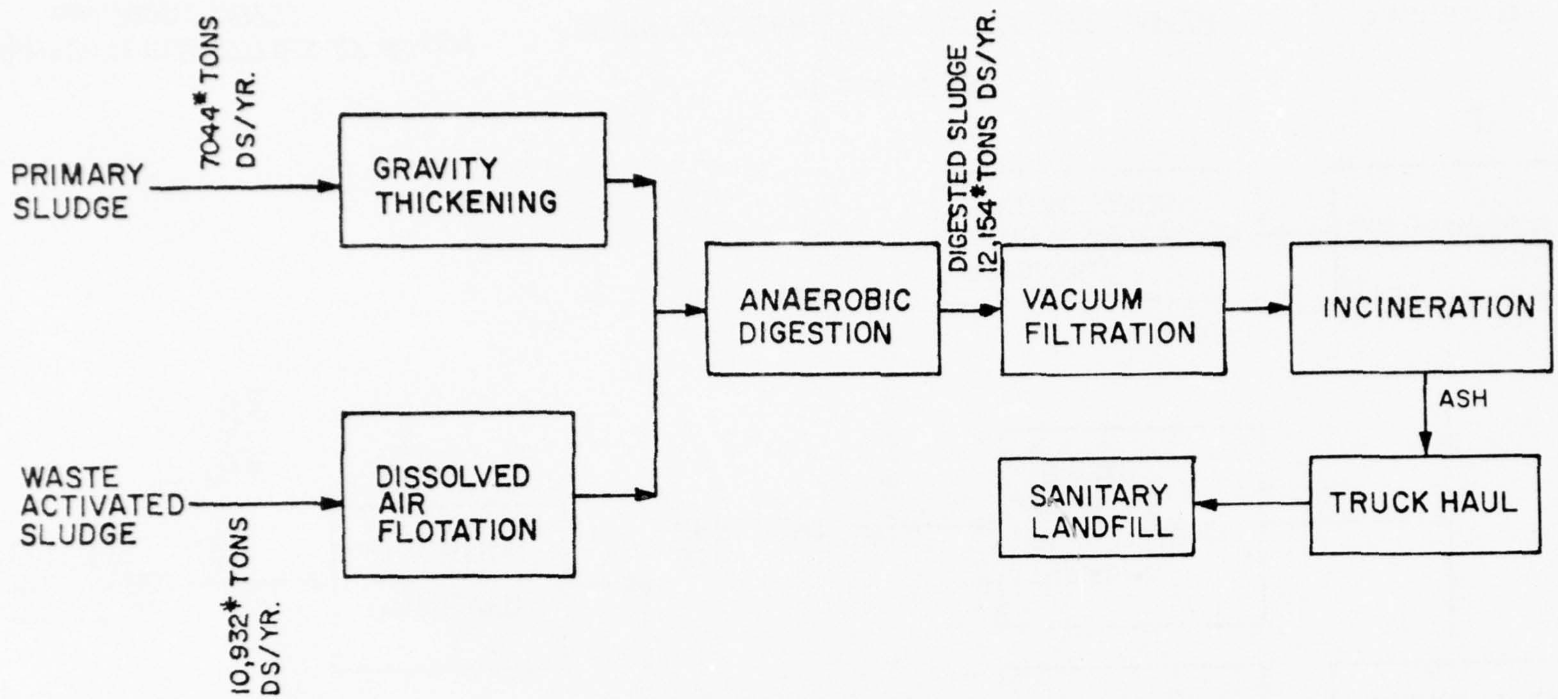
PLAN T-2

DIGESTION, LAND APPLICATION (IRRIGATED)

* *DESIGN QUANTITIES AT 40 mgd from BOVAY (1975)*

FIGURE D

City STP Sludge Alternatives
Schematic Diagram
Plan T-2



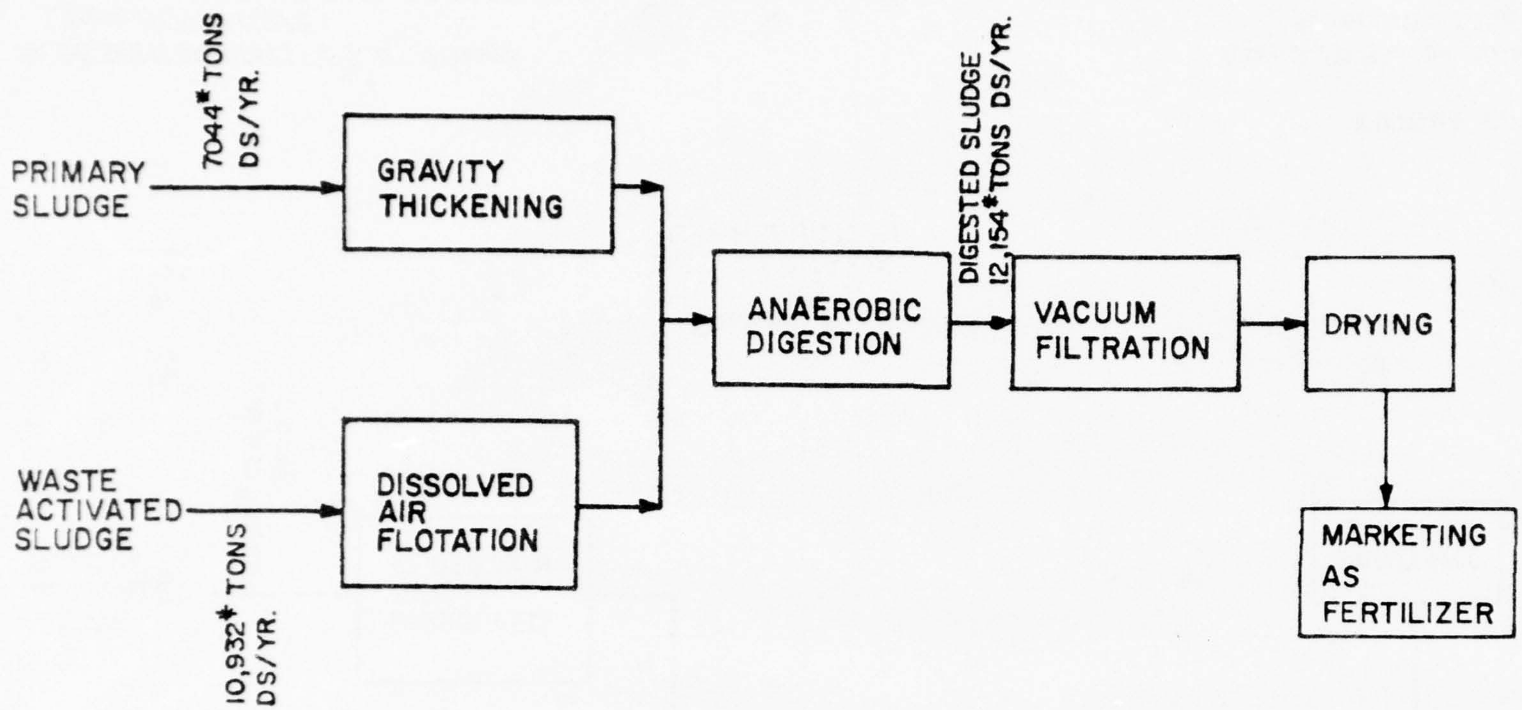
PLAN V

DIGESTION, FILTRATION, INCINERATION

* DESIGN QUANTITIES AT 40mgd from BOVAY (1975)

FIGURE E

City STP Sludge Alternatives
Schematic Diagram
Plan V



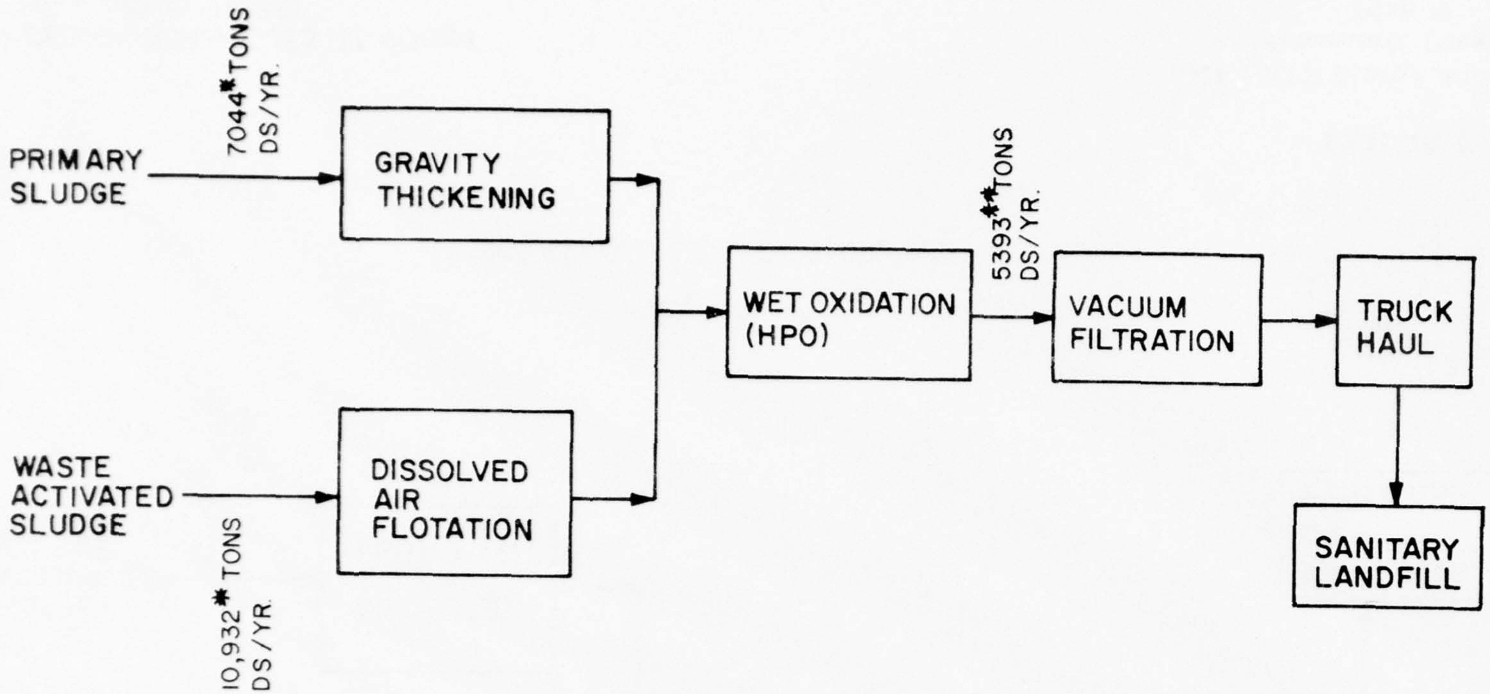
PLAN W

DIGESTION, FILTRATION, DRYING

* DESIGN QUANTITIES AT 40 mgd
from BOVAY (1975)

FIGURE F

City STP Sludge Alternatives
Schematic Diagram
Plan W



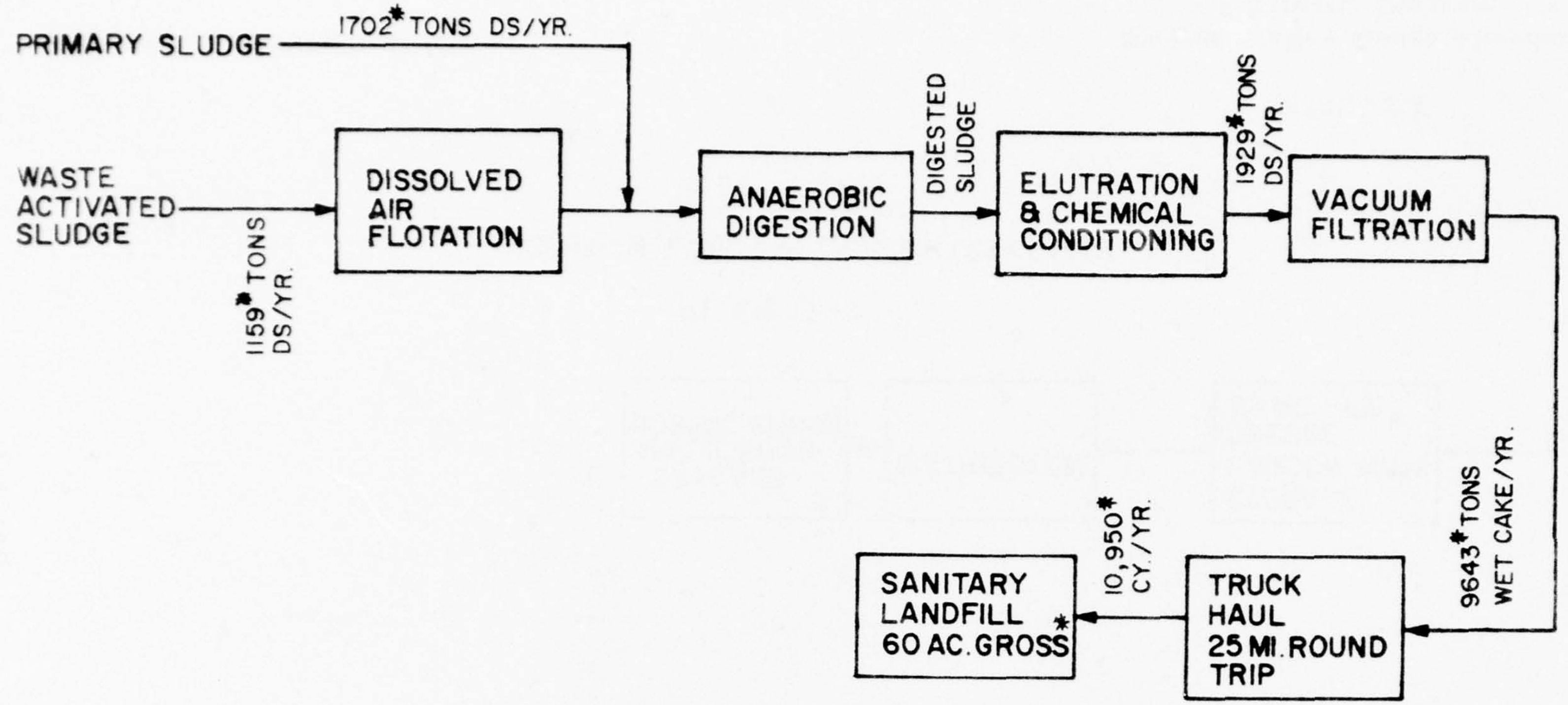
PLAN X

WET OXIDATION
70% REDUCTION

* *DESIGN QUANTITIES AT 40 mgd from BOVAY (1975)*
** *CALCULATED AT 70% REDUCTION*

FIGURE G

City STP Sludge Alternatives
Schematic Diagram
Plan X



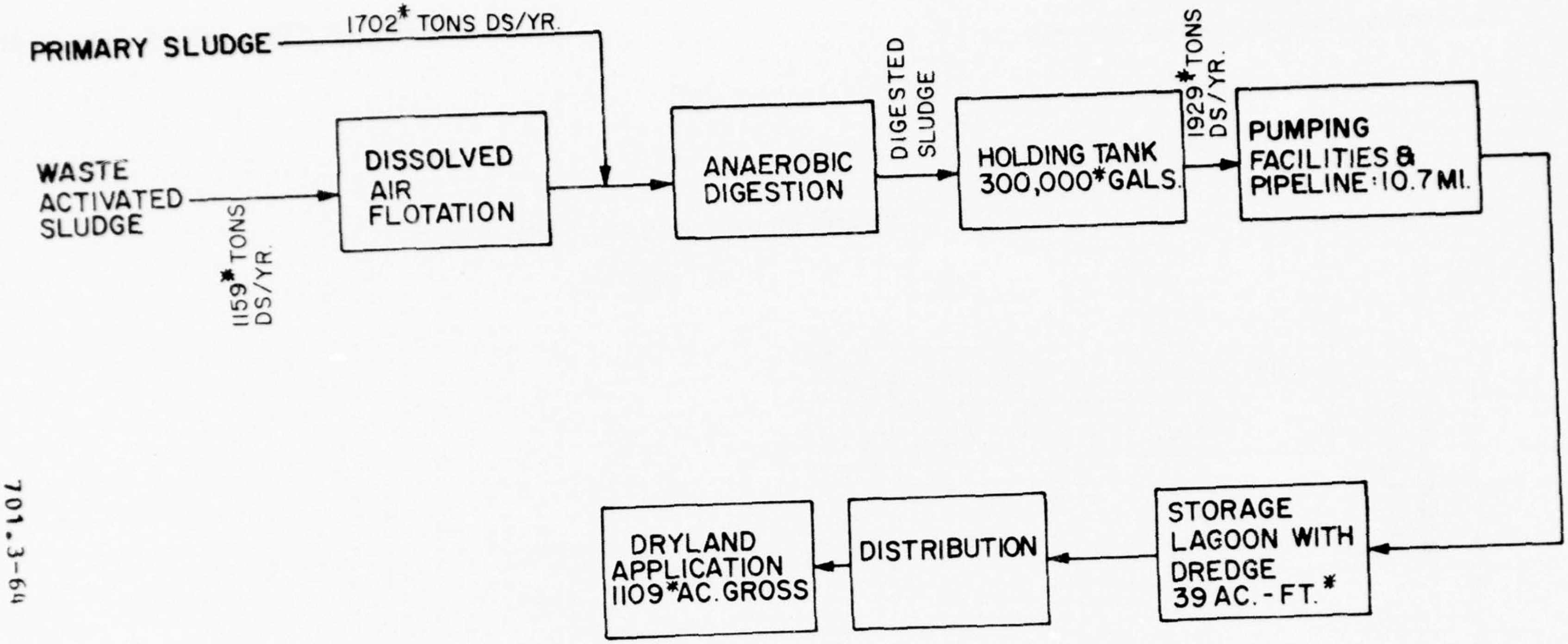
PLAN S

DIGESTION, FILTRATION, LANDFILL

** DESIGN QUANTITIES AT 10mgd*

FIGURE H

Spokane Valley Sludge Alternatives
Schematic Diagram
Plan S



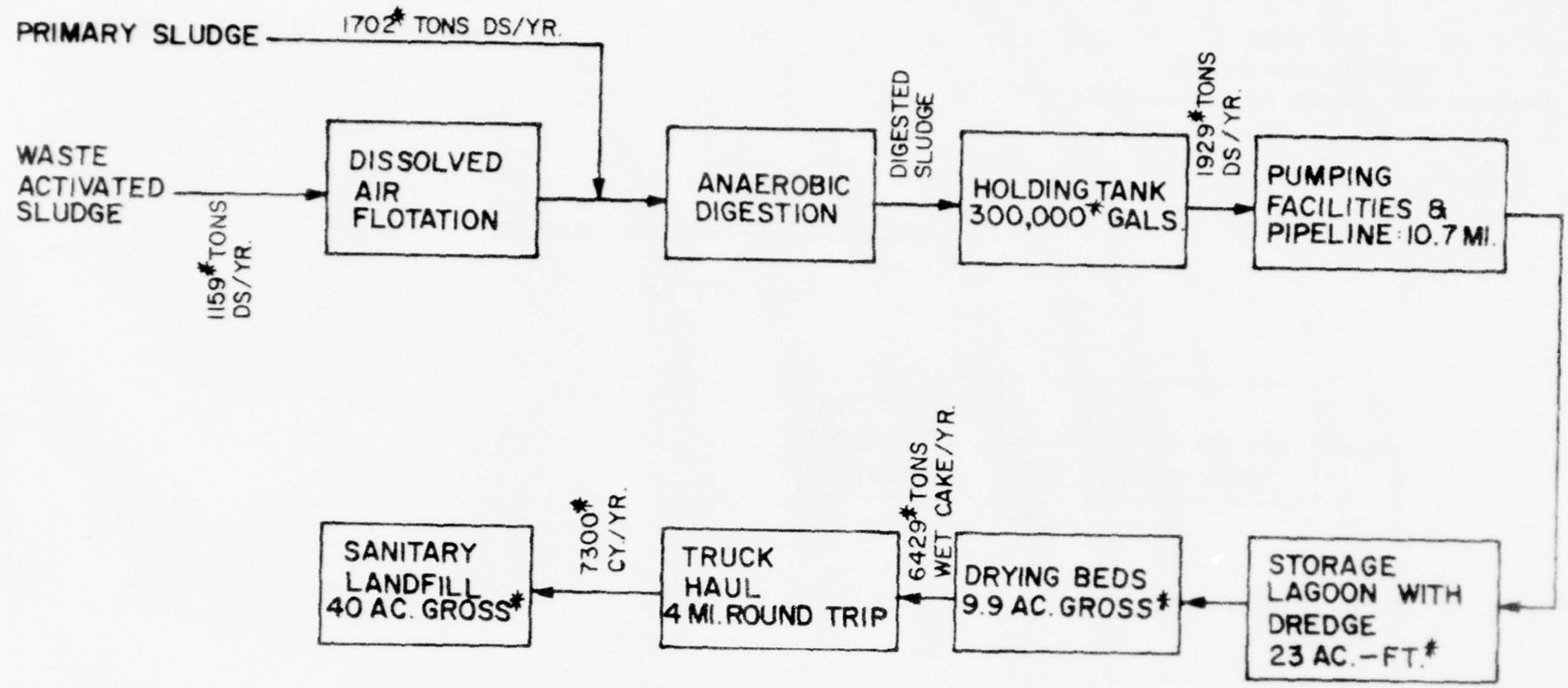
PLAN T-1

DIGESTION, LAND APPLICATION (DRY FARMED)

*DESIGN QUANTITIES AT 10 mgd

FIGURE I

Spokane Valley Sludge Alternatives
Schematic Diagram
Plan T-1



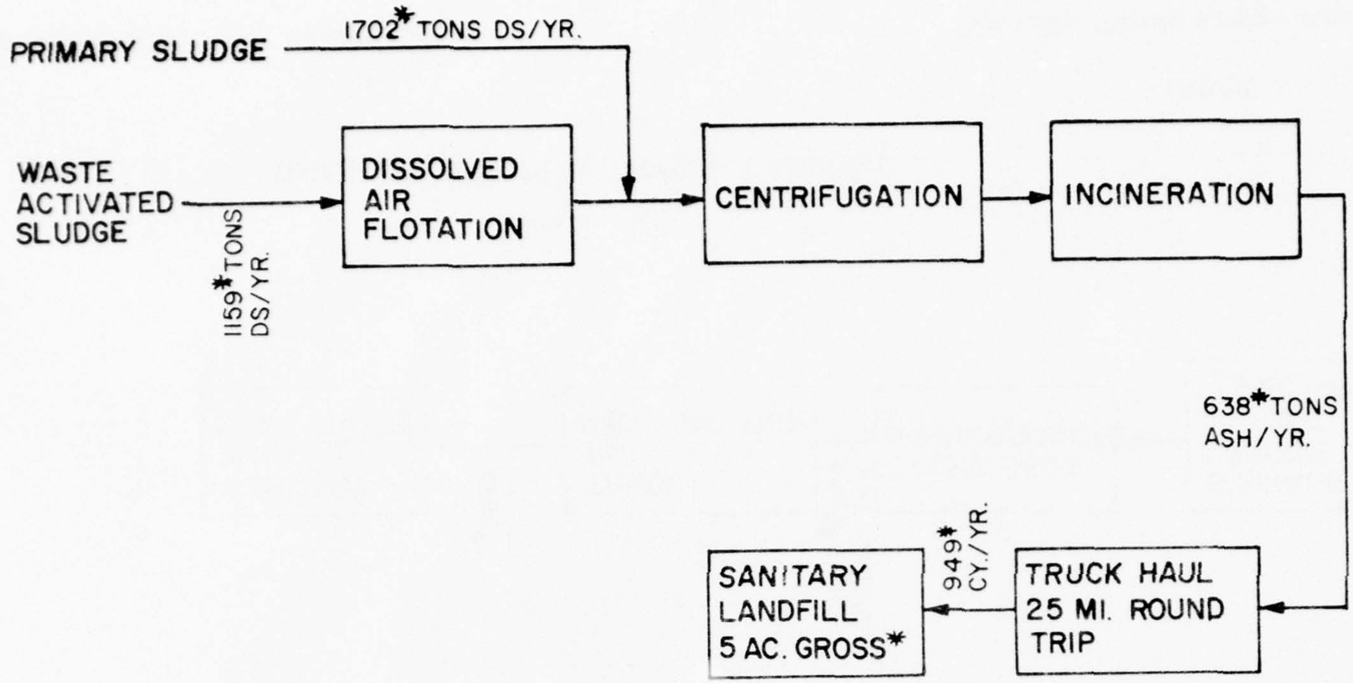
PLAN U

DIGESTION, REMOTE AIR DRYING, LANDFILL

*DESIGN QUANTITIES AT 10 mgd

FIGURE J

Spokane Valley Sludge Alternatives
Schematic Diagram
Plan U



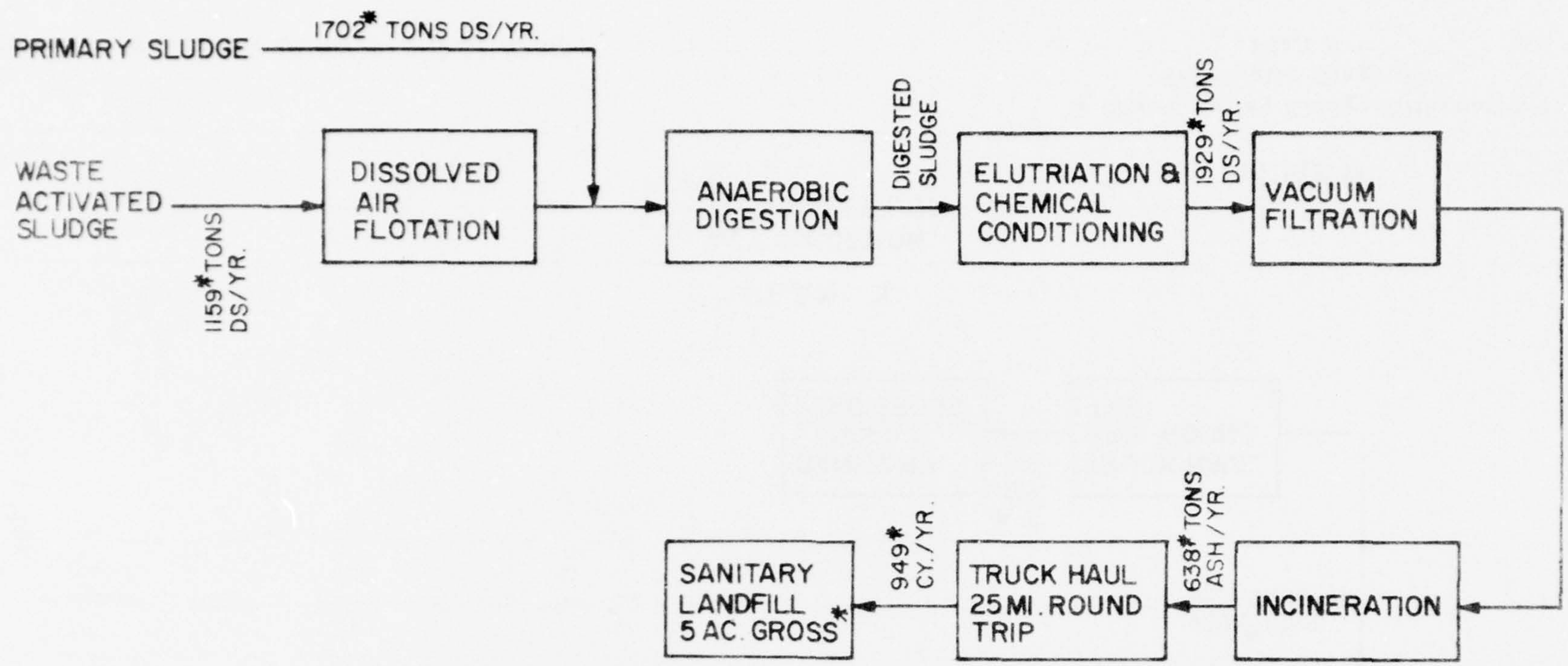
PLAN V-I

CENTRIFUGATION, INCINERATION

*DESIGN QUANTITIES AT 10 mgd

FIGURE K

Spokane Valley Sludge Alternatives
Schematic Diagram
Plan V-1



PLAN V-2

DIGESTION, FILTRATION, INCINERATION

* DESIGN QUANTITIES AT 10 mgd

FIGURE L

Spokane Valley Sludge Alternatives
Schematic Diagram
Plan V-2

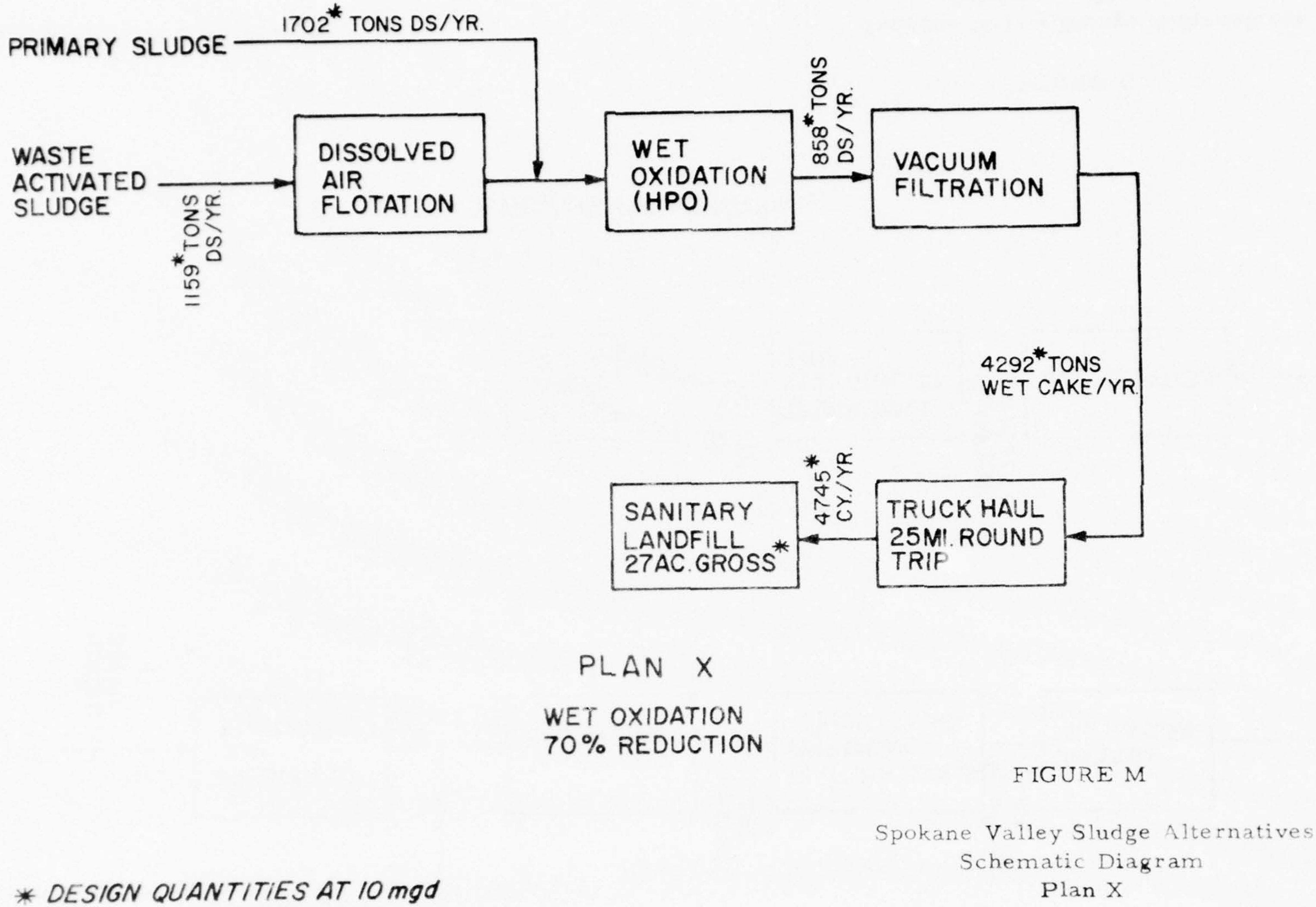


FIGURE M

Spokane Valley Sludge Alternatives
Schematic Diagram
Plan X

LIST OF REFERENCES

Battelle Northwest, 1974, Municipal Sewage Treatment - A Comparison of Alternatives, for Council on Environmental Quality and U.S. Environmental Protection Agency, February 1974. K-T #711.

Bovay Engineers, Inc. 1974. Proposed System for user charges and industrial cost recovery, City of Spokane, Washington, wastewater treatment plant expansion, March 1974. K-T #623.

Bovay Engineers, Inc. 1975. Report on Feasibility Study of Wastewater Solids Application to Land for Spokane, Washington for State of Washington Department of Ecology. K-T #729.

Harding, J. C. and Griffin, G. E. 1965. "Sludge disposal by wet air oxidation at a five MGD plant" in Journal Water Pollution Control Federation, August 1965. K-T #734.

Hinesly, T. D. and Sosewitz, B. 1969. "Digested Sludge Disposal on Crop Land" in Journal Water Pollution Control Federation, May 1969. K-T #713.

Irving, C. E. 1965. "Flash drying and incineration, operating results after six years at Schenectady, N.Y...." in Water Works and Wastes Engineering, September 1965. K-T #735.

Joint Conference on Recycling Municipal Sludges and Effluents on Land, 1973. Proceedings of the meeting July 9-13, 1973 Champaign, Ill. Co-sponsored by U.S. Environmental Protection Agency, U.S. Department of Agriculture and the National Association of Land-Grant Colleges. K-T #605.

Manson, Robert J. and Merritt, Clifford A., 1975. "Land Application of Liquid Municipal Wastewater Sludges," Journal Water Pollution Control Federation, January 1975. K-T #682.

McKinley, J. B., 1965. "Wet air oxidation process, Wheeling, W. Va..." in Water Works and Wastes Engineering, September 1965. K-T #733.

National Conference on Municipal Sludge Management, 1974. Proceedings of the meeting June 11-13, 1974 Pittsburgh Pa., "Municipal Sludge Management" in association with American Society of Civil Engineers and U.S. Environmental Protection Agency. K-T #730.

Patterson, W. L. and Banker, R. F., (Black and Veatch) 1971, Estimating Costs and Manpower Requirements for Conventional Wastewater Treatment Facilities, for U.S. Environmental Protection Agency, October 1971. K-T #710.

U.S. Environmental Protection Agency, 1974. Acceptable Methods for the Utilization or Disposal of Sludges. Technical Bulletin Draft Supplement to Federal Guidelines: Design, Operation and Maintenance of Wastewater Treatment Facilities. EPA 430/9-75-XXX. K-T #731.

U.S. Environmental Protection Agency, 1974. Process Design Manual for Sludge Treatment and Disposal, Technology Transfer Seminar Publication, Oct. 1974.
(Cited as EPA Tech. Trans. Sludge 1974)

APPENDIX I
ABSTRACT OF THE "REPORT ON FEASIBILITY STUDY
OF WASTEWATER SOLIDS APPLICATION TO LAND
FOR SPOKANE, WASHINGTON"

Introduction. A study prepared by Bovay Engineers, Inc. for the State of Washington Department of Ecology bears the title "Report on Feasibility Study of Wastewater Solids Application to Land for Spokane, Washington" and was completed in May 1975. This report is most significant to the formulation and evaluation of sludge alternatives throughout the Spokane area. For this reason its findings, criteria and methodology are abstracted herein.

Scope. The report studies the economic and environmental impacts of the application of liquid stabilized sludge to dry and irrigated agriculture from the proposed enlarged and upgraded City of Spokane sewage treatment plant (STP). The economic elements of the study are for the STP operating at its design capacity of 40 mgd and with year-around 85 percent phosphorus removal. Disposal sites are considered in an area up to 30 miles from the STP. Following a detailed analysis of site specific land application alternatives, the highest ranked is compared with three non-land application alternatives.

Summary of Conclusions. The study concludes that land application is feasible but more costly than vacuum filtration and sanitary landfill. The proposed enlargement and upgrading, now under construction, includes facilities for vacuum filtration and sanitary landfill. A recommendation is made that additional on-site agronomic studies be made to establish firm criteria for land application before full scale operation is actually undertaken. There is no recommendation either to continue with the planned vacuum filtration and sanitary landfill or to change to agricultural land application. Presumably, the recommendation is to continue with vacuum filtration and sanitary landfill while making additional tests for land application and monitoring progress in this field nationally. It is pointed out that the present unfavorable cost for agricultural land application may change as future increases in chemical and energy prices raise the cost of vacuum filtration and future increases in fertilizer costs make the nutrient value of sludge more attractive to the farmer.

The Bovay study indicates that the most favorable agricultural land application system and location will have total costs of $123 per ton of dry solids as compared with $90 per ton for vacuum filtration and sanitary landfill. This comparison is based on including all costs for both systems; that is, the proposed facilities now under construction are not regarded as sunk costs.

Application to dry land agriculture is identified as more cost effective than to irrigated agriculture and the region extending from Indian Prairie west to Reardan is determined to be the most favorable location from both cost and environmental impact considerations. At design loading conditions the area required is estimated at from 6,000 to 8,000 acres for dry and 2,000 to 3,000 acres for irrigated application. The criteria limiting application rate is the ability of the crop to assimilate the nitrogen content of the sludge. Life of the sites to receive sludge is estimated on the basis of cation exchange capacity of the soil to fix toxicants to be from 57 years dry farmed to 168 years irrigated.

Analysis of three non-land application alternatives determined that digestion-vacuum filtration-landfill at $90 per ton of dry solids was more cost effective than vacuum filtration-incineration at $133 per ton or vacuum filtration-drying at $163 per ton.

The basic economic analysis of land application alternatives does not take credit for the value of commercial fertilizer displaced by nitrogen in the applied sludge. A separate calculation for the most favorable site under dry farming conditions concludes that the disposal per ton cost would be reduced from $123 to $116.[1] This calculation is based on a current price of $0.22 per pound of nitrogen available in commercial ammonia fertilizers.

<u>Solids Quantities and Characteristics</u>. All calculations are based on forecast solids quantities and characteristics as follows for a design capacity of 40 mgd wastewater flow:

1. Digestion tank input at 4.0% of dry solids
   a. Primary sludge at 962 pounds per million gallons (MG), 75% volatile
   b. Waste activated sludge at 1160 pounds per MG, 75% volatile
   c. Chemical sludge at 335 pounds per MG, for an alum feed of 120 mg/liter, no volatiles
2. Digestion tank output at 2.7% dry solids with 50% reduction in volatile input

[1] This calculation on per ton basis does not appear in Bovay (1975); it is left in annual cost form at $1,398,500 for 12,045 tons per year.

The above, at 40 mgd wastewater flow results in a digestion tank output of 300,000 gallons per day containing 66,600 pounds of total solids composed of 31,900 pounds volatile and 34,700 pounds fixed.

Forecast chemical characteristics of digested sludge are given for a wide spectrum of parameters, from which the following critical parameters are selected.

Parameter	mg/Kg of Dry Solids	mg/l in 2.7% Solids Slurry
Total Kjeldahl nitrogen	66,100	1180
Organic nitrogen	33,100	890
Ammonia nitrogen	33,000	890
Total phosphorus	30,000	810
Cadmium	12.8	0.35
Zinc	790	21

For 40 mgd wastewater throughout the mass emission of total nitrogen is 4,400 pounds per day.

The forecast bacterial quality of the digested sludge and percent removal from raw are given as follows:

	Log mean organisms per 100 ml		
	Total Coliform	Fecal Coliform	Fecal Streptococci
Digested sludge	1.39×10^7	7.30×10^5	7.80×10^5
Removal through digestion	99.2%	98.6%	67.4%

EPA Criteria for Sludge Disposal. The formulation of alternatives for land application in Bovay (1975) are based on criteria contained in the U.S. Environmental Protection Agency document dated August 5, 1974 titlted "Notice of intent to issue a policy statement acceptable methods for utilization or disposal of sludges." The most critical of the criteria are summarized below for land application:

1. Stabilization must provide not less than a 40 percent reduction in volatile solids and 97 percent reduction in fecal coliforms.

2. Pathogen content must be further attenuated by the equivalent of

   a. Pasturization for 30 minutes at 70°C

   b. High pH lime treatment for 3 hours at pH 12

   c. Long term storage of 60 days at 20°C or 120 days at 4°C.

3. Heavy metals not to be applied beyond 5% of soil cation exchange capacity (CEC) and cadmium to zinc ratio not to exceed 0.005

4. Impact on groundwater quality to be governed by:

   a. Not to degrade below drinking water standards

   b. Protected from possible nitrogen enrichment by application of nitrogen balance techniques in determining nutrient application rate to crops.

Sludge Application Rate. The critical criterion for establishment of sludge application rates is determined to be the requirement for a balance between rate of nitrogen application and ability for crops to fully utilize the available portion of the applied amount. The methodology selected to make this determination is that of Pratt et al (1973)* and Willrich et al (1974)* which recognizes the loss of a portion of the ammonia component and the mineralization of the organic component. The net result is a non-uniform loading rate, higher at first and decreasing asymtotically to where the applied

*See page 79 for references.

organic equals the annual rate of mineralization.

Crop uptake capability is based on the selection of a specific system consisting of 1/3 grass seed, 1/3 alfalfa and 1/3 cereal production for both dry farmed and irrigated conditions. Recognition is also given to the different rates of growth expected on the soils at specific alternative sites. The nitrogen uptake capability is determined to range between 50 and 55 pounds of nitrogen per acre per year for dry farmed and 145 to 165 pounds of nitrogen per acre per year for irrigation on the various sites. The Willrich et al methodology when applied to Site No. 6 with needs of 55 pounds of N per year dry leads to maximum application rates shown below:

	Maximum allowable annual application	
Year from start	As pounds of total N in sludge	As tons of dry sludge solids
1st	450	3.4
5th	315	2.4
10th	258	2.0

Similar results are computed for all alternative sites and for dry and irrigated conditions. (For 40 mgd wastewater throughput for which the forecast digested sludge output contains 66,600 pounds of dry solids per day, the annual production is 12,155 tons of dry solids. This figure divided by the typical allowable application rates shown above for Site 6 determines the net area needed, in this case ranging from 3575 acres in the 1st year to 7,865 acres in the 10th.)[1]

---

[1] Calculation not shown in Bovay (1975).

Land Application Methodology. The formulation of physical facilities to accomplish land application is based on compliance with EPA criteria and the constraints of the specific treatment plant and sludge characteristics. The planned facilities and their rationale are summarized below:

1. Digestion performance is expected to meet EPA requirements both with respect to volatile and bacterial reductions.

2. It is not feasible to apply liquid sludge to frozen ground. This means a period of at least 135 days when there can be no application and for which there must be storage. There is not room for storage of this magnitude at the STP site.

3. Each day's output of liquid digested sludge must be delivered to a remote storage and/or application site. A subalternative study demonstrated that pipeline delivery is more cost effective than truck haul. A sludge pumping schedule of 8 hours per day is selected to allow for future expansion while maintaining carrying velocities in pipelines. Size 10 inch pipe is selected for all sludge force mains.(1)

4. In addition to frozen ground seasonal storage at 135 days, an additional 75 days storage for operational flexibility and 120 days for pathogen reduction are selected making total storage of the order 330 days. To meet this requirement storage in two cells each of 160 acre feet capacity are selected.(2) Open earth dike reservoirs are selected to meet this volume requirement, sealed with natural clay where available or with membrane liner where not. A 40 acre site is designated for the 320 acre feet of storage implying a mean depth in excess of 8 feet.

5. A floating dredge is selected for recovery of the stored

---

(1)For average daily digested sludge of 300,000 gpd the 8 hour per day pump rate is 625 gpm.
(2) 2 x 160 = 320 Ac. Ft. is equal to 347.8 days at 0.3 mgd.

sludge. Delivery would be to a surge tank from which a pump station would draw for delivery to a distribution network.

6. Distribution of stored sludge to application areas is by pipeline. For dry farmed areas size 24 inch is selected and length required 1.5 miles per square mile. For irrigated areas, size 30 inch is selected to carry both sludge and irrigation waters, with length 1.25 miles per square mile. All distribution piping is assumed to be laid on the surface of the ground except at road crossings.

7. The supply of irrigation water for irrigated land alternatives is determined at 15 inches depth per season to be delivered in a season of 120 days. Subalternative studies are made to determine for each site whether the most economical source of the irrigation water is STP effluent or some other source such as wells or the Spokane River. All pipe is selected at size 30 inch.

8. The method of application of liquid sludge to dry farmed land is selected by subalternative consideration of:

   a. Large nozzle liquid gun

   b. Tractor drawn injector

   c. Modified conventional sprinklers

   d. Truck application

A system made up one-half of injector type and one-half of sprinkler type is selected.

For irrigated agriculture the selection of application equipment is made from a variety of sprinkler systems capable of delivering the sludge and irrigation supplement together. It is determined that towed or center pivot equipment is comparable and lowest in cost.

(For both dry farmed and irrigated land the size and quantity of application equipment appears to be for completion of the annual application in 120 days of the 235 day growing season.)

Site Selection and Screening. From an initial field of 15 sites within a 30 mile radius of the City STP, five sites are selected for detailed cost and environmental analysis. The five final candidate sites are listed below with brief comment about the most critical factor for that site:

Site 1. North of Reardan. Has good soil with an established agriculture. Is about 23 miles from City STP. Primary concern is steepness of parts of site.

Site 4. Between Airways Heights and Deep Creek. Is nearest to City STP, distance 7.5 miles. Major concerns are shallow excessively drained soils and the limited overall area of 3000 acres.

Site 6. Indian Prairie. Has good soil, an established agriculture and adequate area. Is about 15.8 miles from City STP, being next closest to Site 4. There is some concern for some areas of steeper slope with attendant runoff problems.

Site 7. Mt. Godfrey. The area has no established agriculture and soils are in general excessively drained with low CEC. Site is about 19 miles from the City STP. Concern is for leachate reaching surface waters through permeable soils.

Site 9. Williams Valley. Soils are fair and there is established agriculture. Site is 18 miles from City STP. Has shortest growing season. Concerns are relatively high water table.

Environmental evaluation of use of these five sites for sludge disposal leads to a ranking of Sites 1, 6 and 7 as most desirable and Sites 4 and 9 least desirable.

Site specific cost effectiveness analysis of the five sites concludes that Sites 6 and 1 are most cost effective for dry land agriculture and Sites 4 and 6 are most cost effective for supplemental irrigated agriculture. Overall, Site 6 with dry land agriculture is most cost effective.

Site 6, Indian Prairie, is the most favored site considering both environment and cost.

Basis for Cost Effectiveness Analysis. The cost effectiveness analysis is made on the basis of total annual cost including a capital recovery factor and a maintenance and operations factor. Both capital cost and operation and maintenance costs are based on 40 mgd. Capital recovery factor is for 30 years at 8 percent interest for all facilities except application equipment where 15 years at 8 percent is used. An overhead charge of 30 percent is applied to all capital costs except site development.

No land costs are included except that for the storage lagoon and pump station. The cost of agricultural land is not included.

Credit is taken for net return on crops produced after deduction of management costs and taxes.

Credit is not taken for displacement of purchased fertilizer by sludge nutrients in the basic cost effectiveness analysis. This credit is recognized in a supplemental calculation.

Cost Effective Analysis of Non-Land Application Alternatives. Cost effective analyses are made for three non-land application alternatives. These alternatives, like the land application alternatives, all include anaerobic digestion as a preliminary step so that this common feature is not included. The alternatives are:

1. Vacuum filtration and truck haul to sanitary landfill. The capital costs for vacuum filtration and hauling included in the construction cost of the plan enlargement are estimated at $5,160,000.

2. Vacuum filtration, incineration and truck haul disposal of ashes.

3. Vacuum filtration and drying. Costs of ultimate disposal of the dried material such as bagging and marketing are not included on the assumption that they could be offset by income from sales.

As for land application alternatives, all estimates are for 40 mgd quantities. All capital costs are amortized at 8 percent for 30 years.

LIST OF REFERENCES

Pratt, P.F., F.E. Broadbent, and J.P. Martin. 1973. Using organic wastes as nitrogen fertilizers. Calf. Agr. 27 (6): 10-13.

Willrich, T.L., D.O. Turner, and V.V. Volk. 1974. Manure application guidelines for the Pacific Northwest. Presented at the 1974 annual meeting, American Society of Agricultural Engineers, Oklahoma State University, Stillwater, Oklahoma.

APPENDIX II
NARRATIVE EVALUATION
SLUDGE ALTERNATIVE PLANS
ASSOCIATED WITH CITY STP

1. COST EFFECTIVENESS

A summary of the cost-effectiveness data from the DOE study is shown in Table 1 for all plans except Plan X. The cost-effectiveness ranking is taken directly from the DOE study data. Plan X is assigned a cost ranking equal to Plan V, incineration, so that the environmental differences may be considered. Plan S is most cost effective by a significant margin with Plan T-1 next.

2. DIRECT ECONOMIC CONCERNS

a. Lowest requirement for capital.

b. Lowest O&M costs.

The ranking of these two categories is taken from Table 1. Note that the rankings for the two elements of cost-effectiveness do not parallel the total due to the high capital cost associated with the two land application alternatives and the fact that their operation and maintenance (O&M) costs are lowered by credit for crop revenue. A further reduction in O&M costs is proposed in the DOE study by a credit for displaced fertilizer expense, insufficient however, to cause any change in ranking.

c. Minimum loss of employment. Plans S, V, W and X have no potential for affecting employment in the community. The DOE study does not attempt to resolve problems of land ownership and operation associated with land application. If the sludge application is achieved under contract with the existing owners, there should be no significant change in employment on the property involved. If, on the other hand, the property is acquired and operated by the wastewater management agency there could be significant disruption and change in employment on the land affected. The larger land area required for dry land application (Plan T-1) is ranked as having higher potential for disruption of employment than the much smaller area required for irrigated land application (Plan T-2).

d. Minimum loss of tax revenue. Plan W has no need for land for disposal of an end product and Plans V and X require only small amounts for their concentrated ash disposal. Plan S requires more land area for cake disposal, but, on an absolute scale, a relatively insignificant amount considering the study area. The land areas involved for Plans T-2 and T-2 for land application are large and significant. Whether they would be taken from the tax rolls or not is unresolved, as discussed above under item 2c. Plans T-1 and T-2 are ranked on the basis of their potential impact as was done for corresponding wastewater management plans. Plan T-1 is ranked as having the maximum potential for loss of tax revenue and T-2 the next highest.

3. INDIRECT ECONOMIC CONCERNS

Sludge alternative plans are judged to have negligible impact on the category of indirect economic concerns.

4. TRANSIENT ECONOMIC CONCERNS

a. Maximum employment during construction. Plans S, V, W and X all involve highly specialized mechanical installations, most of which arrive at the site prefabricated for assembly and installation by relatively few skilled mechanics. Considering Plan S as a sunk cost it has no potential. Plans T-1 and T-2 involve extensive pipeline work which generates significant local employment. Plan T-1 having the most footage is ranked first and Plan T-2 second.

b. Maximum potential for local supply and manufacture during construction. For the same reasons cited under 4a above Plan S is ranked lowest and Plans V, W and X next lowest. The type of piping materials required for Plans T-1 and T-2 are not in general locally manufactured but the piping and associated materials represent a local supply potential. The larger dollar volume is in Plan T-2 which is therefore ranked highest.

c. Minimum disruption of circulation and business during construction. None of the sludge plans require construction in the urban area. The construction for Plans S, V, W and X is confined to the treatment plant site except for the sanitary landfill. The pipelines required for Plans T-1 and T-2 are almost entirely rural and away from main roads. Plans S, V, W and X are ranked as having negligible impact. Plans T-1 and T-2 are ranked in proportion to length of pipeline involved as having some small impact.

5. SOCIAL CONCERNS FOR THE COMMUNITY

a. Minimum potential for unfavorable health impact. Plans V, W and X produce an end product that has been sterilized and should represent no health hazard. Plan S produces a product with reduced but nevertheless high bacterial content, but the public exposure is minimal if proper trucks are used on the way to the sanitary landfill. The other exposure potential under Plan S is by way of leaching from the sanitary landfill to groundwater. Here again proper operation should reduce this potential. Plan S is ranked as having significantly more hazard potential than Plans V, W and X but less than Plans T-1 and T-2. Plans T-1 and T-2, with the application of liquid sludge to thousands of acres of operating farmland, are ranked as having the highest health hazard potential. Among the health hazards is the potential through aerosols if spray application is used. There are other varied opportunities for human contact both to farm workers and the public at the sites and through products and vectors leaving the sites. T-2 is ranked as less hazardous then T-1 due to the smaller area involved.

b. Minimum disruption of community living patterns

c. Minimum constraints on land use. The ranking under both of these concerns is a function of the area involved. Plans V, W and X involve none or negligible amounts of land outside the treatment plant site. Plan S involves only the small amount needed for a sanitary landfill. The larger land areas required for implementation of Plans T-1 and T-2 can significantly effect both living patterns and land use, in proportion to the areas required. It should be recognized that these impacts could be small on an absolute scale if the land application is

AD-A036 596 KENNEDY-TUDOR SPOKANE WASH F/G 8/6

METROPOLITAN SPOKANE REGION WATER RESOURCES STUDY. APPENDIX H. --ETC(U)

JAN 76

UNCLASSIFIED NL

2 OF 4

ADA036596

done under contract with the existing owners and if it is assumed that the land involved is going to be dedicated to the same kind of agriculture in any case.

One of the constraints imposed by land application is the finite life of any given site caused by heavy metal buildup. This means that eventually, if land application is to continue, a new site must be taken each time the old site is saturated. This could constrain adjacent land by its need for future use as a disposal site. Plans T-1 and T-2 are the only plans that introduce this problem.

6. SOCIAL CONCERNS FOR THE INDIVIDUAL

a. Minimum dislocation of individuals. There is negligible potential for dislocation of individuals due to Plans S, V, W and X. The potential under Plans T-1 and T-2 depends upon the method of land management as discussed under 2c above. Plans T-1 and T-2 are ranked in proportion to land area involved.

7. CONCERNS FOR GROUNDWATER

a. Maximum protection for groundwater. The minimum threat to groundwater is posed by Plans V, X and W which have sterile end products, the only possible threat being through leaching of undesirable chemicals from the landfilled ash or land applied soil conditioner. For a properly operated landfill the threat is small. The nutrients in the dried product are so small that the product is usually fortified with artificial fertilizer, which is probably more of a threat than the original material. Plans V, W and X are rated as giving maximum protection. Plan S which disposes of non-sterilized sludge to landfill is rated next because the potential is there, although it should be reduced to negligible levels by proper operation of the landfill.

Land application criteria (Plans T-1 and T-2) are based on not applying the liquid sludge at rates in excess of those at which the nitrogen supply can be utilized by the crop and removed as a threat of infiltration to groundwater. A lysimeter and groundwater monitoring program is proposed as a basic element of the land application plans. The criteria for site selection are formulated to provide adequate depth of unsaturated soil to remove bacteria before reaching the water table. Thus, if properly designed and operated, the land application alternative should also provide adequate protection of groundwater. Plans T-1 and T-2 are ranked as having lower protection than other plans based on potential for malfunction, not only of the land application itself but appurtenances such as storage lagoons and pipelines. Plans T-1 and T-2 are ranked equal, the larger area involved with T-1 balancing the higher loadings of T-2.

8. CONCERNS FOR SURFACE WATER

a. Maximum protection of surface water. Plans V, W and X with a sterile product and, for Plans V and X one that is additionally sealed into a sanitary landfill, are ranked as providing maximum protection of surface water. Plan S is ranked as providing the next highest level of protection based on the end product being sealed into a sanitary landfill.

The land application alternatives (Plans T-1 and T-2) spread the non-sterile sludge product over large land areas where it is potentially exposed to washoff due to rainfall, snowmelt or excessive irrigation. Again safeguards are provided in criteria for design which should minimize runoff containing undesirable elements from applied sludge. Plans T-1 and T-2 are ranked in proportion to area as having lower protection levels than the other plans due to potential for contaminated washoff.

9. CONCERNS FOR LAND USE

a. Minimum impact on wildlife habitat. None of the sludge management plans have much potential for negative impacts on wildlife habitat since even the land application alternatives are proposed for a site already dedicated to agriculture and furthermore, are not proposed to significantly alter the type of agriculture currently practiced. Plans V, W and X are ranked as having minimum impact and Plan S only slightly lower rank due to greater area needed for landfill. Plans T-1 and T-2 are ranked as having higher impact potential in proportion to the land areas involved. Note that if the land application plan were a site like Mt. Godfrey not now used for agriculture, the potential impact would be high.

b. Minimum undesirable impact on aesthetic quality of the landscape. Plan W has no impact on the landscape and Plans V and X have negligibly small demands for landfill volume. Plan S has significant requirements for landfill which has a negative impact. During spreading operations the land application alternatives T-1 and T-2 would have strong negative impacts over large areas. The magnitude of the impact would depend on the method chosen at design level for actual application. Injection plows would be hardly noticable whereas spray application would be highly visible. The land application alternatives are ranked in order of area for their potential impact.

c. Minimum interference with other beneficial uses. For sludge alternatives there are no signifcant differences between this concern and item 5c above.

10. CONCERNS FOR AIR QUALITY AND NOISE

a. Minimum potential to noxious emissions to the atmosphere. Plan S has negligible potential for emission of gases or particulate matter recognized as air pollutants. The seasonal storage lagoons required for Plans T-1 and T-2 have some potential for evolving short chain organics and sulfur compounds (Bovay 1965). There is also the potential for spray aerosols, upon evaporation, becoming dry particles. Plans T-1 and T-2 are ranked next lowest to Plan S in air pollution potential.

Plans V and W are standard combustion processes with significant potential for air pollution. The plans include air pollution control equipment designed to meet EPA emission standards, which should normally make these plans no more of a threat than Plans S and T. Plan W is ranked more of a threat than Plan V due to the complexity of the process. Plan X is a wet oxidation process which eliminates most of the air pollution threats associated with regular combustion but there are some off gases that pose an air pollution threat and require treatment. Plans V and W are ranked as having the highest threat potential and Plan X much less, but more than Plans S and T.

b. Minimum odor nuisance. All sludge plans have a threat of odor nuisance. Plan S has the minimum potential and is most reliably controlled. The threat from Plans V, W and X are relatively low under proper operation but their location near centers of population increase the criticality. The large volumes of combustion gases associated with Plans V and W pose a greater threat than the smaller volumes of off gases of Plan X. Plan W is more difficult to control than Plan V. These plans are ranked from lower to higher threat: X, V, W. The highest threat from odors is posed by the land application plans both from the storage reservoirs and the widespread application to the fields. The application mixed with irrigation water should be a slightly lower threat than concentrated application to dry land.

c. Minimum noise potential. The only significant noise potential from sludge plans arises from the use of truck transport. Plan S has the most truck transport with Plan W next highest followed by Plans V and X. The land application Plan T-1, even where vehicular type applicators is used, is ranked lower due to the rural location as compared with Plans S, V, W and X which require truck operation near populated areas. Plan T-2 is ranked as having the lowest noise potential.

11. CONCERNS FOR ENERGY AND RESOURCES

a. Minimum use of electrical energy. Plans S, T, V and W have anaerobic digestion in common. Its demands for electrical energy are small being primarily for circulation pumping and mixing. Plan S has vacuum filtration whereas Plans T-1 and T-2 have transmission pumping and distribution pumping. Vacuum filtration energy requirements are of the order .028 kwh per pound of solids. Pumping costs per pound of solids for an average total dynamic head of 600 feet at 3 percent solids are .015 kwh. This indicates that the total electrical energy requirements for Plans S and T-1 and T-2 are of the same order, with Plan S tending to use more, depending on design determination of total head. Plans T-1 and T-2 are ranked as having the lowest electrical energy input with Plan S next lowest. Plans V and W have significant electrical power requirements for incinerator and dryer respectively in addition to digestion and vacuum filtration. The requirements for the more complex drying equipment are higher. The requirements for Plan X are highest due to the need to raise the pressure of the liquid sludge and the air supply for oxidation to over 1700 psi.

b. Minimum use of thermal energy. Plans S, T-1 and T-2 have the lowest input of thermal energy since their only process requirement is for heating of the anaerobic digester and this demand can be more than met from sludge gas. The fuel for truck haul of cake for Plan S is of the same order as the fuel for dredge operation for Plans T-1 and T-2. Plans S, T-1 and T-2 are ranked together as having the lowest requirement. Plans V, W and X all have process fuel requirements.

Drying under Plan W has the highest requirement since the fuel content of the dried product cannot be utilized. Plan V has the next highest fuel requirement for incineration, which although utilizing the fuel content of the sludge has a significant supplemental fuel requirement. Plan X follows Plan V. Plan X also utilizes the fuel energy of the sludge to keep the wet oxidation near self-sustaining, but like Plan V has supplemental fuel requirements for steam generation. The wet oxidation process has some potential for fuel recovery to offset requirements by utilizing process off-gases.

c. Minimum use of chemicals. The primary use of chemicals in the various sludge processes is for coagulants to optimize vacuum filter operation. Plans T-1 and T-2 do not have any mechanical dewatering and hence have no chemical use. Plan X has mechanical, either centrifuge or vacuum filter, separation of solids following wet oxidation. The heat conditioning takes the place of chemical conditioning so that Plan X is ranked next lowest in chemical requirements. All of the other plans as formulated in the DOE study use vacuum filtration following anaerobic digestion and hence have essentially the same chemical requirements. Plans S, V and W are ranked together as having the highest chemical requirements.

d. Maximum recovery or reuse of resources. All plans which utilize anaerobic digestion make it possible to recover the heat energy of the generated sludge gas. All plans except Plan X utilize anaerobic digestion. Plan X, although it utilizes all of the heat released by oxidation of the same quantity of solids transformed to gas in digesters, does not create a surplus over the needs of the process. This is also true of Plans V and W which, in general require more supplemental fuel than the surplus from digestion. Thus Plans X and V which also have no end product recovery are ranked as having lowest and next lowest recovery potential respectively. Plan S also has no end product recovery, but likewise leaves all of the digester gas surplus for other plant use. Plan S is ranked above Plans X and V. Plans T-1, T-2 and W provide for recovery and reuse of the end product as a fertilizer and soil conditioner. Since Plans T-1 and T-2 have no demand on the surplus digester gas whereas Plan W uses the surplus and more, Plans T-1 and T-2 are ranked highest in resource recovery followed by Plan W.

12. PERFORMANCE EVALUATION

a. Minimize degradation of wastewater treatment process. All of the sludge plans except land application result in the return of a liquid fraction to the main wastewater stream. This return fluid adds to the treatment load and tends to degrade the process. Plans S, V and W have in common the return of filtrate from the vacuum filtration of digested sludge and therefore have the same impact on the wastewater process. Plan X returns the filtrate from separation of the inert solids from the wet oxidation process. There is less experience with this material than from digested sludge but it does appear to be more detrimental or at least more difficult to the wastewater process. Plans T-1 and T-2 are ranked as having least potential for wastewater degredation and Plan X the maximum with Plans S, V and W ranked together as in between.

b. Maximum reliability. Plan S is ranked as most reliable since the process utilizes multiple units of a well tried equipment. Plans T-1 and T-2 rely on pump stations and long pipelines both of which are subject to failure stoppages or rupture not usually quickly repairable. The plans as formulated in the DOE study do not contain duplicate pipe lines. Unless an alternative disposal method were available, such redundancy might be required. One of the advantages of the proposed plan to construct the enlarged plant with vacuum filters is that this equipment would provide an alternative disposal method if land disposal were adopted later. Plans V, W and X rely on increasingly complex mechanical equipment, in that order. This equipment is so costly that standby capacity in separate units is prohibitive. These systems are ranked for reliability in inverse proportion to their complexity. Since V and W include vacuum filtration a built-in alternative equal to Plan S is included, so that in this sense these plans are equal in reliability to Plan S. Plan X is ranked least reliable based on complexity and lack of an inherent alternative.

c. Least offensive end product. The inert sterile end products produced by Plans V, W and X are the least offensive. Plan V with minimum volume and dry condition is ranked first, W with a larger volume but also dry is ranked next and X with a moist cake is ranked third. Plan S with a stabilized but not sterile wet cake is ranked fourth and Plans T-1 and T-2 with liquid stabilized sludge are ranked last.

13. FLEXIBILITY

a. Maximum flexibility to meet unanticipated growth. The plans which rely on single units of complex mechanical equipment have the lowest flexibility to meet growth changes. The flexibility of Plans V, W and X are ranked inversely to their complexity and cost making X lowest ranking, W second, and V third. The pipeline capacity provided for Plans T-1 and T-2 is in excess of forecast needs so that this element does not form a bottleneck. The capacity can be expanded by utilizing more land, which is more difficult for Plan T-1 because of its already large requirement than Plan T-2. Plan S with multiple units is most easily expanded by adding units or working more hours per week.

b. Maximum flexibility to meet unanticipated changes in sludge quality. The differences between plans in this respect are relatively small. Those that employ vacuum filtration would all face the same problems of conditioning. Significant changes in heavy metals could alter the expected life of sites under Plans T-1 and T-2. Significant changes in nutrient content could alter the required rates of application under Plans T-1 and T-2. As far as immediate problems of adjustment to quality, Plan X is ranked as having the least problem, Plans T-1 and T-2 next, and the plans utilizing vacuum filtration, Plans S, V and W, last.

c. Maximum flexibility to meet changes in disposal criteria for sludge. Plans V, W and X which produce a sterile inert end product should be essentially unaffected by changes in disposal criteria. The land application alternatives, Plan T-1 and T-2, should be most affected (and are most likely to be subject to changes in criteria as evidenced by recently evolving EPA criteria). Plan S with disposal to landfill of a stabilized but not sterile product would be between these extremes in potential need to meet changes in criteria.

d. Maximum flexibility to incorporate changes in technology. The two paramount problems in processing sludge are (1) to render it stable and safe and, (2) to remove the large quantities of water associated with it. The trend in goals for ultimate disposal is to recover resources rather than get rid of the material without benefit. Those systems which have the smallest investment in stabilization and dewatering facilities and are already including recovery of resources are judged to be best able to take advantage of improved technology. This places the land application system in first rank and the remaining systems in inverse order to capital investment for mechanical equipment.

APPENDIX III
NARRATIVE EVALUATION
SLUDGE ALTERNATIVE PLANS
FOR SPOKANE VALLEY

1. COST EFFECTIVENESS

The cost effectiveness summary is shown in Table 9. Plan S has the lowest forecast cost. Subalternatives to Plan S such as centrifugation in lieu of vacuum filtration are considered represented by these costs. Subalternatives for low pressure or intermediate pressure oxidation in lieu of anaerobic digestion would differ somewhat in cost but not enough to change ranking. The second ranked Plan V-1 is weak in that it has no acceptable fall back mode of operation in case of prolonged failure of the major equipment. This objection is overcome in the third ranked Plan V-2 which could always fall back on operation as Plan S.

The costs for the land application alternative, Plan T, are based on parallel pipelines to the remote area for continuity of operation and maintenance. Comparison with a subalternative considering tank truck haul gives comparable costs so that, from a cost standpoint, the Plan T as stated is representative of both.

The costs for air drying of digested sludge at a remote location, Plan U, are likewise based on parallel pipelines, again for continuity of service but also to return the drying bed underdrain to the treatment plant. As for Plan T, the tank truck haul alternative is comparable in cost.

Although high pressure wet oxidation, Plan X, has not been favored by recent installations due to its very high cost, it is included to provide a measure of the ranking of a system with maximum reduction and lower potential for air pollution. The lack of long term recent operation weakens reliability of estimated operation and maintenance costs.

2. DIRECT ECONOMIC CONCERNS

a. Lowest requirement for capital

b. Lowest O&M costs

The ranking for these categories is taken from Table 9.

c. Minimum loss of employment. The only potential for impact on employment is from plans which utilize significant land areas presently providing agricultural employment. Plan T which provides for application to dry farmed land affects a significant area. For the purpose of this evaluation it is assumed that this could be accomplished under contract with the present land owners and without significant modification of the current cropping. This is judged to be sufficiently feasible for dry farm application and the smaller areas involved, as compared with the City requirements, to neglect potential employment impact in evaluation.

d. Minimum loss of tax revenue. As discussed above, the land requirements for Plan T application are assumed to be met by contract. There are however other land requirements for the various alternatives where ownership must be by a public agency, including storage ponds, drying beds and landfill. The requirements for lands in these categories in increasing order are X, V-1 and V-2 together, S, T and U.

3. INDIRECT ECONOMIC CONCERNS

Sludge alternative plans are judged to have negligible impact on the category of indirect economic concerns.

4. TRANSIENT ECONOMIC CONCERNS

a. Maximum employment during construction. Plans S, V-1, V-2 and X all involve highly specialized mechanical installations, most of which arrive at the site prefabricated for assembly and installation by relatively few skilled mechanics. Plans T and U involve extensive pipeline work which generates significant local employment. Plans T and U have comparable footage. (Note the adoption of the tank truck haul subalternative for T or U would eliminate temporary employment but would create permanent employment for the drivers.)

b. Maximum potential for local supply and manufacture during construction. For the same reasons cited under 4a above, Plan S, V-1, V-2 and X are ranked lowest. The type of piping materials required for Plans T and U are not, in general, locally manufactured but the piping and associated materials represent a local supply potential. The larger dollar volume is in Plans T and U which are therefore ranked highest. (Again, note that the adoption of the tank truck subalternatives for T or U would eliminate this supply during construction.)

c. Minimum disruption of circulation and business during construction. The pipelines for Plans T and U both pass through built-up areas and would constitute a disruption during construction. Plan T has potential for greater disruptive impact in developed areas. The other plans have no significant disruptive impact.

5. SOCIAL CONCERNS FOR THE COMMUNITY

a. Minimum potential for unfavorable health impact. Plans V-1, V-2 and X produce an end product that has been sterilized and should represent no health hazard. Plan S produces a product with reduced but nevertheless high bacterial content, but the public exposure is minimal if proper trucks are used on the way to the sanitary landfill. The other exposure potential under Plan S is by way of leaching from the sanitary landfill to groundwater. Here again proper operation should reduce this potential. Plan S is ranked as having significantly more hazard potential than Plans V-1, V-2 and X but less than Plans T and U. Plan T which involves the application of liquid sludge to thousands of acres of operating farmland is ranked as having the highest health hazard potential. Among the health hazards is the potential through aerosols if spray application is used. There are other varied opportunities for human contact both to farm workers and the public at the sites and through products and vectors leaving the sites. Plan U with open sludge beds on a smaller area is ranked at less hazard than Plan T.

b. Minimum disruption of community living patterns.

c. Minimum constraints on land use. The ranking under both of these concerns is a function of the area involved. Plans V-1, V-2 and X involve negligible amounts of land outside the treatment plant site. Plan S involves only the small amount needed for sanitary landfill. The larger land areas required for implementation of Plan T could significantly effect both living patterns and land use. As discussed under 2c above, the assumption is made that Plan T can be carried out on a contract basis. This would essentially eliminate any impact of Plan T on community living. There is, however, a potential impact of Plan T on land use. One of the constraints imposed by land application is the finite life of any given site caused by heavy metal buildup. This means that eventually, if land application is to continue, a new site must be taken each time the old site is saturated. This could constrain adjacent land by its need for future use as a disposal site.

Plan U does require public acquisition of land for drying beds. The locations considered have as a criteria no current use for crops and very low density population. Therefore the impact on community living is expected to be negligible. The constraint on land use is in proportion to area involved, including a substantial buffer zone.

6. SOCIAL CONCERNS FOR THE INDIVIDUAL

a. Minimum dislocation of individuals. There is negligible potential for dislocation of individuals due to Plans V-1, V-2 and X. The potential under Plan T depends upon the method of land management as discussed under 2c above. For the assumption of contract use rather than public purchase the impact on individuals should be negligible. As discussed in 5c above, the extreme low density sites considered for Plan U should also minimize impact on individuals. Although real impact may not develop, plans are ranked in proportion to potential by area involved.

7. CONCERNS FOR GROUNDWATER

a. Maximum protection for groundwater. The minimum threat to groundwater is posed by Plans V-1, V-2 and X which have sterile end products, the only possible threat being through leaching of undesirable chemicals from the landfilled ash or land applied oxidized solids. For a properly operated landfill, the threat is small. Plans V-1, V-2 and X are rated as giving maximum protection. Plan S which disposes of non-sterilized sludge to landfill is rated next because the potential is there, although it should be reduced to negligible levels by proper operation of the landfill.

Land application criteria (Plan T) is based on not applying the liquid sludge at rates in excess of those at which the nitrogen supply can be utilized by the crop and removed as a threat of infiltration to groundwater. A lysimeter and groundwater monitoring program is proposed as a basic element of the land application plans. The criteria for site selection are formulated to provide adequate depth of unsaturated soil to remove bacteria before reaching the water table. Thus, if properly designed and operated, the land application alternative should also provide adequate protection of groundwater. Plan T is ranked as having lower protection than other plans based on potential for malfunction, not only of the land application itself but appurtenances such as storage lagoons and pipelines. Plan U with both storage lagoons and drying beds as sources of potential malfunction is rated as posing the greatest threat to groundwater.

8. CONCERNS FOR SURFACE WATER

a. Maximum protection of surface water. Plans V-1, V-2 and X with a sterile product sealed into a sanitary landfill are ranked as providing maximum protection of surface water. Plan S is ranked as providing the next highest level of protection based on the end product, although not sterile or inert, product being sealed into a sanitary landfill.

The land application alternative, Plan T, spreads the non-sterile sludge product over large land areas where it is potentially exposed to wash off due to rainfall or snowmelt. Again safeguards are provided in criteria for design which should minimize runoff containing undesirable elements from applied sludge. Plan T is ranked as having the greatest threat nevertheless. Plan U with sludge confined in drained beds poses less threat than Plan T but the large areas and earth dikes constitute a greater threat than posed by dried products confined in a sanitary landfill.

9. CONCERNS FOR LAND USE

a. Minimum impact on wildlife habitat. None of the sludge management plans have much potential for negative impact on wildlife habitat since even the land application alternative is proposed for a site already dedicated to agriculture and furthermore, is not proposed to significantly alter the type of agriculture currently practiced. Plans S, V-1, V-2 and X are ranked as having negligible potential impact due to the small areas needed for landfill. Plans U and T are ranked as having higher impact potential in proportion to the land area involved.

b. Minimum undesirable impact on aesthetic quality of the landscape. Plans V-1, V-2 and X have negligibly small demands for landfill area. Plan S has significant requirements for landfill which has a negative impact. During spreading operations the land application alternative would have strong negative impacts over a large area. The magnitude of the impact would depend on the method chosen at design level for actual application. Injection plows would be hardly noticeable whereas spray application would be highly visible. Plan U, although requiring a smaller area than Plan T, would have a year around negative impact and is therefore ranked as having the greatest undesirable aesthetic impact.

c. Minimum interference with other beneficial uses. For sludge alternatives there is no significant difference between this concern and item 5c above.

10. CONCERNS FOR AIR QUALITY AND NOISE

a. Minimum potential to noxious emissions to the atmosphere. Plan S has negligible potential for emission of gases or particulate matter recognized as air pollutants. The seasonal storage lagoons required for Plans T and U and the drying beds for Plan U have some potential for evolving short chain organics and sulfur compounds. There is also the potential for spray aerosols, if used in Plan T, upon evaporation, becoming dry particles. Plans T and U are ranked next lowest to Plan S in air pollution potential.

Plans V-1 and V-2 are standard combustion processes with significant potential for air pollution. The plans include air pollution control equipment designed to meet EPA emission standards, which should normally make these plans no more of a threat than Plans S, T and U. Plan X is a wet oxidation process which eliminates most of the air pollution threats associated with regular combustion but there are some off gases that pose an air pollution threat and require treatment. Plans V-1 and V-2 are ranked as having the highest threat potential and Plan X much less, but more than Plans S, T and U.

b. Minimum odor nuisance. All sludge plans have a threat of odor nuisance. Plan S has the minimum potential and is most reliably controlled. The threat from Plans V-1, V-2 and X are relatively low under proper operation but their location near centers of population increases their criticality. The large volumes of combustion gases associated with Plans V-1 and V-2 pose a greater threat than the smaller volumes of off gases of Plan X. The highest threat from odors is posed by the land application, Plan T, and drying beds, Plan U. Plan T has threats from the storage reservoirs and the widespread application to the fields. Plan U has threats from storage reservoirs and drying beds. Plans T and U are ranked as having the highest odor nuisance potential.

c. Minimum noise potential. The only significant noise potential from sludge plans arises from the use of truck transport. Plan S has the most truck transport with Plan U next highest followed by Plan T. The land application Plan T, even where vehicular type applicators are used, is ranked lower due to the rural location as compared with Plans S and U, which require truck operation near populated areas. Plans V-1, V-2 and X are ranked as having the lowest noise potential.

11. CONCERNS FOR ENERGY AND RESOURCES

a. Minimum use of electrical energy. Plans S, T, U and V-2 have anaerobic digestion in common. Its demands for electrical energy are small being primarily for circulation pumping and mixing. Plans S and V-2 have vacuum filtration whereas Plans T and U have transmission pumping and distribution pumping. Vacuum filtration energy requirements are of the order .028 kwh per pound of solids. Pumping costs per pound of solids for an average total dynamic head of 600 feet at 3 percent solids are .015 kwh. This indicates that the total electrical energy requirements for Plans S and V-2 and T and U are of the same order, with Plans S and V-2 tending to use more, depending on design determination of total head. Plans T and U are ranked as having the lowest electrical energy input with Plan S next lowest. Plans V-1 and V-2 have significant electrical power requirements for incinerator operation in addition to digestion and vacuum filtration. The requirements for the more complex drying equipment are higher. The requirements for Plan X are highest due to the need to raise the pressure of the liquid sludge and the air supply for oxidation to over 1700 psi.

b. Minimum use of thermal energy. Plans S, T and U have the lowest input of thermal energy since their only process requirement is for heating of the anaerobic digester and this demand can be more than met from sludge gas. The fuel for truck haul of cake for Plan S is of the same order as the fuel for dredge operation for Plans T and U. Plans S, T and U are ranked together as having lowest requirement. Note that if the tank truck haul subalternative for either Plans T or U is undertaken, it would greatly increase the fuel requirements for these alternatives.

Plans V-1, V-2 and X all have process fuel requirements. Between V-1 and V-2, V-2 has the higher supplemental fuel requirement since the fuel content of the sludge is reduced by prior digestion. The supplemental fuel requirements are highly variable depending on operating cycles and condition. Plan X also utilizes the fuel energy of the sludge to keep the wet oxidation near self-sustaining, but like Plan V has supplemental fuel requirements for steam generation. The wet oxidation process has some potential for fuel recovery to offset requirements by utilizing process off-gases. Plans V-1 and X are judged to be comparable in requirement.

c. Minimum use of chemicals. The primary use of chemicals in the various sludge processes is for coagulants to optimize vacuum filter operation. Plans T and U do not have any mechanical dewatering and hence have no chemical use. Plan X has mechanical separation of solids, either centrifuge or vacuum filter, following wet oxidation. The heat conditioning takes the place of chemical conditioning so that Plan X is ranked next lowest in chemical requirements. Plans S and V-2 use vacuum filtration following anaerobic digestion and Plan V-1 has centrifugation of raw sludge. These three are judged to have comparable chemical requirements and are ranked together as having the highest chemical use.

d. Maximum recovery or reuse of resources. All plans which utilize anaerobic digestion make it possible to recover the heat energy of the generated sludge gas. All plans except Plans V-1 and X utilize anaerobic digestion. Plans V-1 and X, although utilizing all of the heat released by oxidation of the same quantity of solids transformed to gas in digesters, does not create a surplus over the needs of the process. This is also true of Plan V-2 which requires more supplemental fuel than the surplus from digestion. Thus Plans V-1, V-2 and X which also have no end product recovery are ranked as having the lowest resource recovery potential. Plans S and U also have no end product recovery, but leave all of the digester gas surplus for other plant use. Plans S and U are ranked above Plans V-1, V-2 and X. Plan T provides for recovery and reuse of the end product as a fertilizer and soil conditioner. Since Plan T also has no demand on the surplus digester gas, it is ranked highest in resource recovery.

12. PERFORMANCE EVALUATION

a. Minimize degradation of wastewater treatment process. All of the sludge plans except land application result in the return of a liquid fraction to the main wastewater stream. This return fluid adds to the treatment load and tends to degrade the process. Plans S and V-2 have in common the return of filtrate from the vacuum filtration of digested sludge and therefore have the same impact on the wastewater process. Plan U returns underdrainage from drying beds which is comparable to vacuum filtrate. Plan V-1 returns the underflow from centrifugation of raw sludge. This material has less impact than the returns from Plans S, V-2 and U. Plan X returns the filtrate from separation of the inert solids from the wet oxidation process. There is less experience with this material than from digested sludge but it does appear to be more detrimental or at least more difficult to the wastewater process than vacuum filtrate. Plan T with no return flow is ranked as having least potential for wastewater degredation.

b. Maximum reliability. Plan S is ranked as most reliable since the process utilizes multiple units of a well tried equipment. Plans T and U rely on pump stations and long pipelines both of which are subject to failure, stoppages or rupture, not usually quickly repairable. The plans as formulated for Spokane Valley do contain duplicate pipelines for reliability. Plan V-2 is operable as Plan S if there is a failure of the incinerator and so ranks in reliability with Plan S. Plans V-1 and X rely on complex mechanical equipment. This equipment is so costly that standby capacity in separate units is prohibitive. These systems are ranked for reliability in inverse proportion to their complexity. In summary, Plan S is ranked as providing maximum reliability followed by V-2, U, T, V-1 and X.

c. Least offensive end product. The inert sterile end products produced by Plans V-1, V-2 and X are the least offensive. Plans V-1 and V-2 with minimum volume and dry residual are ranked first. Plan X with a small volume of moist cake is ranked second. Plans S and U, with a stabilized but not sterile wet cake, are ranked third and Plan T with liquid stabilized sludge is ranked last.

13. FLEXIBILITY

a. Maximum flexibility to meet unanticipated growth. The plans which rely on single or paired units of complex mechanical equipment have the lowest flexibility to meet growth. These include Plans V-1, V-2 and X. The pipelines provided for Plans T and U for design reasons have capacity in excess of forecast needs so that this element does not form a bottleneck to moderate unexpected growth. Since Plan T already involves a large area of land assumed to be under a contract arrangement, securing additional area may be difficult. If, however, fertilizer becomes costly there may be eager acceptance on additional land. Plan U does not require as much land and expansion should be less difficult. Plan S which can be expanded with additional vacuum filtration units at the treatment plant site is best able to cope with unexpected expansion. The plans are ranked from Plans S through U and T with Plans V-1, V-2 and X last.

b. Maximum flexibility to meet unanticipated changes in sludge quality. The differences between plans in this respect are relatively small. Those that employ vacuum filtration (Plans S and V-2) would face the same problems if the quality change affected difficulty of conditioning. Significant changes in heavy metals could alter the expected life of sites under Plan T. Significant changes in nutrient content could alter the required rates of application under Plan T. As far as immediate problems of adjustment to quality, Plans U, V-1 and X are ranked as having the least problem, Plan T next, and the plans utilizing vacuum filtration, Plans S, and V-2, last.

c. Maximum flexibility to meet changes in disposal criteria for sludge. Plans V-1, V-2 and X which produce a sterile inert end product should be essentially unaffected by changes in disposal criteria. The land application alternative, Plan T, should be most affected (and is most likely to be subject to changes in criteria as evidenced by recently evolving EPA criteria). Plans S and U with disposal to landfill of a stabilized but not sterile product would be between these extremes in potential need to meet changes in criteria.

d. Maximum flexibility to incorporate changes in technology. The two paramount problems in processing sludge are (1) to render it stable and safe, and (2) to remove the large quantities of water associated with it. The trend in goals for ultimate disposal is to recover resources rather than get rid of the material without benefit. Those systems which have the smallest investment in stabilization and dewatering facilities and already include recovery of resources are judged to be best able to take advantage of improved technology. This places the land application system in first rank with Plan U second and the remaining systems in inverse order to capital investment for mechanical equipment.

SECTION 604.8

WASTEWATER MANAGEMENT NONSTRUCTURAL ALTERNATIVES AND EVALUATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 604.8

WASTEWATER MANAGEMENT
NON-STRUCTURAL ALTERNATIVES
AND EVALUATION

14 October 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

SECTION 604.8
WASTEWATER MANGEMENT NON-STRUCTURAL ALTERNATIVES AND EVALUATION

Scope and Objectives

It is widely recognized that structural wastewater facilities such as pipelines, pumping stations, and treatment plants could be more efficiently and economically utilized if there were some effective way to control the quantity and quality of wastes discharged at their source. This section will deal with various non-structural wastewater management alternatives which provide some means of controlling water quality by influencing waste sources.

This section will also evaluate the effectiveness of the various non-structural alternatives considered and will relate this evaluation in general terms to the effectiveness of related structural measures. A general evaluation will be made of the relative impact of various non-structural measures on the economic and operational effectiveness of related structural measures. This section will also develop a conclusion with regard to the extent that non-structural wastewater management alternatives can be expected to supplant structural measures.

Need for Consideration of Non-Structural Wastewater Management

There are several basic reasons to consider non-structural wastewater management options, particulary those which may provide for conservation of resources, economic benefits, and improvement of environmental quality. As water quality standards become more stringent and treatment and handling costs of wastewater escalate, there is increased emphasis on consideration of non-structural measures which may improve structural measures efficiency and reduce cost. This reflects the continuing evolutionary transition of wastewater management from emphasis on conveyance and disposal to the increasing emphasis on absolute water quality.

Historical wastewater management practices, dating back to the Romans, medieval Europe, and continuing to within the past 50 years, have emphasized conveyance of wastes by water from their source and disposal to the most convenient body of water capable of providing further conveyance (as in a river) or dilution and stabilization (as with a lake or ocean). This traditional concept of wastewater management encouraged the use of water inasmuch as increased water usage resulted in improved initial and final dilution and improved conveyance flow velocities. Since ultimate dilution has been the policy controlling disposal practices for many years, this consideration has encouraged the use of flushing water, combining storm runoff with sanitary wastes, and encouraging pipeline infiltration. This policy has resulted in encouraging the construction of combined stormwater sanitary sewers in many of the metropolitan areas of the country, one of which is Spokane.

With the current emphasis, as reflected in Federal and local environmental control legislation, placing absolute values on the quality of used water being returned to the environment, the historical policies for wastewater management are in serious conflict with the modern policies. It is unfortunately much easier to change the policies than it is to change existing wastewater facilities which are not compatible with these revised policies. With the high standards being set for discharge of wastewater to the environment, cost of treatment to meet these quality standards has increased radically to the point where the economics of treatment demand a much closer look at methods which will reduce the quantity of wastewater treated and which will encourage source limitation of waste solids and dissolved compounds introduced to the wastewater stream, particularly those which are difficult and costly to remove by treatment.

An additional element to the consideration of the need for non-structural wastewater management is the concern for wasteful utilization of the water resource. Water resources, being available in a finite quantity, are subjected to the accellerating demand by increasing population compounded by increasing unit use of water by industry and households. In many areas where water resources are limited and demands are being met by depletion mining of the groundwater, it is critical that ways of limiting water use for the conveyance of waste matter be adopted. This need, which is the primary stimulant of non-structural wastewater management in many areas of the world, is not of primary significance in the immediate Spokane metropolitan area which enjoys such a plentiful water resource. It is a primary consideration in those areas currently relying on the basalt aquifer where importation from the Spokane River or aquifer is not economically feasible.

Non-Structural Wastewater Management Alternatives

Alternatives for non-structural wastewater management may be categorized as either regulatory or non-regulatory measures. Many alternatives may involve both regulatory and non-regulatory management options depending whether they are to be mandatorily legislated and enforced or voluntarily encouraged.

Regulatory Measures are incorporated within existing areas of governmental control which may or may not be primarily intended as wastewater management regulations. Many regulatory provisions involve objectives other than wastewater management, such as land use or population density control, which in turn have a very significant effect on wastewater management. This discussion will emphasize consideration of regulatory policies in these traditional areas which will be given primary emphasis in influencing the control of wastewater and protection of the enviroment.

Regulatory non-structural wastewater management alternatives are as follows:

1. Land Use Controls

Land Use Control measures include the total range of legal controls which may be enacted to restrict the use and development of land which may affect the quantity, quality and location of generated wastewater. These measures include the following:

a. Zoning

Zoning as a wastewater management control could be utilized to restrict certain critical waste producing activities to those areas where that waste can best be collected, treated and most safely and economically be disposed or reclaimed. Zoning could recognize the logic of limiting toxic waste producing industries to an area which could be served by the appropriate industrial waste treatment facilities. Similarly high BOD_5 waste producing industries could be restricted to an area providing separate industrial waste treatment or pretreatment facilities. Industries with a high risk potential for discharge of contaminants to the groundwater could be restricted from those areas overlying aquifers utilized for public water supplied.

Residential development could be controlled by zoning which would encourage efficient use of wastewater facilities and which would recognize the economies and efficiency related to permitting and possibly encouraging higher population densities in those areas where wastewater collection and treatment facilities can most effectively and economically be provided while at the same time discouraging scattered development (such as has been permitted in Spokane Valley) which is both difficult and costly to serve with public wastewater facilities and which is detrimental to preservation of open space.

b. Covenants

Deed covenants could be similarly used and is a more common European practice. This provides for stricter and more permanent land use control and reflects a less democratic procedure than the practice of zoning.

c. Building Regulations

Building Code and building permit regulations could restrict the type of structure which could be constructed on those sites which cannot be effectively served by permanent wastewater facilities.

2. Health Regulations

Enactment and enforcement of health regulations has traditionally been a primary wastewater management measure and the primary basis for requirement of community wastewater facilities dating back to the initial recognition of the significance of water pollution in the communication of disease. It is possible that the review and updating of health regulations relating to wastewater have not received the same attention as the concerns for the more visible environmental quality of surface water. With the reduced incidence of epidemics and prevalence of disease vectors, the public has grown to take public health for granted and therefore has become less motivated to support financially those facilities which are necessary to continue this high level of public health protection. The traditional recognition of the preventative emphasis of health regulations has been eroded by the public and political pressures to guarantee maximum individual freedom in the utilization of private property. The reliance on arbitrary standards applied to such considerations as separation of wells from septic tanks is not consistent with current knowledge of the travel of water and wastes as related to soil permeability and does not recognize the expanded knowledge of the behavior and significance of viral pathogens, and the growing concern regarding the public health significance of complex dissolved organic compounds. The application of regulations which require 100 foot horizontal separation of a well from any possible waste discharge and yet permits an undisinfected waste discharge with less than a 50 foot vertical separation of a public water supply in permeable soil is inconsistent.

Health regulations should not be voided by political expendiency and should continue to receive primary rather than secondary consideration in setting water quality management goals and priorities for the expenditures of public funds.

3. <u>Water Use Controls</u>

The control of water use as a wastewater management measure recognizes that a limitation of water usage will limit the quantity of wastewater generated. This measure would force more efficient use of water and place a higher premium on present wasteful use practices. Efficiencies in wastewater management would result from reduced total flow and the reduction of dilution from uncontaminated wastewater. The method of enforcing water use control is considered to be difficult since no practical means of allocation of distribution is available and would be very unpopular if attempted. The only reasonable means of encouraging water use control appears to be through the rate structure by applying concepts such as increased unit rates for consumption above normal usage requirements.

4. <u>Waste Generation Charges</u>

The concept of waste generation charges as a means of encouraging dischargers to pre-treat or reclaim wastes is a commonly accepted measure which is incorporated into most ordinances governing sewerage service. Provisions for charging users for excess quantity and for high-strength wastes is also consistent with the industrial waste facilities cost recovery requirements of PL 92-500. The major difficulty in administering a program of waste generation charges is the problem of maintaining adequate measurement of flow and quality monitoring.

<u>Non-Regulatory Measures</u> include a broad range of wastewater management concepts which cannot be effectivelly controlled by government regulations and which rely primarily on public understanding and encouragement of positive motivation on a personal basis for their effectiveness. Any non-regulatory approach to wastewater management is by definition a voluntary procedure which requires effective public education to be

successful. The consideration of economic incentives in many cases is partially regulatory and provides a stronger motivation than dependance on public goodwill and cooperation which tend to run strong for brief periods only under the influence of publicity or popularity as a "fad".

Non-regulatory, non-structural wastewater management alternatives are as follows:

1. Waste Source Reduction

Waste source reduction is very broadly defined in terms of any technical, social, or economic measure which will affect a reduction in wastewater generation and which could include any of the following:

a. Population Stabilization

The recent trend towards population stabilization can be considered to influence the rate of increase of wastewater generation. This is definitely a non-regulatory measure being influenced by social, biological, educational, and economic influences.

b. Reclamation and Recycling

The potential for the reclamation of reusable materials from industrial wastes particularly can sometimes be affected through education and research into the economics of recovery practices. Fiber recovered in a pulp mill can be recycled into product. Chrome lost from a plating operation is costly to replace. By-products from food processing industries have increasing value.

c. Encourage Waste Producers to Locate Elsewhere

The very significant attraction of adequate water resources of excellent quality will increasingly encourage industries to consider Spokane location. Consideration should be given to the consequences of providing adequately for wastes generated, as well as the more attractive benefits to the community relating to industrial growth. The difficulties and cost of providing adequate waste treatment at an inland location should influence policies concerning the types of industry which should be encouraged to locate in Spokane.

d. Discourage Solid Wastes Discharges to Sewerage Systems

The increasing practice of using waterbourne disposal of solid wastes by permitting and encouraging the use of such things as garbage grinders should be examined. Increased costs of solid waste disposal has encouraged individuals, as well as industry and grocery stores, to make increased use of sewers for solid waste disposal. This trend should be reversed.

e. Encourage Industrial Waste Pre-Treatment

Industrial waste pre-treatment, as a non-regulatory measure, depends almost completely on the awareness of the industry of the potential economic benefits of reclamation and use of by-products. It is not realistic to expect voluntary industrial waste pre-treatment at additional cost to the industry.

2. Economic Incentives

Encouragement to voluntarily use the land more efficiently and in a manner which is conducive to cost effectiveness in wastewater management may be affected by various economic incentives such as tax benefits, user fees, related public services, grant restrictions, housing subsidies and other economic incentives. The economic incentive of avoiding participation in a public sewer system could be offset by an environmental pollution tax. Waste generation charges have been discussed under regulatory measures. A very simple economic incentive which would serve to avoid the current problem of providing public wastewater facilities to a large unsewered area would be to commit the initial development of the land to public wastewater facilities. Tax benefits to industries which demonstrate efficient use of water and waste reduction might be more cost effective than the cost of treatment works.

3. Water Use Conservation

Public education and awareness of the need to conserve water as a means of reducing wastewater quantities should be emphasized in addition to the more commonly understood need to conserve water resources. This category of alternatives for non-structural wastewater management also includes the somewhat technical considerations of modifying fixtures and appliances to utilize less water such as reducing the size of flush tanks on toilets. Other considerations such as on-site separation of wastewater which could be directly reused for irrigation purposes and the elimination of the practice of using water for cooling purposes would be included as water conservation measures with wastewater reduction significance.

4. Efficient Land Use

Non-regulatory encouragement and education towards more efficient use of land as a means of simplifying wastewater systems could result in more cost-effective and reasonable development of these systems. Cluster development and multiple dwellings, combined with open space arranged to minimize utility corridors should be encouraged by education and by various zoning and economic incentive measures previously discussed. The continued practice of haphazard expansion of urban residential development into rural areas should be examined in terms of the ultimate requirement to provide public wastewater facilities to serve these areas. Land which cannot be efficiently served by utilities should be considered for non-residential uses.

5. Re-Use

The reuse of reclaimed wastewater should receive a high priority for consideration. The cost-effective water reuse opportunities in the Spokane area, other than for agricultural purposes, are very limited due to the availability of major surface and groundwater resources at very reasonable cost. Reuse of reclaimed water for agricultural purposes is limited to cultivatible land within reasonable vertical and horizontal distances in order to be cost-effective.

Evaluation of Non-Structural Wastewater Management Alternatives

The evaluation of non-structural wastewater management alternatives does not lend itself to any great degree of quantitative precision at least relative to structural measures. Non-structural alternatives, may be evaluated in performance relative to each other, the major difficulty being that of realistically being able to predict, with even a limited degree of certainty, the effectiveness of control measures which depend on effective legislation and enforcement. The effectiveness of non-regulatory measures is even more speculative inasmuch as they are dependent on the effectiveness of public education and limited by the vagaries of personal motivation.

The predictability of alternatives which employ various methods of economic incentives are more reasonably evaluated inasmuch as effectiveness is greatly influenced by the amount of the monetary benefit being offered.

In the comparison of non-structural wastewater management techniques with structural alternatives, the difficulties of making a meaningful comparison are even greater. The only absolute measurement of the effectiveness of non-structural wastewater management alternatives is institute a given measure and then devise some method of physical measurement of effectiveness in terms of water quantity and quality, making certain that structural variables are accounted for.

The following is an evaluation of non-structural wastewater alternatives:

1. Land Use Controls are effective in controlling the allowable quantity of waste to be generated in a given area in its effectiveness to control population density and to control industrial waste quantities permitted. Concurrently land use controls can be effective in controlling quality of waste by limitation of permitted industrial land use.

Enforcement of land use controls is not dependable due to the political pressure which may be exerted to influence both legislation and enforcement.

2. Health Regulations have traditionally been the most effective non-structural approach to wastewater management and is still a primary consideration in spite of modern emphasis on water quality. With the general absence of the public exposure to major epidemics, and the associated public attitude which tends to take public health for granted, health regulatory authority in many situations is difficult to maintain under the attack by political and economic interests.

3. Water Use Control, except by the assessment of punitive charges, is a very difficult measure to implement except in those areas where water supply is very limited and is controlled as a means primarily of ensuring equitable distribution of a limited resource. Water use control as a means of wastewater management is fairly limited.

4. Waste Generation Charges offer a wide range of application and can be a very effective wastewater management tool. The inherant equity in charging for wastes handling in proportion to the problem generated by the originator makes this a very effective non-structural measure. It is possible to consider extension of this concept into areas not normally considered such as relating waste generation charges to land use by providing preferential rates for land use which is most compatible with effective wastewater management such as providing reduced rates to industry which locates in proximity to treatment facilities and conversely which penalizes land use which increases the problem and cost of wastewater management.

5. Waste Source Reduction should involve a cooperative effort between the discharger and the responsible agency particularly where there is a potential savings to the discharger in terms of byproduct reclamation, or energy savings. Since waste source reduction, as a non-regulatory category includes such a wide range of considerations and is based on the influence of education and voluntary response, it must be evaluated as a measure of limited total impact. The inherent convenience of waterborne disposal as opposed to the complications of pre-treatment and waste source reduction work against the effectiveness of this approach unless reinforced with economic incentive. Broader aspects of waste source

reduction through population control and relocation are less predictable and are subject to only limited local control.

6. Water Conservation as a non-regulatory alternative is of limited effectiveness where the natural water resource is as plentiful and economical as Spokane. In the adjacent basalt aquifer areas water conservation has become a necessity to protect the availability of a limited resource. It is not realistic to consider that voluntary water conservation in the Spokane metropolitan area could influence measurably the quantity or quality of wastewater generated.

7. Water Reuse in the Spokane area primarily involves the possibility of utilizing structural measures as previously described in Section 604.2. Water reuse by source separation on an individual basis in the Spokane area is not a realistic alternative considering the availability of plentiful, low-cost water. Water reuse, other than land application, would not modify the ultimate quantity of wastes treated. Water reuse is primarily a water resource conservation measure.

An evaluation of the basic non-structural wastewater management alternatives considered herein have been evaluated in terms of the Group 1 concerns used in the evaluation of structural wastewater alternatives. Not all of the Group I evaluation concerns are clearly applicable for the evaluation of non-structural alternatives. However, for the sake of comparison, Table 1 has been prepared which ranks the non-structural alternatives in comparison with Group 1 concerns.

Conclusion

1. It is concluded that generally non-structural wastewater management alternatives cannot be planned to significantly reduce the

extent of structural wastewater facilities required.

2. That no individual non-structural wastewater management policy or combination of non-structural alternatives will have sufficient impact to influence the configuration of the recommended structural alternative plan. It can be hoped that application of non-structural wastewater management concepts may influence the efficiency of structural alternatives, thus affording benefits in reducing system cost as well as hoped for improvements to flow quantity and quality. Planning, at this time, cannot assume that this will happen.

3. That the greatest expectancy of successful application of non-structural wastewater alternatives are those measures which incorporate some means of economic incentive.

4. That regulatory measures which will augment structural management measures, such as effective land use control, should be implemented.

TABLE 1

RANKING OF GROUP 1 CONCERNS
MODERATELY WEIGHTED TO WATER QUALITY

Concern	(3) Weight	Land Use Controls (1) Rel.	Land Use Controls (2) Wtd.	Health Regulations Rel.	Health Regulations Wtd.	Water Use Controls Rel.	Water Use Controls Wtd.	Waste Gen. Charges Rel.	Waste Gen. Charges Wtd.	Waste Source Reduction Rel.	Waste Source Reduction Wtd.	Economic Incentive Rel.	Economic Incentive Wtd.	Water Conservation Rel.	Water Conservation Wtd.	Reuse Rel.	Reuse Wtd.
1a. Has lowest total cost for the planning period.	30	1.00	30.0	1.00	30.0	.90	27.0	1.20	36	1.00	30	.90	27	1.00	30	.40	12
2d. Causes minimum loss of tax revenue.	6	.90	5.4	.90	5.4	.90	5.4	1.00	6	1.00	6	1.00	6	1.00	6	1.00	6
5b. Causes least disruption to community living patterns.	5	.80	4	1.00	5	.80	4	1.00	5	1.00	5	1.00	5	1.00	5	1.00	3
7a. Provides maximum protection of groundwater quality	20	.80	16	1.00	20	.50	10	.80	16	.80	16	.50	10	.50	10	.50	10
8a. Provides maximum protection of surface water quality	20	.80	16	.90	18	.60		.90	18	.90	18	.80	16	.80		1.00	20
11d. Has lowest net energy requirements	7	1.0	7	1.0	7	1.1	8	1.2	8	1.0	7	1.1	8	1.1	8	0	0
12a. Provides best technical performance of wastewater renovation	7															1.0	7
13a. Has maximum flexibility for unanticipated growth	5	.6	3	1.0	5	.60	3	1.0	5	1.0	5	1.0	5	1.0	5	-	-
TOTAL	100		81		90		57		94		87		77		64		58

(1) Relative ranking within each concern
(2) Weighted ranking, the product of relative ranking and concern weight
(3) Moderately weighted to water quality

FIGURE A

SUMMARY OF NON-STRUCTURAL
WASTEWATER MANAGEMENT ALTERNATIVES

WASTEWATER MANAGEMENT

NON-STRUCTURAL ALTERNATIVES

REGULATORY MEASURES

LAND USE CONTROLS

- ZONING
- COVENANTS
- BUILDING REGULATIONS

HEALTH REGULATIONS

- SOIL RESTRICTIONS
- GROUNDWATER LOCATIONS
- WELL LOCATIONS
- PARCEL AREA

WATER USE CONTROLS

- COOLING
- WET INDUSTRIES REUSE
- GENERAL REUSE

WASTE GENERATION CHARGES

- LARGE QUANTITIES
- HIGH STRENGTH
- REUSE CREDIT

NON-REGULATORY MEASURES

WASTE SOURCE REDUCTION

- POPULATION CONTROL
- RECLAMATION & REFUSE
- RELOCATE WASTE PRODUCERS
- DISCOURAGE SOLID WASTES
- INDUSTRIAL PRE-TREATMENT

ECONOMIC INCENTIVES

- TAX BENEFITS
- USER FEES
- GRANT RESTRICTIONS
- HOUSING SUBSIDIES
- ENVIRONMENTAL POLLUTION TAX

WATER CONSERVATION

- PUBLIC AWARENESS
- FIXTURE MODIFICATIONS

EFFICIENT LAND USE

- CLUSTER DEVELOPMENT
- MULTIPLE DWELLINGS
- UTILITY CORRIDORS

REUSE

SECTION 601.7

[illegible]

[illegible]

[illegible]

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 604.7

WASTEWATER MANAGEMENT CONCERNS

OF WEST PLAINS COMMUNITIES

AS RELATED TO THE URBAN AREA PLAN

5 August 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

SECTION 604.7

WASTEWATER MANAGEMENT CONCERNS OF WEST PLAINS COMMUNITIES AS RELATED TO THE URBAN AREA PLAN

Scope and Objectives

The West Plains communities are presently relatively small and isolated from the major urban development by unoccupied areas. There are uncertainties about the growth of these communities and their individual disposal problems which combine to suggest that circumstances may develop favoring incorporation into the wastewater plan for the urban area. It is the purpose of this section to explore these uncertainties of growth and disposal to determine if there are conditions under which combination with the urban plan would be beneficial and, if so, what impact such combination would have on the urban area plan.

It is not within the scope of this study to develop detailed wastewater management plans for these small individual communities except as their requirements relate to and impact on the metropolitan area plan.

West Plains Area Identified

The West Plains area is defined as the area west of the City plus South West service areas as defined in Section 602. The area includes the communities of Airway Heights, Fairchild AFB, Medical Lake, Four Lakes and Cheney. Not included are Spokane International Airport and Geiger Heights. It is in the later respect that the West Plains area is different than the Spokane Plains area defined by Black and Veatch (1973).

The Spokane International Airport is presently sewered to the City of Spokane system and is assumed to continue that service. Geiger Heights, presently sewered to an interim facility operated by Fairchild AFB, is in the South West service area and is assumed to be sewered to the City system in the future.

The concern of this section is with the West Plains area not previously considered for sewerage in association with the urban plan.

Growth Uncertainties

All West Plains communities except Fairchild AFB have inadequate water supplies drawn from wells in the basalt aquifer which underlies the area. Fairchild AFB is an exception because a water supply has been developed from the Spokane Valley aquifer and delivered by transmission pipeline. The inadequate water supply limits growth throughout the area.

The individual communities also have their own particular growth constraints. The AFB growth, constrained by the base mission, is forecast to have no growth despite its augmented but still marginal water supply. Cheney is highly dependent upon the enrollment at Eastern Washington State College and the State policy related to growth of that particular campus. Medical Lake is dependent upon the patient load at Eastern Washington State Hospital as established by State policy.

A change in the available water supply or a change in individual community constraints or a combination of these forces could radically alter the forecast growth pattern. A study has been completed by Black and Veatch (1973) to provide a new water supply for the West Plains area from the Spokane Valley aquifer via a system of transmission mains. This study contains a range of population forecasts designated "moderate" and "rapid" predicated on the availability of an adequate water supply. Before a comparison can be made between the forecasts generated in this study based on the SMATS model and the Black and Veatch forecasts, an explanation of area names and designations is required.

The urban plan service area for the City of Spokane used in urban plan alternatives herein includes an area designated "South West" which includes an area both inside and outside the southwest corner of the present city limits and extending west to Spokane International Airport. This area is assumed to be provided wastewater service through the City system and has a year 2000 forecast population of 4,839.* In the Black and Veatch study this area is designated Spokane Plains S.E. and is forecast to have year 2000 populations ranging from 8,100 (moderate) to 15,360 (rapid). This area has at present no significant concentrations of development and no existing community sewerage facilities. The South West service area and Spokane International Airport which is already sewered to the City system are not a part of the concern in this section since they are included in the wastewater management plan for the urban area. The higher forecast growth per Black and Veatch could impact the urban area plan to the extent of increased flow. The City plus South West and Moran Prairie are forecast in this study to have a service population of 189,283. If the populations per Black and Veatch are realized instead, the service population could be increased from 3

* Forecast developed in this study based on SMATS projections and as concurred in by local planning agencies.

to 6 percent maximum if the increment is regarded as additive to the forecast County control total or something less if regarded as a redistribution of population within the County control total.

The area designated the West Plains area herein and the subject of concern in this section therefore corresponds to the Black and Veatch potential water service area less the area designated Spokane Plains S.E.

Table 1 compares the year 2000 population forecasts for the West Plains area developed in this study with those in Black and Veatch (1973) which are based on an augmented water supply. This study did not develop separated forecasts for the Black and Veatch areas designated Four Corners and Spokane Plains N.E. These two are included in the scattered population of the West Plateau service area outside of Airways Heights.

Table 1 indicates that the gross West Plains service population at year 2000 could range from 25,003 to 33,100 to 56,890.

Disposal Uncertainties

All present and future development in the West Plains area faces the same disposal dilemma. They will all be located on the basalt aquifer and they will all be in an area where the only surface streams are both small and ephemeral.

The basalt aquifer exists as fractures and seams in the underlying basalt. This type of aquifer has essentially no inherent capability of limiting the spread of any pollutant once the water table is reached. In general, the basalt is overlain with relatively thin layers of coarse sandy materials which provide limited filtering capability to surface applied water before the percolate has passed through to the surface of the fractured basalt. Thus, the opportunity for satisfactory infiltration disposal is limited. Fairchild AFB presently utilizes infiltration percolation with apparent success but this may be due to the fact that there are no active wells in the part affected. There would be no doubt that the secondary effluent would contain excessive levels of nitrogen and that these excessive levels would still be present after filtering through the overburden. The character of the generally permeable overburden and the low capacity aquifer pose a problem not only for infiltration-percolation but for the surface storage of wastewater in unlined earth lagoons.

The lack of year around streams or streams of significant flow precludes surface water disposal if criteria for dilution and quality of the receiving stream are strictly enforced. The Cheney lagoons discharge to Minnie Creek and constitute essentially the entire flow during the dry season. Medical Lake has evaporative lagoons, which occasionally overflow to a dry creek bed. It is not known whether either of these lagoons lose water by percolation.

The importation of an outside supply of water for communities would not solve the disposal problem by eliminating the need for a groundwater supply of potable quality since there would still be many isolated water users.

With the above described limitations of the environment on disposal, compliance with the letter and the spirit of disposal regulations could put the continued operation of all existing wastewater facilities in jeopardy and call for very costly upgrading or, alternatively, exportation of the wastewater from the basalt area. The kinds of upgrading required could include going to carefully controlled rates of land application for irrigation or tertiary treatment including nitrogen removal and possibly filtration and carbon adsorption or lined ponds with algae removal.

The communities of the West Plains area may be presently violating the letter of the law with regard to meeting disposal requirements but do not at present population levels appear to be suffering significant groundwater or surface water degradation. The uncertainty arises from future interpretation and enforcement of disposal requirements and the possible impact of suddenly burgeoning population spurred by an imported water supply.

Possible Responses to West Plains Uncertainties

Either a significant increase in population or an enforcement of more stringent disposal criteria or a combination of both could cause West Plains communities to singly or collectively seek alternative wastewater management systems. Of particular concern to this study, would be any plan to convey wastewater to the City STP for treatment and disposal. The goals of this section are: (1) to determine if a plan to convey West Plains wastewaters to the City STP is likely to be the most attractive of possible alternative responses and (2) to determine the impact of such an alternative on the basic urban area plan.

To determine if the "convey to City STP" plan is likely to be utilized if the present pattern of disposal practice becomes infeasible, the other alternatives must be formulated for comparison. It is assumed that the constraints on formulation of alternatives is that the method of disposal must not pose a threat to the basalt aquifer and can be made to surface waters only if there is adequate dilution with secondary effluent or if there is inadequate dilution with tertiary treatment. With these constraints, the following alternatives are formulated:

Plan Designation	Description
AA	Conveyance of raw wastewaters to the City STP
BB	Collection to a single point for secondary treatment and land irrigation disposal
CC	Collection to a single point for tertiary treatment and surface streambed disposal
DD	Collection and conveyance to a separate secondary plant for disposal to the Spokane River

In order to make cost effectiveness comparisons it is necessary to determine the impact of increased flows on the City STP to determine whether Plan AA should be charged with capital expense for an increase in treatment capacity. This is discussed in the following paragraph. If no capacity addition is required, the sharing of existing capacity is a sunk cost.

Impact of Potential West Plains Flows on City STP

The range of potential West Plain service populations and the estimated associated average dry weather flows (ADWF) are as follows:

Population Forecast Basis	Service Population	ADWF Year 2000 Mgd
Per this study	22,600(1)	2.5
Black & Veatch, moderate	33,200(2) (3)	3.7
Black & Veatch, rapid	57,000(2) (4)	6.3

Under Plan A for the urban area, it is recommended that North Spokane be combined with City flows for treatment at the City STP. The forecast ADWF at year 2000 for the City and North Spokane are 34.25 and 5.8 mgd respectively for a total of 40.05 mgd. The nominal capacity of the expanded and upgraded City STP is 40 mgd. Thus the year 2000 forecast ADWF of the City and North Spokane together are equal to the nominal capacity of the City STP. Satisfactory operation at throughputs in excess of nominal capacity are quite feasible if the excesses are relatively small, particularly if the diurnal flow variation can be minimized through the introduction of equalizing storage. It is judged that satisfactory performance could be realized at total ADWF of up to 45 mgd if the excess 5 mgd could be delayed to the off peak hours of the basic 40 mgd by flow equalization. Flows of 42 to 43 mgd could probably be handled with no diminution of effluent quality without equalization.

Solids handling facilities in the expanded and upgraded plant are conservatively sized and provide for the solids load associated with year around phosphorus removal. The possible maximum of 10 percent over nominal capacity is a feasible overload with design phosphorus removal.

---

(1) Based on service population.
(2) Based on gross population.
(3) Designated as "most probable" by Black & Veatch.
(4) Designated as "remote but not unreasonable" by Black & Veatch.

If seasonal phosphorus removal is feasible, there would be more than adequate nominal capacity in the off-season. Here again, consideration must be given to the nature of the West Plains population increment under the impact of an improved water supply. If regarded as a redistribution of the forecast County control total, the impact on the total population tributary to the City STP could be small, depending upon the area from which the redistribution took place. If the West Plains population increment in response to an augmented water supply is regarded as an addition to the forecast County control total, the full impact of the corresponding added flow would be realized at the City STP. Conservatively it is assumed that the forecast flow associated with the Black and Veatch "moderate" population forecast could be additive to the City STP without any offsetting reduction due to redistribution from within the North Spokane and City service areas. Even with this conservative assumption, the flow increment appears to be feasibly handled by the plant of 40 mgd nominal capacity. The conclusion is that the most probable maximum forecast load from the West Plains communities if added to the City STP is a small enough increment over nominal capacity that no additional capacity would be needed to year 2000. The "remote but not unreasonable" forecast becomes a borderline case.

In the cost effectiveness evaluation of conveyance of West Plains flows to the City STP it is assumed that the alternative need not be charged with a capital cost for increased treatment capacity to year 2000.

Cost Effective Comparison of Alternatives

In order to make cost effectiveness comparisons it is necessary to select design flows for sizing and operation. Since growth is one of the primary uncertainties, no one design population can be selected as representative of the range under consideration. For initial screening, the population forecast developed in this study is selected. This is not significantly different than the Black and Veatch "moderate" forecast which is described by Black and Veatch as the most probable growth rate.

The alternatives are based on all the communities being a part of the system, including Fairchild AFB. Schematic plans of each are shown in Figures A through D. Results of the initial cost effective comparison are shown in Table 2.

Table 2 shows that conveyance to the City STP, Plan AA, has the lowest total cost at 7.6 million dollars for a study period of 20 years, 1980 to 2000. The operation and maintenance cost for Plan AA includes the pro-rated share of operation and maintenance costs of the City STP assuming seasonal phosphorus removal. Also included in O&M is a payment to reimburse the City for its share in the capital funding of the City STP not covered by grants. Significantly, the next lowest cost at 10.5 million dollars i Plan DD which provides for conveyance to the Spokane River but with construction of a separate secondary treatment plant rather than use of capacity is the existing City STP. Plan BB for a central treatment plant discharging to land irrigation is ranked third at 12.9 million dollars and Plan CC, a central tertiary treatment plant for dry stream disposal, ranks last at 16.0 million dollars.

A cost estimate is not prepared for the no action plan which would have the lowest cost by far. The no action plan would leave Airway Heights and Four Lakes with individual on-site disposal, Fairchild AFB with its existing secondary treatment and percolation disposal and Medical Lake and Cheney with lagoon disposal to dry streams.

To test the cost trend under conditions of "rapid" growth, the capital costs only are computed for Plans AA, CC and DD. The capital costs for Plan AA are found to increase from 5.8 million to 8.5 million dollars, an increase of 47 percent. The capital costs for Plan CC are found to increase from 9.8 million to 15.7 million dollars, an increase of 60 percent. This indicates that the larger the population increase in West Plains, the more favorable it will be to convey to the City STP rather than treat to a high level separately. Note that for Plan DD which combines high conveyance costs, equivalent to Plan AA, plus separate treatment, the capital cost increases from 8.1 to 12.3 million dollars, an increase of 52 percent, intermediate between Plan AA and CC. As population increases, conveyance costs tend to increase less rapidly than treatment costs.

Economic, Social and Environmental Considerations

The economic, social and environmental concern for the above formulated alternative plans are evaluated in Appendices I, II and III. This evaluation indicates that Plan AA is most favorably rated overall by a significant margin. If cost is completely eliminated from ranking considerations, the ranking under Group 1 concerns is relatively uniform with no one alternative having a distinct advantage, but with Plan CC having the highest rank. Considering Group 2 concerns, there is little to distinguish Plans AA, CC and DD from each other as having a high rank, but Plan BB is found to rank much lower, due to the impact on the extensive area required for treatment and disposal.

This analysis indicates that Plan AA conveyance to the City is equal or superior in rank to other alternatives for considerations other than cost and becomes distinctly most favored when its lower cost is also considered. Thus, refined analysis which might find means to lower the cost of other alternatives would not be expected to change the overall desirability of Plan AA.

Conclusions and Recommendations

1. The cost of providing a wastewater management system to serve West Plains communities that will provide a high level of protection to the basalt aquifer is very high. Conveyance to the City STP appears to be the least costly alternative if pressures of population growth and aquifer protection require an upgraded system.

2. The added flow potential at year 2000 from the West Plains communities on the City STP ranges from 2.5 to 6.3 mgd. This range of incremental flows together with the forecast flows from the City and North Spokane are judged to be within the capability of the expanded and upgraded City STP to year 2000. Flow equalization may be necessary to accommodate the higher range increment.

3. The costs of providing conveyance to the City STP is of the same order of magnitude as the projected costs of an augmented water supply. Since the augmented water supply could lead to the early need for corresponding improvement in wastewater disposal for the West Plains area, the planning and implementation of these two functions should be coordinated and should be carried out simultaneously. It is recommended that conveyance to the City STP be one of the alternatives considered in such a planning study. This detailed planning could be carried out as part of a Step I wastewater facilities plan.

TABLE 1

COMPARISON OF FORECAST POPULATIONS
FOR WEST PLAINS AREA AT YEAR 2000

Service Area	This Study	Forecast By Black & Veatch (1973) Moderate	Rapid
Airways Heights	1,243	5,950	11,280
Cheney	10,887	8,450	16,050
Fairchild AFB	6,700	6,700	6,700
Four Lakes	259	900	1,760
Medical Lake	3,500	5,000	9,540
Subtotal	22,589	27,000	45,330
Four Corners (3) }		3,150	5,990
Spokane Plains NE (3) }	2,414 (1)	2,950	5,570
Subtotal	25,003	33,100	56,890
Spokane Plains SE (3)	4,839 (2)	8,100	15,360
TOTAL	29,842	41,200	72,250

(1) Specific location not designated in this study. The 2,414 is West Plateau total less Airways Heights, regarded as too scattered for community sewerage service.

(2) This study designates the service area "South West" and includes with City in urban area alternatives.

(3) Black and Veatch area designations.

TABLE 2

COST EFFECTIVENESS COMPARISONS
OF WEST PLAINS ALTERNATIVES

Plan Identifier	Description	Present Worth of Study Period Costs, 1980-2000, Millions of Dollars: Capital	Operation & Maintenance	Total
AA	Conveyance to and treatment in City STP[1] and river disposal	5.8	1.8	7.6
BB	Collection to a single point for secondary treatment and land irrigation	11.9	1.0[2]	12.9
CC	Collection to a single point for tertiary treatment and surface streambed disposal	9.8	6.2	16.0
DD	Conveyance to a new separate secondary treatment plant[1] on the Spokane River for river disposal	8.1	2.4	10.5

(1) Assuming seasonal phosphorus removal.
(2) Includes credit for crop revenue.

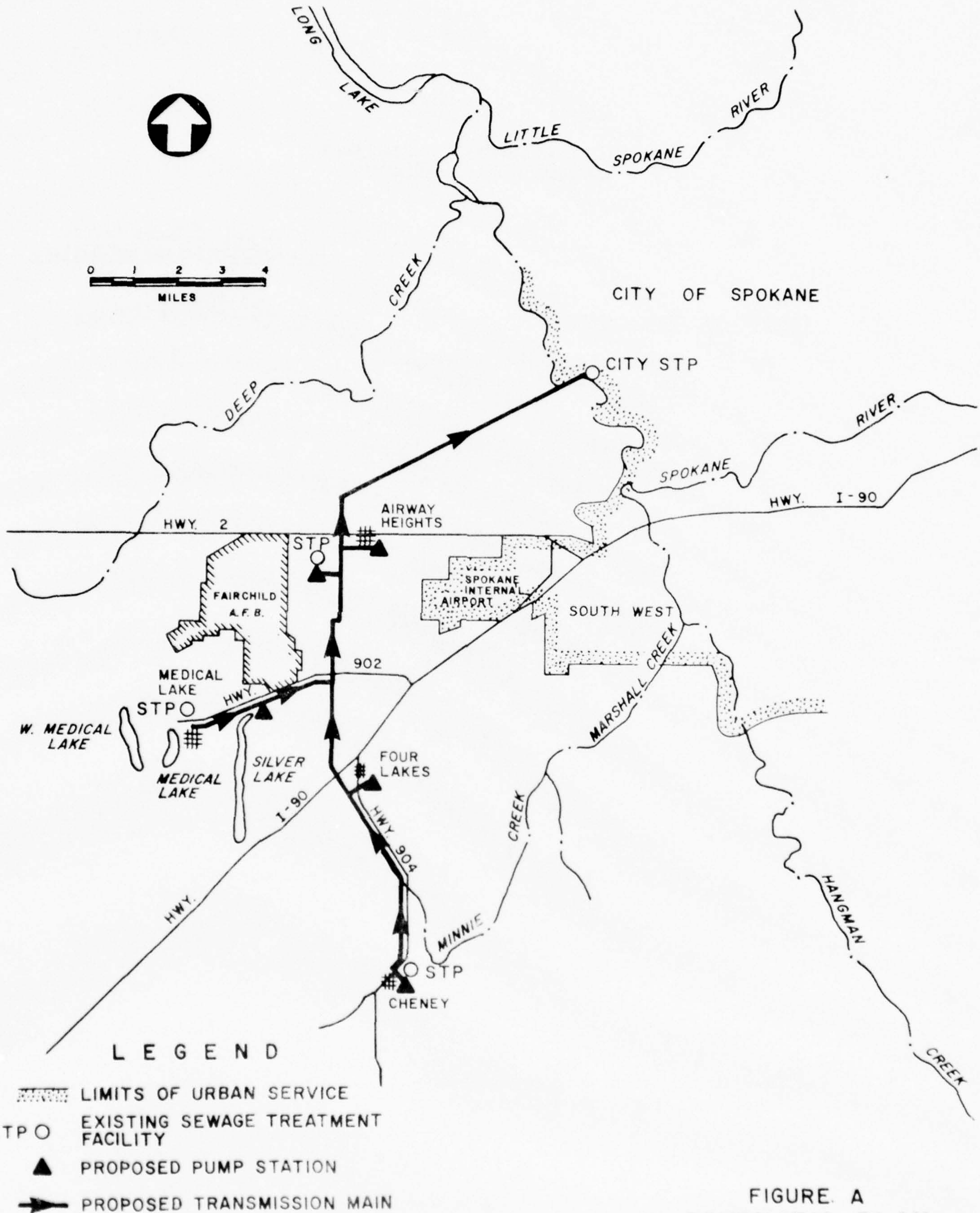
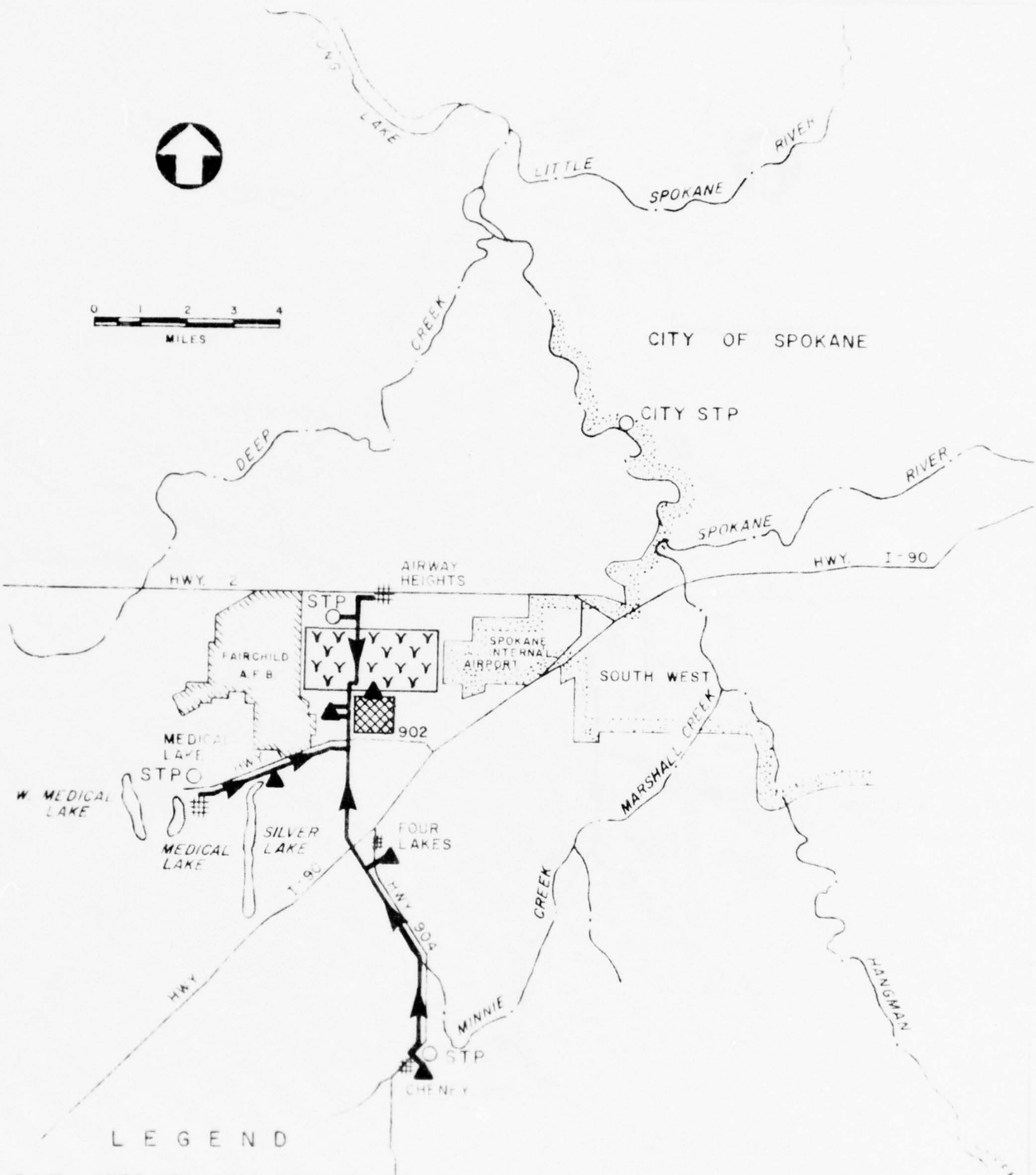


FIGURE A
SCHEMATIC PLAN
WEST PLAINS
ALTERNATIVE AA



LEGEND

LIMITS OF URBAN SERVICE

STP ○ EXISTING SEWAGE TREATMENT FACILITY

▲ PROPOSED PUMP STATION

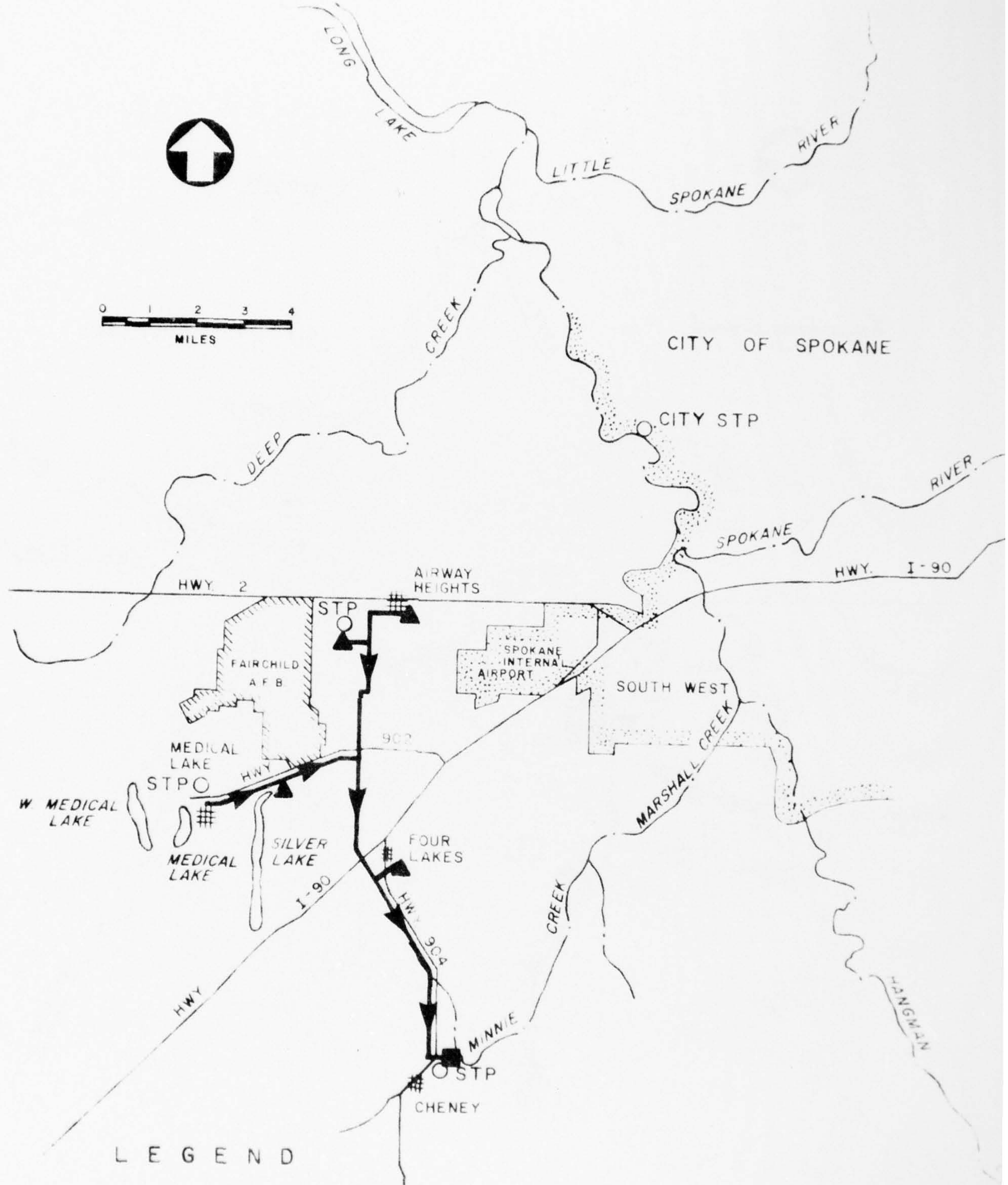
PROPOSED TRANSMISSION MAIN

PROPOSED LAGOONS AND SEASONAL STORAGE (LINED)

PROPOSED IRRIGATION AREA

FIGURE B
SCHEMATIC PLAN
WEST PLAINS
ALTERNATIVE BB

604.7-17



LEGEND

LIMITS OF URBAN SERVICE

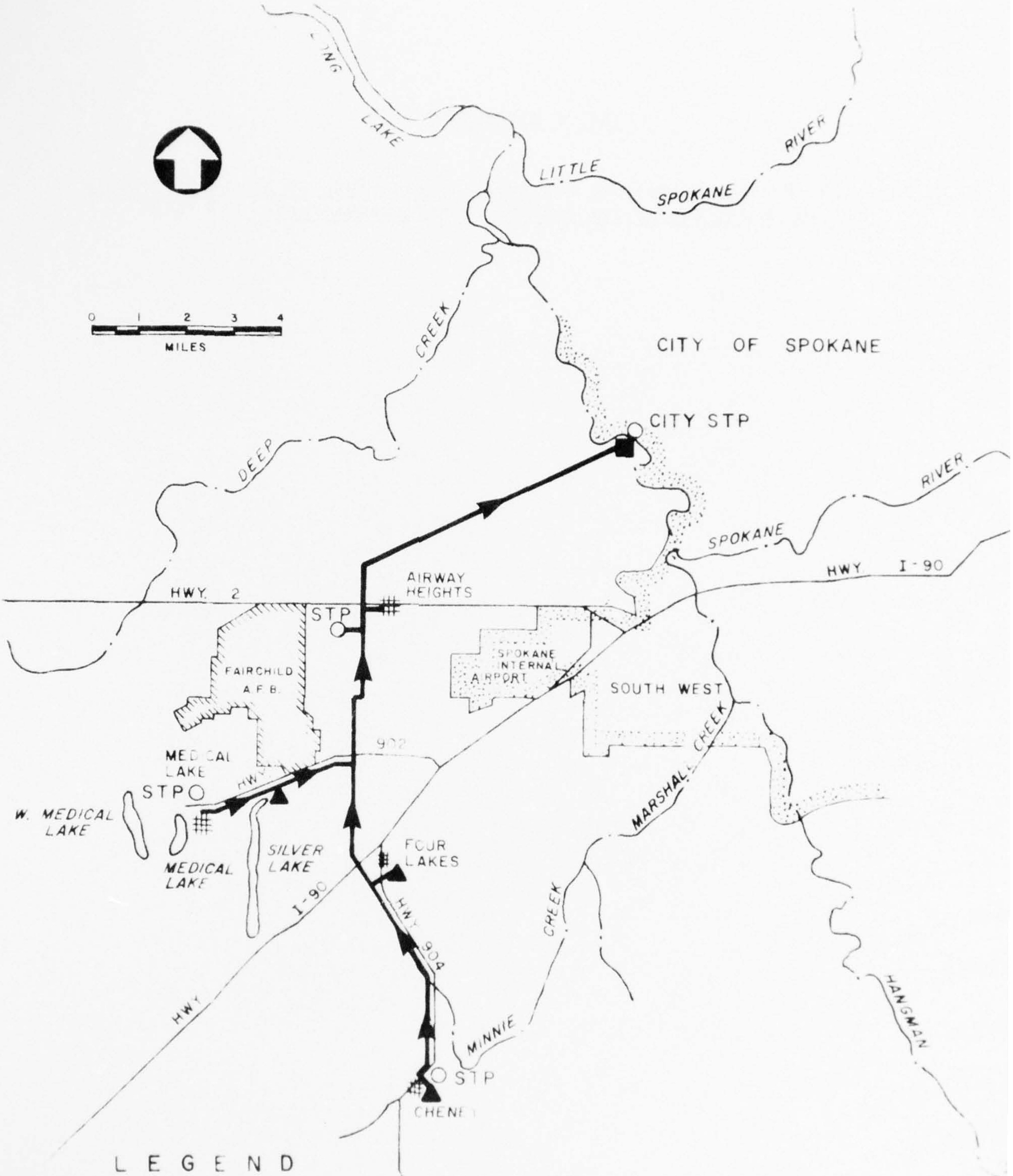
STP ○ EXISTING SEWAGE TREATMENT FACILITY

▲ PROPOSED PUMP STATION

PROPOSED TRANSMISSION MAIN

■ PROPOSED TREATMENT FACILITY

FIGURE C
SCHEMATIC PLAN
WEST PLAINS
ALTERNATIVE CC



LEGEND

- LIMITS OF URBAN SERVICE
- STP ○ EXISTING SEWAGE TREATMENT FACILITY
- ▲ PROPOSED PUMP STATION
- ➤ PROPOSED TRANSMISSION MAIN
- ■ PROPOSED TREATMENT FACILITY

FIGURE D
SCHEMATIC PLAN
WEST PLAINS
ALTERNATIVE DD

604.7-19

LIST OF REFERENCES

Black and Veatch, Consulting Engineers, 1973. Interim Report on Spokane Plains Water Supply for Spokane County, Washington. K-T #112.

ECONOMIC, SOCIAL AND ENVIRONMENTAL RANKING OF GROUP 1 CONCERNS FOR WEST PLAINS ALTERNATIVES

			Weighted Ranking of Candidate Plans							
			AA		BB		CC		DD	
CONCERN		WEIGHT[3]	Rel[1]	Wtd[2]	Rel	Wtd	Rel	Wtd	Rel	Wtd
1a	Has lowest total cost for the planning period	38	1.0	38.0	0.6	22.8	0.5	19.0	0.7	26.6
2d	Causes minimum loss of tax revenue	5	1.0	5.0	0.5	2.5	0.9	4.5	0.9	4.5
5b	Causes least disruption to community living patterns	4	1.0	4.0	0.5	2.0	1.0	4.0	1.0	4.0
7a	Provides maximum protection of groundwater quality	20	1.0	20.0	0.7	14.0	0.9	18.0	1.0	20.0
8a	Provides maximum protection of surface water quality	20	0.7	14.0	1.0	20.0	0.9	18.0	0.7	14.0
11d	Has lowest net energy requirement	5	0.8	4.5	1.0	5.0	0.7	3.5	0.8	4.0
12a	Provides best technical performance of wastewater renovation	5	0.5	2.5	1.0	5.0	1.0	5.0	0.5	2.5
13a	Has maximum flexibility for unanticipated growth	3	0.8	2.4	1.0	3.0	0.7	2.1	0.9	2.7
	TOTALS	100		90.4		74.3		74.1		78.3

[1] Relative ranking within each concern.
[2] Weighted ranking, the product of relative ranking and concern weight.
[3] Balanced weighting between cost and environmental concerns.

APPENDIX II

ECONOMIC, SOCIAL AND ENVIRONMENTAL
RANKING OF GROUP 2 CONCERNS FOR
WEST PLAINS ALTERNATIVES

Balanced			Weighted Ranking of Candidate Plans AA		BB		CC		DD	
CONCERN		Weight	Rel[1]	Wtd[2]	Rel	Wtd	Rel	Wtd	Rel	Wtd
2c	Causes minimum loss of employment and real income	6	1.0	6.0	0.7	4.2	1.0	6.0	1.0	6.0
3a	Has maximum favorable impact on business and economic activity	5	1.0	5.0	0.8	4.0	1.0	5.0	1.0	5.0
4a	Has maximum potential local employment during construction	5	0.7	3.5	1.0	5.0	0.9	4.5	0.8	4.0
4b	Has maximum potential for local manufacturing and supply during construction	5	0.7	3.5	1.0	5.0	0.9	4.5	0.8	4.0
4c	Will cause minimum disruption during construction	7	0.9	6.3	0.7	4.9	1.0	7.0	0.8	5.6
5a	Has most favorable impact on health safety and welfare	5	0.9	4.5	0.8	4.0	1.0	5.0	0.9	4.5
5c	Has most beneficial impact on availability of recreation	5	1.0	5.0	0.8	4.0	1.0	5.0	0.9	4.5
5d	Introduces least constraints to land use and planning	5	1.0	5.0	0.5	2.5	0.9	4.5	0.9	4.5
6a	Causes least dislocation of individuals	5	1.0	5.0	0.5	2.5	1.0	5.0	1.0	5.0
9a	Preserves or increases land available for habitat or open space	5	1.0	5.0	0.7	3.5	0.9	4.5	0.9	4.5
9b	Preserves or enhances aesthetic value of landscape	5	1.0	5.0	0.5	2.5	0.9	4.5	0.8	4.0
9c	Creates least interference with other beneficial use of land	5	1.0	5.0	0.5	2.5	0.9	4.5	0.9	4.5

Balanced		Weighted Ranking of Candidate Plans AA		BB		CC		DD	
CONCERN	WEIGHT	Rel[1]	Wtd[2]	Rel	Wtd	Rel	Wtd	Rel	Wtd
10a Provides maximum protection of health aspects of air quality	7	1.0	7.0	0.8	5.6	1.0	7.0	1.0	7.0
10b Provides minimum potential for deterioration of aethetic quality of air	5	1.0	5.0	0.8	4.0	1.0	7.0	1.0	7.0
11b Requires minimum input of chemicals	7	0.7	4.9	1.0	7.0	0.5	3.5	0.7	4.9
12b Provides highest degree of reliability	8	1.0	8.0	0.8	6.4	0.7	5.6	0.9	7.2
13b Has maximum flexibility to meet changes in disposal criteria	5	0.7	3.5	1.0	5.0	1.0	5.0	0.7	3.5
13c Has maximum flexibility to incorporate changes in technology	5	0.9	4.5	0.8	4.0	0.7	3.5	1.0	5.0
TOTALS	100		91.7		76.6		91.6		90.7

(1) Relative ranking within each concern.
(2) Weighted ranking, the product of relative ranking and concern weight.

APPENDIX III

SUMMARY RANKING OF
WEST PLAINS ALTERNATIVES

	ALTERNATIVE			
	AA	BB	CC	DD
GROUP 1 CONCERNS				
Balanced	90.4	74.3	74.1	78.3
GROUP 2 CONCERNS				
Balanced	91.7	76.6	91.6	90.7
COMBINED GROUPS WEIGHTED				
75% G-1, 25% G-2	90.73	74.88	78.48	81.4
COMBINED GROUPS WEIGHTED				
90% G-1, 10% G-2	90.53	74.53	75.85	79.54

SECTION 604.9

SEWERAGE OF MORAN PRAIRIE

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 604.9

SEWERAGE OF MORAN PRAIRIE

2 September 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

SECTION 604.9

SEWERAGE OF MORAN PRAIRIE

Objective

The present development in the extreme southeast corner of the City as well as the unincorporated area known as Moran Prairie are served by the City water system but topography and low density have prevented their connection to the City sewerage system. These areas are proposed for sewerage service and disposal through the City system. It is the objective of this section to consider the alternative methods for extending sewerage service to these areas. The areas are not tributary to the City collection system by gravity except by a route extending outside the City limits. The two sewerage alternatives are the use of pump stations and a gravity system outflanking the intervening high ground by a longer route through unincorporated area.

Defining the Topographic Problem

Refer to Figure A for illustration of the matters discussed below. The limits of the present gravity collection system extend to the vicinity of 37th Avenue. There is a ridge running from S.W. to N.E. from the vicinity of 40th Avenue and Pittsburg to where Congress Avenue meets the east City limit. This ridge defines the topographic limit of gravity service since the ridge is paralleled by a swale on its southeast side which grades out of the City limits into Glenrose Prairie. There are at present three City sewage lift stations in the southwest end of this swale. One at 46th Avenue and Cook Street serves the southernmost part of the City including the Manito Golf and Country Club. The second, at 44th and Regal, serves an area along Regal. The third serves the Joel E. Ferris High School.

All of the projected growth areas both inside and outside the City are topographically tributary to the above described swale except for a small area south of Moran Cemetery which is tributary to a canyon leading west to Hangman Creek. Thus, the areas served by the three existing lift stations and most of the potential growth service area are tributary to this swale which leads out into Glenrose Prairie. The Great Northern R.R. starts to follow this swale as it leaves the City limit, swings out into Glenrose Prairie but then turns west again back into the City paralleling the contours and crossing Freya St. between 14th and 15th Avenues. There is a City trunk sewer in Freya St. extending south to 15th Avenue and east in 15th Avenue to Myrtle. The Freya St. trunk is rated at 22 cubic feet per second.

Alternative Sewerage Plans

It would be feasible to serve the southeast corner of the City and Moran Prairie by gravity with a trunk sewer extended from the Freya St. trunk and generally following the Great Northern right-of-way through Glenrose Prairie into the swale. This trunk would make it possible to eliminate the three existing sewage lift stations. The length of trunk outside city limits is estimated at 1.8 miles and 2.1 miles to the Freya trunk.

A pump station would be required to serve the southern part of Moran Prairie tributary to the branch canyon from Hangman Creek.

The alternative to the gravity sewer through Glenrose Prairie following the Great Northern Railway would be a pump station at the point where the swale leaves the City limit with a force main up 36th Avenue to Myrtle, up Myrtle to 30th and west on 30th to the trunk in Ray St., total length about 0.8 miles.

Estimated Service Population

The present estimated gross population in the Moran Prairie service area is approximately 5000 persons. It is estimated that about 3000 would be feasibly sewered at 1980. The forecast gross population in the service area is 12,950 in year 2020 of which it is estimated that 11,000 would be feasibly sewered. The forecast year 2020 ADWF of the sewered population is 1.3 mgd and the corresponding PWWF is 3.6 mgd.

Cost of Alternative Facilities

The gravity sewer size would be 18" maximum. The estimated construction cost of 11,088 feet (2.1 mi.) of 18" in unpaved area at $19.72[1] per foot is $219,000.

A raw sewage lift station for 3.6 mgd would cost $260,000[2] and 4224 feet (0.8 miles) of 16 inch force main, half in paved streets at

---

(1) Task Report 401.2 Figure B-1.
(2) Task Report 401.2 Figure B-3.

\$29.92[3] per foot and half in unpaved streets at \$21.59[3] per foot, would cost \$109,000 for a total cost of pump station and force main of \$369,000.

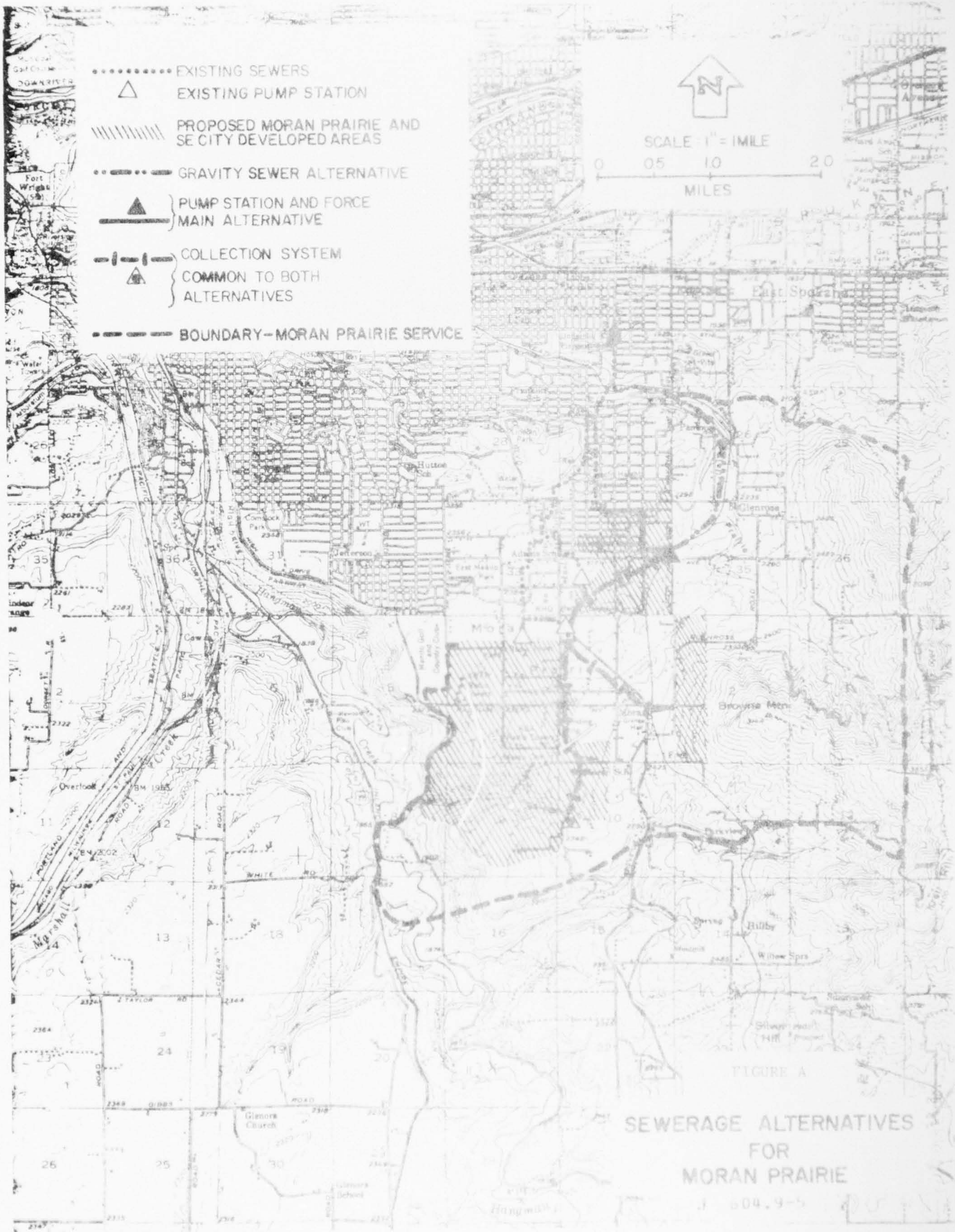
The gravity sewer has a lower capital cost and would also have lower operation and maintenance costs. Therefore, the gravity sewer appears to be significantly more cost effective. Reliability is also an important factor favoring the use of a gravity sewer.

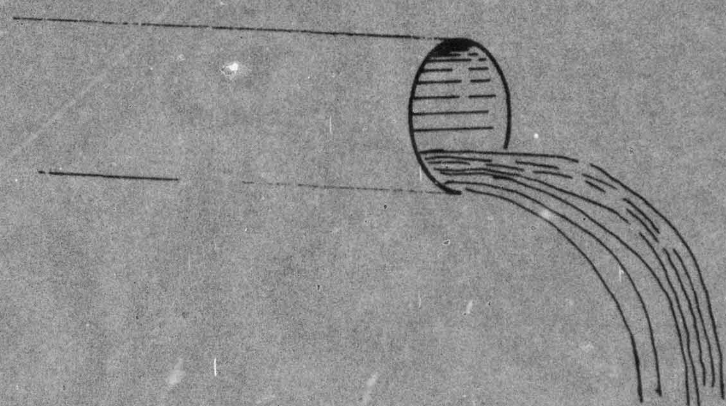
Recommended Plan

It is concluded that the Moran Prairie area is feasibly sewered to the City system by gravity at a project cost (1.4 times constru tion) of \$307,000 for conveyance or about \$300 per household of initial customers and about \$90 per future, year 2020 household. The gravity sewer is recommended not only for lower cost but for greater reliability and freedom from operational problems.

---

(3) Task Report 401.2, Figure B-2.


EXISTING SEWERS
EXISTING PUMP STATION
PROPOSED MORAN PRAIRIE AND SE CITY DEVELOPED AREAS
GRAVITY SEWER ALTERNATIVE
PUMP STATION AND FORCE MAIN ALTERNATIVE
COLLECTION SYSTEM COMMON TO BOTH ALTERNATIVES
BOUNDARY-MORAN PRAIRIE SERVICE
N
SCALE: 1" = 1MILE
0 0.5 1.0 2.0
MILES
East Spokane
Glenrose
Browne Mtn
Moran
Overlook
Marshall
Gilmore Church
FIGURE A
SEWERAGE ALTERNATIVES
FOR
MORAN PRAIRIE
J 604.9-5



SECTION 604.5

FORMULATION AND EVALUATION OF ALTERNATIVE PLANS FOR URBAN RUNOFF MANAGEMENT

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 604.5

FORMULATION AND EVALUATION OF ALTERNATIVE PLANS FOR URBAN RUNOFF MANAGEMENT

8 October 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

INDEX

TABLE INDEX

SECTION 604.5

FORMULATION AND EVALUATION OF ALTERNATIVE PLANS FOR URBAN RUNOFF MANAGEMENT

Scope and Objectives

The objectives of this section are to: (1) consider the widest possible range of structural and non-structural alternatives for urban runoff management; (2) to formulate from this choice of alternatives, candidate plans and (3) to evaluate these candidate plans for selection of a recommended plan for integration into the overall waste management system.

The scope of work includes the urban runoff problem posed by the sewered areas in the City of Spokane, the partially sewered suburban areas in North Spokane and the essentially unsewered urban areas of Spokane Valley. Also to be considered are the urban runoff which will be generated by the future urban and suburban development in all three of these areas.

The primary problem to be addressed is the impact of urban runoff on surface and groundwaters.

General

The urban drainage problem for the study area is unique in several respects. In general, the presently and forecast areas of urban development did not and do not have a natural surface stream drainage pattern. Almost the entire area of urban development is on such highly permeable soils that a surface stream system never existed in nature. The one fairly extensive area that is an exception to this description is that part of the City of Spokane south of the Spokane River where preexisting streams, swamps and springs have lost their natural identity be being incorporated into the city sewer system.

In nature, before the creation of impervious areas by urban development, most of the precipitation falling on the present and forecast urban areas never reached a surface stream but rather percolated into the soil where the ultimate pathway was split between evapotranspiration and recharge of groundwaters. Hence, there are and were no natural surface streams of even an ephemeral nature to provide a baseline of natural runoff quantity or quality.

Within the City of Spokane, runoff from manmade impervious areas is now discharged into the Spokane River through a system of sewers, mostly of the combined type in which sanitary sewage flows in the same pipe, but some in separate storm sewers. The combined sewer problem is the subject of an extensive ongoing study program by the City of Spokane. The goal of the City program is to minimize the pollution caused by overflow of untreated sanitary sewage not inextricably mixed with storm waters rather than to address the problem of the storm waters themselves. It is not the interest of this study to duplicate the work of the proposed City program which will deal specifically with the flooding and overflow problems of each sewerage subsystem in detail. This study is to address the overall urban runoff problem by assessing its total pollution threat and evaluating the needed pollution control and the various methods of achieving that control. The relationship of this study to the City Plan of Study is discussed in detail below.

The North Spokane suburban area contains a limited storm drainage system that includes both sewers and roadside ditches. The ultimate point of discharge is the Little Spokane River. There are no combined sewers in the North Spokane suburban area. The area in general slopes directly toward the Little Spokane River.

The Spokane Valley suburban area contains practically no storm drainage systems. All drainage is essentially by percolation, either from "dry wells" dug for this purpose or by simple infiltration into the ground surface. The ground surface slopes to the Spokane River so that the Spokane River would be the recipient of any collected storm drainage. The drainage configuation in general consists of swales parallel to the river and separated from the river by low ridges so that any collection system would require an extensive trunk system.

The approach taken herein toward evaluation of the urban run-off for these three major service areas is as follows:

1. The urban runoff volume is estimated for forecast conditions in terms of total annual flow, summer season flow and typical rainfall event flow corresponding to specific recurrence intervals.
2. The range of probable pollutant load is estimated corresponding to the various forecast flow estimates.
3. The estimated range of pollutant loads is compared with:

a. The corresponding forecast treated sanitary effluent from the same area.

b. The low flow condition in the potential receiving water.

Following evaluation of the magnitude of forecast urban runoff, consideration is given to formulation of alternative methods for controlling the impact of urban runoff. The alternatives are then evaluated for their applicability to the specific service areas and for integration with wastewater management alternative.

Relationship of this Study to the City "Plan of Study"

The City Commitment. The City has submitted to the Department of Ecology a Plan of Study dated September 1974 for "Facilities Planning for the City of Spokane Sewer Upgrading and Overflow Corrections". A copy of the Plan of Study is included as Appendix I.

This study is not intended to duplicate the effort of other planning programs. The referenced Plan of Study is an outgrowth of the overall plan for the City of Spokane approved by the Department of Ecology and the EPA under which the City is committed to an upgrading of the existing sewage treatment plant.

It is accepted that the City has assumed the responsibility for the indicated planning and implementation and will, within the time schedule indicated in the Plan of Study, plan, design and construct facilities which will, in a cost effective manner, solve the combined sewer overflow problem. That is, the City will select and implement remedial measures which will either eliminate the discharge of sanitary wastes mixed with storm water or will provide treatment for the mixed sanitary and storm waters to minimize the impact of the sanitary component on the receiving waters. The City Plan of Study is not intended to address treatment of urban runoff of itself. Urban runoff would be treated only as incidental to treatment of sanitary wastes in combined flows. As of this date, EPA has not established criteria for any level of treatment for separated urban runoff and the City is not under directive to abate pollution due to urban runoff per se. Refer to NPDES Waste Discharge Permit No. WA-002447-3 for the City treatment plant.

The Plan of Study is recognized as indicative of a commitment to action by the City and is therefore, a consideration in the formulation of wastewater management plans in this study. The City commitment involves selection from alternative plans of action for nine separate areas. The choice of alternatives and their application to particular areas can affect the future utilization of available capacity in the City STP and can affect the total pollution load which will reach the Spokane River. Solutions developed in this study must have the flexibility to deal with the possible range of affects which can be realized by the options under the City Plan of Study.

Alternatives Considered by the City Plan of Study. The four alternative methods for correction of the combined sewer overflows specifically enumerated in the City Plan of Study will have the following impacts on STP utilization and on quantity of pollutants reaching the river:

Alternative 1. Storm relief sewers with satellite treatment facilities at various overflow points to the Spokane River.

This alternative does not require storm water capacity in the STP. The sewage being treated by the satellite treatment facility is combined storm and sanitary sewage overflow. The pollutant impact on the river depends upon the degree of treatment provided, and the frequency and quantity of combined overflow.

Alternative 2. Storm relief sewers with storage facilities so that all potential overflows can be stored for later conveyance to the sewage treatment plant without requiring any capacity increase in the existing interceptor sewers or the new sewage treatment plant.

This alternative requires using some of the STP capacity for storm water treatment on an equalized flow basis. One alternative basis for sizing the required storage is to assign all of the spare capacity for treatment to minimize the required storage volume. For example, the year 2000 ADWF for the City alone is 35 mgd. The entire difference between 35 mgd and 40 mgd capacity could be reserved for treatment of stored combined flow leaving none available for possible incorporation of areas outside the City.

This alternative has the minimum impact for urban runoff pollutant load to the river since all flows including the urban runoff component would experience full treatment at the STP.

Alternative 3. Storm relief sewers combined with new relief interceptor sewers to the City's sewage treatment plant and further enlargement of the new sewage treatment plant to treat all combined flows.

This alternative specifically requires addition to the City STP to accommodate combined flows. It is not stated whether the increased capacity would be in the form of complete treatment or as excess flow clarifiers as presently provided in the proposed STP upgrading. Presumably consideration would be given to a combination of both.

The impact on pollutant load to the river would be the residual waste load following combined flow primary treatment by excess flow clarifiers.

Alternative 4. Complete storm and sanitary sewer separation with direct discharge of storm waters to the Spokane River.

This alternative makes no demand on the available capacity in the City STP. The impact on pollution load to the river is that associated with discharge of untreated separate urban runoff.

These four alternatives are to be tested for cost-effectiveness for nine different areas. It is possible that different alternatives will prove most cost-effective for different areas.

Integration of the City Plan of Study with this Study

The detailed outcome of the City Plan of Study in applying at least four alternative solutions to nine separate areas cannot be anticipated. The possible range of outcomes must be reduced to those of significant impact to this study. This study has two primary interests in the outcome of the City Plan of Study. The first is in regard to utilization of the design capacity of the proposed expanded and upgraded sewage treatment plant.

The design capacity of 40 mgd is in excess of the forecast needs for the City dry weather flow and is indicated in Bovay (1973) as being for use by contiguous areas. This difference between forecast City dry weather flow and design capacity is herein referred to as excess capacity.

The City, although the nominal owner of the expanded treatment facility, does not have a proprietary interest in it from a regional viewpoint since it is built with grant assistance from federal and state sources. This is recognized in EPA regulations that prevent the nominal owner of a treatment facility from discriminating against the inclusion of a service area outside the owner's political jurisdiction where regionalized treatment is indicated by planning considerations. Therefore, it cannot be presumed that the City could unilaterally reserve this excess capacity for its use for combined flow treatment to the exclusion of any possible use by other areas.

For this study in the formulation and evaluation of wastewater management alternatives, the highest and best use for the excess capacity for dry weather flows is assumed to be the year around treatment of sanitary flows as opposed to the intermittant use for combined flow treatment. It is assumed for this study that the excess dry weather flow capacity is available for treatment of sanitary flows from adjoining areas on a "sunk cost" basis. This assumption should not and does not preclude the City in their Plan of Study from considering the utilization of the excess capacity for combined flow treatment as indicated above in the alternative proposed for evaluation. Only by considering both potential uses and weighing the trade-offs involved can a complete evaluation be made.

The second interest of this study is the effect of the possible City plans on the pollution load to the Spokane River. Alternatives 2 and 3 will provide not less than primary and a significant proportion of secondary treatment for combined flows. The level of treatment selected for combined flows in Alternative 1 will certainly be no less than would limit pollution to the equivalent of discharging the storm flow separately and Alternative 4 does in fact discharge the storm flow separately and untreated. The most severe impact on receiving water quality would therefore be the assumption of discharge of separate untreated storm flows. In order for the City to weigh the performance of other alternatives, the consequences of this most severe condition should be known. This study is directed toward forecasting the separate storm water pollution load and evaluating its possible impact assuming no treatment. This study is also directed toward identifying any abatement needs from these evaluations so that they may be used as input by the City in these detailed studies.

Criteria for Urban Runoff Pollution Evaluation

Introduction. Criteria for either the limitation or evaluation of pollution due to urban runoff have not been established by EPA or DOE. It is the stated goal of EPA to quantify the urban runoff problem and identify the effects on receiving waters, ultimately leading to codified standards. For the purpose of this study, it is necessary to attempt to anticipate the probable standards.

AD-A036 596 KENNEDY-TUDOR SPOKANE WASH F/G 8/6

METROPOLITAN SPOKANE REGION WATER RESOURCES STUDY. APPENDIX H. --ETC(U)

JAN 76

UNCLASSIFIED NL

3 OF 4

ADA036596

The urban runoff pollution load is known to be highly variable in intensity, frequency and duration of occurrence due to the interaction of the corresponding characteristics of rainfall and the pollutant accumulation and washoff process. Therefore, it is anticipated that urban runoff criteria will recognize this variability in being stated in statistical terms except where cumulative effects are of prime concern such as discharge of nutrients to a lake. It is further anticipated that the criteria for surface water discharge to streams and rivers will be of a compound statistical character combining the variability of the pollutant load with the variability of the flowing stream.

For a given intensity, duration and frequency of loading, different pollution parameters will have a significantly different impact. Thus, the various pollutant parameters introduce another degree of variability.

The pollutant parameters fall into the following categories with respect to setting the duration and level of concentrations in receiving waters:

1. Oxygen demanding
2. Coliforms
3. Nutrients
4. Toxicants

Biochemical Oxygen Demand (BOD)*

Under the oxygen demanding category, BOD is here considered as the indicator for the group. Since BOD is exerted in a fairly uniform manner over the first 5 days (during which about 60% of the ultimate

* Unless otherwise noted, BOD indicates 5-day BOD

BOD is exerted), very short durations of high oxygen demand may not be as significant as longer demands of lower intensity. A one hour bulge of high demand for example would be mixed and diluted before much of the demand could be exerted. A twenty four hour sustained high would extend over a long enough reach of the stream so that the mid part probably would not be attenuated by mixing.

The following loading conditions are selected for evaluation of the impact of 5-day BOD from urban runoff (URO):

1. The 24 hour BOD contribution associated with a 2 year return event tested against the long term mean summer flow for the lowest summer month.

2. The BOD contribution associated with a typical rainfall event tested against the 10 year 7 day low flow.

Actual criteria in the future will probably be expressed in terms of the allowable dissolved oxygen sag and its duration for specific frequency conditions. For the specific conditions of the receiving waters in this study, a depression of 1 mg/1 of DO or more at 24 hours is assumed as indicative of the possible need for abatement measures.* For typical summer temperature and flow conditions in the Spokane River such a critical level would be associated with a BOD of the combined river and URO flows in excess of 5 mg/1. To limit depression to the same amount after 3 days, the

Bacterial Pollution

Urban runoff has a highly variable index coliform bacteria

* Assumption is based on wasteload allocation for urban runoff using BOD loading which combined with wastewater effluent will not violate D.O. standards for "Class A" waters.

content but there appears to be no question that urban runoff total coliform levels exceed 1000 organisms per 100 ml more than 99 percent of the time and range upward into the millions of organisms per 100 ml for individual samples. Average values in excess of 10,000 organisms per 100 ml are observed for many Seattle test areas.

The total coliform requirements for Class A waters provide that the median count not exceed 240/100 ml and that less than 20% of the samples not exceed 1000/100 ml, when associated with a fecal source. Completely separated storm drainage is here interpreted to be a fecal source, although it would presumably be from other animal sources than man.

The foregoing regulation for Class A waters indicate that coliform levels higher than 1000 org/100 ml might be tolerated for very short times. To obtain a quantifiable basis for evaluation of the possible need for abatement of coliform pollution from urban runoff the following conditions and criteria are selected based on untreated URO being assumed to have a mean coliform concentration of 100,000/100 ml:

1. The receiving water total coliform concentration from URO sources not to exceed 1000 mg/100 ml when the URO from a 2 year 24 hour storm is tested against the mean summer flow for the lowest summer month.
2. The receiving water total coliform concentration from URO sources not to exceed 10,000 org/100 ml when the URO from a typical rainfall event is tested against the 10 year 7 day low flow.

Nutrients-Phosphorus. The concern for phosphorus is primarily related to the summer long and possibly year long accumulation in Long Lake. Therefore, short term peak levels are of no critical concern. Any long term phosphorus enrichment is the primary concern to such an extent that absolute quantities are not the measure of abatement needs but rather the long term accumulative total. The abatement need must be determined in relation to other sources of this same nutrient and the relative cost of its removal from the other sources as compared with removal from urban runoff and its related cost. For this reason, the selected test condition is a comparison of the annual and summer seasonal phosphorus loads from urban runoff with the background level in the receiving stream and the phosphorous quantity in the treated sanitary sewage effluents and other identified point waste sources.

Nutrients-Nitrogen. The short term concerns for nitrogen compounds relate to their potential for exceeding the drinking water standards for nitrates, which is 10 mg/l, and the potential for encroaching on ammonia toxicity levels. Nitrogen has not been identified as the potential limiting nutrient factor in Long Lake algael blooms due to the present abundance of phosphorus[1]. As in the case of phosphorous, absolute nitrogen quantities would not be the criteria for abatement, if such a need developed, but rather the relative quantity as compared with other nitrogen sources. For this purpose the annual and seasonal levels are selected for comparison with treated sanitary effluent and

---

[1] Refer to Soltero et al (1973) and (1974).

stream background levels as a matter of information but no attempt is made to evaluate possible need for long term abatement.

For evaluation of nitrate and ammonia toxicity, durations of less than 24 hours are not considered critical. The evaluation condition is selected as the yield from a 2 year return event of 24 hours duration tested against the mean flow for the lowest summer month. The limiting N level for ammonia toxicity is selected at 0.4 mg/l for short term exposure.

Toxic Substances. Many organic and inorganic materials can be classified as toxic substances, but there is a lack of data on specific levels of toxic substances in urban runoff except for lead which is believed to have its source in automobile fuels and is therefore of widespread occurrence. Since limited data are available for lead, it is selected as an index to possible need for toxic material abatement. The mean concentration of lead observed in Seattle area measurements of urban runoff is 0.30 mg/l. The USPHS drinking water standard limits lead content to 0.05 mg/l, a level set for continuous exposure. The USPHS standards do not specify limits for short term exposure. The application factors for conservative toxicants are given as not exceeding 1/20 of the established lethal concentration at any time or place and 1/100 for the 24 hour average (see FWPCA 1968). It is possible that intermittant short term concentrations of up to 5 times the USPHS standards might be tolerated for Class A waters. Such a determination should, of course, be made only by an appropriate regulatory agency after thorough investigation. For the purpose of evaluating the possible need for toxic substances abatement, the following comparisons are made:

1. The forecast URO pollutant load of level for a 2 year 24 hour event is tested against the mean stream flow for the lowest summer month to see if the concentration exceeds 0.05 mg/l, the USPHS standard.
2. The forecast URO pollutant load of lead from a typical rainfall event is tested against the stream 10 year 7 day low flow to see if the concentration exceeds 0.10 mg/l, twice the USPHS drinking water standard.

Forecast Urban Runoff

General. It has been demonstrated under the foregoing paragraphs on criteria for urban runoff pollution evaluation that the primary concern should relate to the total volume of runoff and its associated pollutant load over significant periods of time rather than in instantaneous or peak flow rates. The shortest period of interest is the typical rainfall event as a whole. Other periods of interest are the 24 hour event with stated return frequency, the summer season total and the annual total.

With the possible exception of an interest in determining the instantaneous peak coliform concentration in receiving water, the evaluation of significant pollutant load impacts does not require determination of the shape of the runoff hydrograph or the corresponding pollutograph. A computer methodology for synthesizing pollutographs and the necessary supporting data analysis from the literature are presented in Section 406.3. Implementation of this computer methodology is beyond the scope of this study but is a recommended ongoing procedure, particularly for its capability in providing a statistical basis for storage sizing as related to the City Plan of Study.

For the purpose of determining total runoff volumes, where the shape of the hydrograph is not required, the rational formula provides an adequate methodology. In order to determine the corresponding pollutant loads associated with runoff volumes calculated from the rational formula it would be necessary to use literature data on observed mean concentration of the various pollutant parameters. The methodology developed in Section 406.3 for computer application presents an alternative method of determining the pollutant yield independently and more specifically for Spokane rainfall patterns. A manual calculation using the methods of Section 406.3 is used to determine pollutant yields, results of which are converted to concentrations in the rational formula runoff for comparison with Seattle area observations as reported in U.S.C.O.E. 1974. General agreement with the observed Seattle area data substantiate the adoption of the methodology from Section 406.3.

Urban Runoff Quantities. The application of the rational formula requires the estimation of the impervious area and an appropriate runoff coefficient in addition to rainfall data.

The interest here is in estimating the flow which would appear at the point of discharge of a drainage basin collection system or which would percolate to groundwater where uncollected. For the highly permeable soils of the study area, the flows which would appear at the point of discharge of a collection system would include substantially only those impervious surfaces which are directly connected to the conveyance system. For example, an isolated roof discharging to ground surface would not reach the conveyance system. Where the determination is to be for the quantity to percolation, the runoff from such an isolated roof or paved surface would be tributary. Therefore, two values of impervious area are required, one a minimum value excluding impervious areas that are not connected to conveyance and the other a maximum value including essentially all impervious areas. Due to the permeable soils, the gross service area has minimal effect on the volume of runoff and adds another variable which would have to recognize density of development. The forecasts, therefore, are based on per capita impervious areas developed for the two conditions above.

Estimates of the overall impervious area of the sewered portion of the City of Spokane by Esvelt-Saxton/Bovay indicate that there is an average of 0.045 Acres per resident including impervious area associated with commercial and industrial as well as residential area. This estimate includes roofs connected to paved areas or drainage systems as "impervious". Similar calculations made for this study on a random sampling basis yield per capita impervious areas for the City, North Spokane and Spokane Valley as follows:

Service Area	Impervious Area, Minimum Excluding Isolated Surfaces	Acres per Capita Maximum Including All Surfaces
City	0.032	0.045
North Spokane	0.023	0.036
Spokane Valley	0.028	0.041

These figures are likewise overall averages including impervious areas associated with commercial and industrial land use. The smaller commercial and industrial component in the North Spokane Area accounts for the significantly smaller impervious area. It is assumed that these patterns will continue into the future so that the per capita figures are valid for forecast purposes.

Measurements made by Esvelt and Saxton/Bovay determined that a runoff coefficient of 0.7, based on impervious areas, was appropriate for the City. This same figure is adopted for the entire study area. From the isohyetal map, the mean annual rainfall for the three service areas are selected as follows:

Service Area	Mean Annual Rainfall, Inches
City	18.2
North Spokane	19.3
Spokane Valley	19.5

Combining the forecast populations of the three service areas for the period 1980 to 2020 with the above criteria for impervious area, runoff coefficient and mean annual rainfall, the forecast annual urban runoff is developed in Table 1.

Pollutant loads are computed in accordance with the method of

Section 406.3 based on the yield per typical event. Therefore, the identification and definition of a typical Spokane rainfall event are of primary interest. A year is selected for analysis with annual rainfall approximating the mean annual for the three service areas from the records of the Spokane weather bureau airport station. The selected year is 1971 which had an annual total of 18.48 inches. An "event" is defined as a storm with total precipitation of at least 0.1 inches in which the peak rate reached at least 0.03 inches per hour rate and was separated from another event by at least 24 hours. The results of the analysis are summarized in Table 2. On an annual basis, there are 49 events per year averaging 0.38 inches per event and 7-1/2 days between events. The spacing of events is uniform except during summer when the time between events doubles. The average percipitation per event, however, is remarkably uniform throughout the year. The length of storms is highly variable. For evaluation purposes an average length of 6 hours is selected for a typical event which is in the short range for a 0.38 inch event, usually lasting 1-1/2 to 2 days intermittantly, and therefore represents a more severe impact potential for evaluation.

In addition to the annual and typical event runoff, the runoff for the summer season and other specific rainfall events is required. The summer season is defined as extending from June 1 through September 30. Study of the annual rainfall pattern indicates that 20 percent of the annual rainfall occurs in this period.

The 24 hour runoff from storms of 2 years recurrence are also of interest. This event is defined from the Intensity-Duration-

Frequency curves for Spokane WBAS* (see Figure C of Section 304) as having an average intensity of .044 inches per hour of 1.06 inches per event.

Table 5 shows the forecast for year 2020 urban runoff for annual, summer season, 24 hour with 2 year return frequency and typical average rainfall event for the three service areas.

Urban Runoff Pollution Loads. In order to make an evaluation of potential pollutant wash-off more specific to Spokane precipitation and soil permeability, a calculation is made of the pollution yield based on the Lombardo and Franz equations and loading factors developed from the literature, all as shown in Section 406.3. The methodology developed in 406.3 is intended for potential simulation modeling. The calculation made here is a manual one for a typical rainfall year as defined above. The results are shown in Table 3 for a unit of impermeable area. Note that the results in Table 3 indicate a yield per impermeable acre approximately of the same order as the yield per gross acre from literature sources.

The resultant yields expressed as mean concentrations in the calculated Spokane runoff are shown below.

Parameters	Mean Concentration mg/l
BOD	15
Kjeldahl N	1.6
Ortho P	0.7

*Spokane Weather Bureau Airport Station.

These results are in good agreement with the range of values for BOD and Kjeldahl N measured for the Seattle area. The values measured at Seattle for Ortho P are substantially lower than the calculated values but within the same order of magnitude. A comparison with the Seattle area observations is shown below:

Parameter	Seattle Area Measurements for 6 acres, 32 events High	Low	Mean	Calculated Values
BOD mg/l	75	1	18.4	15
Kjel. N mg/l	7.6	.46	2.29	1.6
Ortho P mg/l	.31	.01	0.10	0.7

For the purpose of evaluating the impact of forecast potential urban runoff flows, a range of unit pollutant yields is selected. The calculated unit yields for BOD and nitrogen are taken as representative of the probable low end of the range and twice the calculated unit yields are taken as representative of the high range. For phosphorus, the calculated values are taken as representative of the high range and one fourth of the calculated values (still almost twice the measured Seattle area levels) are taken as representative of the low range. To be comparable with sanitary effluent loadings, the nitrogen data are converted from Kjeldahl (sum of organic plus ammonia) to total N and the phosphorus data are converted from ortho P to total P (ortho plus hydrolyzable) both by the ratios observed in the Seattle Area data. These ratios are not available from the basic Tulsa source used in Section 406.3.

The selected range of unit yields for evaluation purposes based on the above are summarized in Table 4.

The selected criteria in Table 4 are combined with forecast impervious areas for the year 2020 in Table 5 to develop ranges of forecast pollutant loads from the three service areas for annual, summer season, 24 hour two year return and average typical events. The 24 hour two year return event is assumed to have a unit pollutant yield of 2-1/2 times the typical event; there being no direct method of evaluating this relationship. This estimate is conservative since the typical average accumulation is approximately 60 percent of the maximum and the typical washoff due to a .38 inch rainfall event is also approximately 60 percent of that due to a 1 inch event. The year 2020 is selected for analysis to demonstrate the extreme condition in the study period. The corresponding levels at earlier years can be estimated in proportion to the forecasts for years 1980 to 2020 shown in Table 1.

Comparative Treated Sanitary Pollution Loads

One basis for evaluation of the impact of urban runoff pollution loads is a direct comparison with the corresponding sanitary pollution load from the same area. These data are also provided in Table 5 for the forecast treated sanitary effluent assuming 1983 effluent standards for activated sludge secondary treatment plus seasonal phosphorous removal.

Evaluation of Urban Runoff Impact

General. Tables 6 through 10 are presented to quantify the potential pollutional impact of the discharge of untreated urban runoff at forecast conditions in the year 2020. These tables are directly responsive to the selected disposal criteria formulated above. In each case the potential impact is evaluated for five conditions: (1) annual, (2) summer seasonal, (3) a mildly severe short range condition exemplified by 24 hour rainfall event of 2 year return interacting with a low mean monthly flow, (4) a very severe short-range condition in which a typical rainfall event impacts on a 10 year, 7 day low flow condition and (5) a commonly occurring short-range condition exemplified by a typical rainfall event interacting with the mean monthly flow for the lowest summer month.

Tables 6, 7 and 8 demonstrate the impact of the three service areas independently. Table 9 shows the combined impact of the City and North Spokane together and Table 10 shows the combined impact of all three service areas together.

The conditions at year 2020 are selected to show the maximum impact within the study period. Table 1 indicates the forecast growth for each service area and provides a means of estimating the earlier impacts in terms of the forecast maximum.

The evaluations in Tables 6 through 10 are in terms of assumed discharge to surface waters. Under the discussion of the Spokane Valley service area below, the impact of discharge to groundwater is also evaluated. The surface streamflow conditions for receiving waters are selected to best represent the probable point of impact relative to available gaging points. The separate discharge of the North Spokane service area is evaluated against the Little Spokane River Dartford gage which does not include the significant groundwater intrusion flow increment between Dartford and the mouth. The probable point of discharge of urban runoff is in the same reach in which the groundwater intrusion takes place. Hence, the evaluation against the Dartford flow is conservative and shows a more severe impact than would probably take place.

The City separately is evaluated against the flow represented by the Spokane River at Spokane gage which does not include the Hangman Creek increment. Since the Hangman Creek increment is small to negligible in the critical summer season, this selection makes only a slightly conservative approximation of expected conditions.

For the Spokane Valley separately, the Spokane at Spokane gage is also selected for evaluation although downstream from the probable point of impact. The natural point of concentration of the Spokane Valley service area is at a point below where substantially all of the groundwater intrusion increment has entered the Spokane River. Hence, the flow at the point of impact is better approximated by the Spokane gage than the other available gages which are upstream from the groundwater intrusion increment.

Combined service areas are evaluated against the Spokane River gage at Long Lake which is representative of the total flow below the Little Spokane River confluence.

To provide a measure of the natural background levels of pollutants of concern from urban runoff, the mean observed values of these parameters in the receiving waters are summarized in Table 11. The observed data are selected from available locations that best approximate "natural" conditions. For the Spokane River the data are from locations at the Idaho boundary. For the Little Spokane River the data are from a location near the mouth. The Little Spokane data take into account the changes that result from blending of groundwater increments but the Spokane River data do not. The mean values of the groundwater parameters are also shown in Table 11.

City Service Area. (Refer to Table 6.) On a long term basis the Spokane River provides large dilutions to the City urban runoff flows. Only for short term events is the dilution of the order of 10 to 1 or less.

With large dilutions over the long term the long term increment in pollutant parameter concentrations from urban runoff sources are small in an absolute sense, in comparison with natural background and in comparison with treated sanitary effluent from the same area. The only parameter which requires long term concern is the phosphorus increment. The potential summer season phosphorus enrichment from City urban runoff is 10,625 pounds compared with 41,000 pounds in sanitary effluent treated for P removal.

The short term potential impact of BOD on dissolved oxygen is below the estimated abatement need level for 24 hour 2 year return events. Significant dissolved oxygen depressions due to BOD in City urban runoff are shown to be only of short duration and infrequent occurrence. A BOD increment in excess of 5 mg/l is forecast only for the interaction of a typical event with 10 year 7 day low flow conditions.

Maximum forecast incremental nitrate and ammonia levels at 0.14 and 0.07 mg/l are not critical as compared with the respective limiting values of .014 and 0.175 mg/l.

Lead is at negligible concentrations for long term considerations but is at the USPHS limiting value for short term events.

Total coliform counts due to urban runoff are forecast to cause receiving water concentrations in excess of Class A water limitations for all short term events.

North Spokane Service Area. (Refer to Table 7.) The Little Spokane River provides relatively low levels of dilution of potential urban runoff flows from the North Spokane Area on both a long term and short term basis. For short term events, the dilutions are 4 to 1 and less. If the groundwater increment is added to the Dartford gage flow, the dilutions would be increased radically since the groundwater increment is approximately 200 cfs year around compared with the Dartford mean summer flow of 180 cfs and the Dartford 10 year 7 day low flow of 92 cfs.

The forecast BOD incremental concentrations for all short term events exceed 5 mg/l but would be reduced to at or below this limit if the groundwater increment is considered. The length of the Little Spokane River below the point of impact is less than 10 miles. Hence, even at very low flow velocities, the combined urban runoff and stream flow would have joined the Spokane River in less than 24 hours. The potential groundwater dilution and the short period before mixing with the Spokane River flow combine to cast doubt on whether BOD from North Spokane urban runoff would need abatement.

The potential summer season phosphorus enrichment from North Spokane urban runoff is 2,325 pounds compared with 11,400 pounds from sanitary effluent treated for P removal.

The forecast nitrate and ammonia incremental concentrations are a maximum of 0.40 and 0.21 mg/l respectively. The nitrate increment is not significant but the ammonia increment is half the limiting value and could be a problem if combined with another source. It is not proposed to add sanitary effluent to the Little Spokane so that combination with ammonia from that source is eliminated.

Lead is forecast at negligible concentrations for the long term but is in excess of the USPHS limit for all short term situations, ranging up to 2.34 times the USPHS limit. If dilution from groundwater increment is added, the lead concentrations are reduced to the same order of magnitude as the USPHS limits.

Total coliform counts due to urban runoff from the North Spokane service area are forecast to be over 20,000 org/ml for all short term events.

Spokane Valley Service Area. (Refer to Table 8.) Considered separately, potential urban runoff from the Spokane Valley is subject to such large dilutions in the Spokane River that the only parameter to exceed limiting values is total coliforms. Potential phosphorus enrichment remains a concern regardless of concentration and is discussed further below.

At present, Spokane Valley urban runoff is disposed of to groundwater via "dry wells" and general percolation. For percolation disposal, the pollution parameters of concern are those which can traverse the 40 feet or more of percolation through the soils overlying the saturated zone. It is generally recognized that the phosphorus and coliforms are subject to substantially complete removals and that BOD is removed to a very large extent. The nitrogen compounds are largely unaffected by the filtering action (it is assumed that application is below the root zone). The removal of heavy metals and organic toxicants is not established.

For constituents that can reach the saturated zone, the concentration in the applied wastewater flow is of concern since the degree of mixing in the groundwater may be small and the percolated wastewater may exist as a relatively unmixed layer on the surface of the native groundwater. On this basis, the concern for nitrates requires examination of the total N concentration in the urban runoff flow itself. This is shown in Table 5 to be in the range of 3 to 5 mg/l which is half of the nitrate limitation of 10 mg/l. There is no question that the percolate from urban runoff would represent a degradation of quality in this respect but it would not in itself be in violation of standards.

The concentration of lead in urban runoff is taken as a mean of .30 mg/l based on data obtained in the Seattle area. If concentrations of this order reach the saturated zone, they would constitute gross violation of the USPHS standard which is 0.05 mg/1.

Combined Service Areas. (Refer to Tables 9 and 10.) The service areas can impact separately only if alternative treatment or land disposal is applied to the other two service areas. Therefore it is of concern to evaluate the potential pollutional impact from combinations of service areas. Table 9 evaluates the combined impact of City and North Spokane service areas on surface waters of the Spokane River, showing the possible result of Spokane Valley continuing with a land application disposal for urban runoff. Table 10 evaluates the combined impact of all three service areas to surface water discharge.

Dissolved oxygen concerns due to BOD in urban runoff appear to be less than critical for both the City plus North Spokane and for all three service areas except for infrequent events of short duration. Since these combined impacts cannot reach their maximum until the flows are well into Long Lake, these concerns are specifically for Long Lake. If the proposed phosphorus removal program alleviates the algael blooms in the lake, reoxygenation in the future will be limited to normal surface transfer. Under these conditions, the maximum dissolved oxygen deficiency occurs at about the third day and a 1 mg/1 depression is caused by a 2.5 mg/1 BOD increment. This compares with the 2.42 mg/1 increment forecast for City plus North Spokane for the 24 hour 2 year return event and 3.1 mg/1 forecast for all three service areas for the same event.

The results for nitrates and ammonia for combined service areas indicate no critical conditions.

Total coliforms for combined service areas exceed Class A requirements for all short term conditions.

Lead concentrations approach or slightly exceed USPHS limits for all short term conditions for combined service areas.

The effect on summer season and annual phosphorus budget in Long Lake for combined service areas is of special concern.

The estimated natural total phosphorus background in the tributary streams on an annual and summer season basis are as follows:

	Annual Basis			Summer Season Basis		
Stream	Mean Flow cfs	Est. Mean Conc. mg/l	Annual Load Pounds	Mean Flow cfs	Est. Mean Conc. mg/l	Seasonal Load Pounds
Spokane R.	6,927	.0565	769,000	4,770	.024	74,000
Hangman C.	264	.246	128,000	36	.085	2,000
Little Spokane R.	316	.0598	37,000	180	.039	4,600
Total			934,000			80,600

The estimated present total P enrichment due to the existing City primary STP is 456,000 pounds on an annual basis and 150,000 pounds for the June through September summer season. The impact of the City sanitary sewage discharge is to be reduced by the requirement for phosphorus removal in the proposed plant expansion. By 1980, the expected total P load due to treated City discharges would be reduced to 93,000 pounds annually with year around P removal and to 31,000 pounds for the critical summer season.

At year 2020 the annual and summer season total P contributions in sanitary effluents treated for seasonal P removal are forecast to be as follows for the three service areas:

Total P in Treated Sanitary Effluent, Pounds

Service Area	*Seasonal* P Removal Annual	*Year Around* P Removal Annual	*Seasonal* P Removal Summer Season
City	520,000	123,000	41,000
North Spokane	144,000	34,200	11,400
Subtotal	664,000	157,200	52,400
Spokane Valley	217,000	51,600	17,200
Total	881,000	208,800	69,600

At year 2020 the maximum annual and summer season total P contributions from urban runoff for the three service areas are as follows:

Midrange Total P Washoff, Pounds

Service Area	Annual	Summer Season
City	38,500	10,625
North Spokane	8,440	2,325
Subtotal	46,940	12,950
Spokane Valley	15,000	4,150
Total	61,940	17,100

It can be seen that the forecast urban runoff enrichment for the critical summer condition is of the order of one third of the stream background and approximately one half of the treated sanitary effluent. The scale of the potential enrichment from urban runoff does not call for abatement as a first line of attack. Reduction of the urban runoff contribution would appear to be appropriate only if the already proposed reductions in the sanitary component prove inadequate. Entire diversion of the Spokane Valley sanitary flow from surface water disposal would reduce the total enrichment by as much as 60 percent P removal from all urban runoff flows.

Summary of Pollution Abatement Needs

It is shown above that there are no demonstrable absolute needs for abatement of potential pollution from urban runoff sources, per se, in the Spokane urban planning area. All apparent needs are conditional, some dependent upon the as yet unestablished short term pollution limits and some dependent upon the interaction with other sources of pollutants.

The need for BOD abatement is marginal and depends upon the frequency, depth and duration of short term dissolved oxygen depression that can be tolerated. Even when compared with normal long term standards, the expected potential dissolved oxygen depressions are not grossly excessive. The BOD removals incidental to storage would probably be sufficient to keep dissolved oxygen within long term standards. Therefore, the goal with respect to BOD abatement in general is set at achieving whatever reductions can be made through non structural approaches plus taking advantage of storage wherever possible. Specifically by service area the need for abatement is marginal for the City and Spokane Valley potential. For North Spokane, relatively low levels of removal such as 20 to 30 percent are judged to be beneficial.

The need for nitrogen removal from urban runoff for surface water disposal is not required for nitrate control or ammonia toxicity with one possible exception. For North Spokane urban drainage there is a possible need to consider ammonia reduction if other sources introduce significant ammonia into the Little Spokane River. This potential need exists because the short term urban runoff increment in this case approaches 50 percent of the long term ammonia limit. The nitrate potential in undiluted urban runoff is of the order 15 percent of the USPHS limit. Therefore, percolation of undiluted urban runoff to groundwater, while obviously causing a degradation in quality, would not exceed the long term limits. Nitrogen abatement measures are judged to be not required for any service area.

Any phosphorous discharge to surface waters no matter how small is an addition to the enrichment of Long Lake. Therefore the need for phosphorous removal from urban runoff, although small in an absolute sense must be weighed against the relative cost effectiveness of further offsetting reductions from other sources, primarily the sanitary component of the wastewater flow. The urban runoff phosphorus potential is approximately one half that from sanitary effluent treated for phosphorus removal. At this time it is not known whether this combination of untreated urban runoff and treated sanitary effluent will be a nuisance or not. Considering the enormous difficulty of trying to treat urban runoff for phosphorus removal by present technology, other alternatives would deserve first consideration if further reduction in the phosphorous budget were found necessary. Diversion of urban runoff to either land application or groundwater disposal are two possibilities. Although phosphorous abatement from urban runoff sources cannot be identified at this time as an absolute need, the potential attack on this source through land application or groundwater disposal should be kept in mind while selecting alternatives.

There is no doubt that urban runoff will cause short term conditions of total coliform counts that are far in excess of Class A stream standards. The public health consequences of these short term excesses are a function of the specific kind of recreational demands that are being put on the receiving waters. If there is a need to have the receiving water available for unrestricted body contact recreation such as swimming at all times, including periods of inclement weather, abatement by disinfection is required. Disinfection by chlorination however, must be recognized as creating a threat to use of the stream as a fish habitat. The risk in creating excessive chlorine residuals or toxic chlorine compounds is much higher where application is to highly variable uncontrolled urban runoff flows. Although an absolute unqualified need for disinfection cannot be identified, selection of alternatives should recognize the threat and take every advantage of reducing the coliform count by all measures from non structural ones to consideration of storage to control flow and make disinfection reliable or diversion of flows to land application or groundwater discharge. The coliform removal by percolation is expected to be satisfactory for the depths to groundwater in this particular area.

The short term threat of toxicants to surface water, exemplified above by lead, is marginal in an absolute sense when compared with long term standards and further because the standards are uncertain. The accepted drinking water level for long term exposure to lead at 0.05 mg/l is not based on any epidemiological or toxicological evidence (Journal AWWA, February 1975). Therefore the threat posed by short term low level excesses over the long term standards cannot be evaluated, particularly for recreational exposure and fish habitat as opposed to potable water supply. The specific need for treatment removal is not seen at this time but the known undesirable nature of this pollutant should be attacked by non structural means at the source, namely use of unleaded auto fuels. A literature search for data on the ability of soils to remove lead disclosed no specific data. The ability of soils to remove other heavy metals is believed to be indicative of the action on lead but this should be confirmed by specific research to justify percolation disposal.

One pollution impact not discussed above, since it cannot be quantified, is the aesthetic concern for unsightly floating materials and scums which can result from untreated urban runoff. This is a pollution concern that requires abatement for all urban runoff flows regardless of source.

The City of Spokane uses salt for street deicing in the winter. The significant amounts of salt used are discharged to the Spokane River through storm drains, combined sewer overflows and by combined sewage treatment since treatment does not remove salt. Since the time of salt use and runoff is coincident with higher flows in the river, there have been no identified excesses in the receiving waters. In addition to corrosion of treatment plant elements, there are potential adverse environmental impacts due to use of salt for deicing. Refer to U.S. Environmental Protection Agency publication "Environmental impact of highway deicing." It is recommended that alternatives to use of salt, as pointed out in this same publication, be investigated for possible future implementation.

Flooding Potential of Urban Runoff

City of Spokane. The forecast growth in volume of urban runoff from the City of Spokane service area is relatively small corresponding to the small forecast population growth. The forecast annual volume of urban runoff is expected to grow from approximately 6000 acre feet per year in 1980 to approximately 7000 acre feet in year 2020, based on flow from connected impervious surfaces. Depending upon the degree to which other impervious surfaces are joined to the system, the forecast annual discharge could range up to 8500 acre feet in 1980 and 9800 acre feet in 2020. The maximum level of discharge at 2020 is equal to a mean daily flow of 8.72 mgd or 13.5 cfs. This discharge is less than 0.2 percent of the mean annual discharge, 6,927 cfs, of the receiving water, the Spokane River. The potential unrouted instantaneous peak discharge for a 2 hour storm of 10 year return frequency is 2381 cfs which is 6.5 percent of the calculated 10 year flood flow of the Spokane River. The forecast volume of urban runoff is not a significant increment to the flooding potential of the Spokane River.

The City of Spokane north of the Spokane River has generally adequate natural slope for drainage but no distinct natural system of drainage channels. The existing system of combined sewers in general follow the natural drainage pattern. Drainage problems within the City exist due to lack of sewer capacity and in some case deliberate ponding to minimize peak wet weather flows in the combined sewers. South of the Spokane River the drainage pattern is more typical in that there are areas in which there are natural drainage channels. There are also areas of swamp and spring outcrops. Here the combined sewer problem is compounded by the presence of infiltration flows. The City study program is directed toward solution of these existing internal flooding problems concurrent with resolution of the combined sewer overflow problem. It is not the intent of this report to duplicate the planned City effort in either of these fields.

North Spokane. There is a natural drainage way through the North Spokane development that has been improved as an urban drain. This drainage discharges into the Little Spokane River. This natural drain does not serve the entire area. A collection system extended to serve the runoff from streets, sidewalk and commercial parking lots and buildings could be expected to grow from an annual discharge of 446 acre feet in 1980 to 1618 acre feet by year 2020. On an average annual flow basis, the year 2020 discharge is equal to 1.44 mgd or 2.23 cfs. This is only 0.7 percent of the mean annual discharge, 316 cfs, of the receiving waters, the Little Spokane River. The potential unrouted peak discharge for a 2 hours storm of 10 year return frequency is 372 cfs* which is 14 percent of the calculated 10 year flood on the Little Spokane River. Therefore, the forecast potential increase in runoff due to urban development in the North Spokane suburban area does not significantly affect the Little Spokane River flood potential.

Certain locations in North Spokane currently experience flooding due to a combination of runoff from urban development and runoff from presently undeveloped areas which must pass through developed areas. This current flooding problem is evaluated, preliminary plans for its alleviation by the County are described and a recommended plan of action is developed in the following paragraphs.

The area of most concentrated existing development in the

*This mean discharge over a two hour event should not be equated with routed instantaneous peak flows for internal drainage design.

North Spokane planning area is in subunit NS-3. Portions of this area suffer from flooding from three causes. One cause is encroachment on and restriction of the primary natural drainage path that extended through the area. This first cause is aggravated by the second cause, namely, the increase in runoff due to development. The third cause is topographic, resulting from local low spots that do not have natural surface drainage.

A natural drainage way existed prior to development extending from the center of Five Mile Prairie to the Little Spokane River through what is now the Country Homes and Whitworth College areas of North Spokane. The route of this drainage way begins in agricultural lands in the vicinity of Strong and Five Mile Roads on Five Mile Prairie and runs southeasterly through an undeveloped canyon approximately 1.2 miles to the southeast base of the plateaus in the vicinity of Country Homes Boulevard and Cedar Road. At this point the natural flow line turns north. The first 1.1 miles north follows Country Homes Blvd., mostly as a paved ditch in the median of the divided roadway. About 400 feet north of Carolina Way, the drainageway leaves Country Homes Blvd. and continues north 2.0 miles meandering through private property along back lot lines and across lots. There are at least eleven culverts at road crossings through this reach. At Waikiki Road (Wall Street extended) and North Five Mile Road, the drainageway emerges from developed lots and generally follows parallel to Waikiki Road for 0.6 miles until its starts down a canyon at the north side of the Spokane Country Club golf course, continuing about 1.1 miles to the

Little Spokane River.

The areas along this natural drainage way that are currently subject to flooding are from the north end of the paved median ditch in Country Homes Boulevard to Graves Road where the drainage way is through private property and six road culverts.

In addition to these areas along the primary drainage way, there are local low areas at the following locations that are subject to varying degrees of flooding.

1. Wall Street and Rhoades Avenue. This area extends several blocks in all directions including into Holy Cross Cemetery which is practically all in a sink.
2. South of Country Homes Boulevard west of Division Street, a low spot located at the point of concentration of an extensive area south to Price Road.
3. An extensive area at the foot of the slope north of Whitworth College.
4. Both east and west of Division Street in the vicinity of Holland and Westview.
5. South of Holland at Ivanhoe.
6. South of Whitworth Drive west of the drainage way.

Some of the drainage problems described above and located in Figure A were the subject of extensive preliminary investigations by the

County Engineer's office, particularly with respect to the primary drainage way. As many as seventeen alternative plans have been developed for a solution to the primary drainage way problem. The basic philosophy of these alternative plans is diversion of tributary flows upstream from the section through private property to relieve that section to flows which cause negligible damage or inconvenience. There are no available estimates of historical damage for either the main drainage way or for the local low areas.

There is an institutional concern and a concern for the effect of future development associated with the upstream end of the tributary area on Five Mile Prairie. The tributary area upstream from the Cedar Road culvert is 1126 acres which is 48 percent in the City of Spokane but is presently either undeveloped or in agriculture. Significant proportions of the present agricultural lands are forecast to become residential development, mostly in the City part of the tributary area. One of the physical features of the area considered in the County alternatives are the gravel pits north west of the intersection of Francis Avenue and Cedar Road. These pits are considered for possible use as retention and percolation ponds for all or a portion of the runoff from the tributary area on Five Mile Prairie.

Appendix II lists the seventeen alternatives and their estimated construction costs, adjusted to mid 1974 price levels, studies informally by the County Engineers office for relief of the natural drainage way through private property. It is understood that these alternative plans represent facilities sized for flows associated with a return period of 5 years. No formal action has been taken to select or implement one of these plans. These alternative plans do not address the local drainage problems that exist separately from the primary natural drainage way.

To indicate the scope and kind of problems involved, one of the lower cost solutions shown in Appendix II is described more fully as follows. Concept Number 8 is selected for description. This plan calls for diversion of all the flow from the area on Five Mile Prairie presently tributary to the Cedar Road culvert to the old gravel pits north west of the intersection of Francis Avenue and Cedar Road for disposal by percolation with no overflow to surface conveyance. (The costs of this diversion are not included in the estimate of County work.) This diversion relieves the natural drainage way of an estimated 253 cfs of flow. A detention pond would be constructed at the upstream end of the existing Country Home Boulevard median ditch in the area east of Country Home Boulevard and Excell Drive to further reduce the flow from local inflow. The existing median ditch would remain unchanged. From the downstream end of the median ditch in the vicinity of Carolina Way underground piping would be constructed to the natural ponding area west of Wall Street north of Price Road replacing the natural drainage way in this section. The natural ponding area would be retained for further flow attenuation. The outflow from the ponding area is calculated to have been reduced by diversion and ponding to 123 cfs which is estimated to be within the safe capacity of the natural drainage way of 150 cfs so that the flow can continue from this point in the natural drainage way. Underground piping would continue in Wall Street beginning at Jay Avenue to intercept all drainage west of Wall Street from reaching the natural drainage way and continue to College Road where it would discharge into the natural drainage way downstream from the critical section. The above described Concept No. 8 is one of the lower cost alternatives at $295,000 construction cost, at 1974 price level. Other alternatives range up to almost one million dollars construction cost and include concepts that involve complete by-passing of the natural drainage way with underground piping.

It is judged to be premature to select and recommend a plan for implementation based on the work to date. The following action plan is recommended.

1. Complete an inventory of existing drainage facilities in the area. There is no existing complete compilation of existing facilities including County, private developer, Rural Improvement District, State (associated with Hwy. 395) and City.
2. Complete a maximum "no damage" and a maximum "nominal inconvenience" water surface for the natural drainage way and the associated flow capacity for each.
3. Complete a detailed inventory of unmet needs for drainage relief throughout the area.
4. Make physical flow measurements of the existing rainfall-runoff relationship for the Five Mile Prairie tributary area.

5. Make physical measurements of the infiltration capability of the existing gravel pits.

6. Establish design criteria for analysis.

   a. Level of future development to be provided for in Five Mile Prairie and related surface imperviousness.

   b. Level of protection, return period, of conditions which cause damage or inconvenience.

   c. Methodology for runoff calculations and hydrograph volumes.

7. Establish a working relationship between City and County for how alternatives will be presented to policy levels of both where solutions involve responsibility and costs to both parties.

8. Prepare an overall integrated drainage plan for the entire area before undertaking any piecemeal solutions.

9. The overall drainage plan should consider minimizing the impact of urban drainage on surface water quality. The location of the terminus of the natural drainage way at the Little Spokane River appears to present an opportunity for storage in the flood plain which could be utilized to effect economical treatment for the primary concern of bacteriological contamination.

10. The overall drainage plan should consider non-structural alternatives for minimizing increases in runoff from future development by regulation of such development to utilize on-site retention.

Spokane Valley. At present, with a few minor exceptions, substantially no urban runoff reaches the Spokane River from the existing urban development. The forecast volume of runoff, should a collection system be constructed, would represent a negligible addition to the flood flow potential of the Spokane River. The forecast unrouted instantaneous peak flow from a 10 year 2 hour storm at 2020 development is 660 cfs which is only 1.3 percent of the 100 year flood of the Spokane River.

Although there were and are no natural streams on the surface of the Spokane Valley due to the highly permeable soil, the topography has a configuration similar to land shaped by surface runoff, consisting of a system of low ridges and swales paralleling the river and converging on a natural point of concentration in the vicinity of the east end of Felts Field. Therefore, any collection system for urban runoff would necessarily follow these land forms. The potential for flooding due to urban runoff is related to these same land forms. Once the collection process is started, any inadequacies or failures of the system would be concentrated along the bottom of these swales. At present there are no valley floor collection systems, all runoff disposal being to dry wells or surface percolation. In general these facilities provide adequate drainage.

Pasadena Park on the north side of Spokane Valley is not currently experiencing any critical urban flooding problems but it presents examples of two typical situations which are of growing concern. One situation involves development from the valley floor up into the bordering slopes in an area of relatively impervious soil where some storm sewers have been constructed. The other situation is where there is already unsewered development on the valley floor and development is beginning in the bordering slopes. Refer to Figure B for locations of drainage problems.

The first situation is exemplified by County Road Project 1101 in Elton Road above Upriver Drive. There is a large undeveloped area above this storm sewer project which picks up the natural runoff from the undeveloped lands and conveys it and local drainage through developed lands on the valley floor. An example of future conditions is presented in the proposed Northwood addition which will become tributary to this existing storm drain system. If uncontrolled, the new development in previously undeveloped area will increase the peak flow reaching the storm drain system. A small increment like Northwood will probably not overtax the existing facilities. But a succession of similar developments will eventually exceed the capability of the downstream system.

The second situation is demonstrated by areas farther east in Pasadena Park where the valley floor extending from the boundary slopes is permeable and has been developed without storm drainage systems. When development takes place in the relatively impermeable bordering slopes, the resultant increased runoff is confronted with development which has encroached on the pervious valley floor. When the runoff becomes large enough or the area for percolation small enough, flooding is the result. A proposed new subdivision northwest of Argonne Road and Wellesley Avenue has been approved by the Spokane County Planning

Commission contingent upon a solution of the storm runoff disposal problem by on-site percolation. This particular development is fortunate and unique in that it extends onto the permeable valley floor far enough to provide its own percolation area. This will not be true for most future development in the bordering slopes which will be confronted with a valley floor already developed.

The Bannen Road area in Trentwood is another example on the north side of the valley of a growing concern for the relationship between drainage of the bordering slopes and the valley floor.

On the south side of the valley there is an unusual example of the potential problem from bordering slope drainage associated with Chester (also known as Plouf) Creek. Chester Creek above Schafer Road drains an area of approximately 14.5 square miles, extending almost to the community of Mica south of Spokane Valley. The main branch of the creek, the Union Pacific Railroad and the Mica-Dishman Road, follow parallel routes from the vicinity of Mica to Chester. The creek is east of the Mica-Dishman Road as it reaches the floor of the valley. North of 44th Avenue the creek turns westward and crosses under the Mica-Dishman Road. The last half mile before crossing the Mica-Dishman Road the creek channel appears to have been straightened as it passes through agricultural lands.

After crossing under the Mica-Dishman Road, the creek continues northeasterly about 1000 feet between the road and the railroad then crosses westerly under the railroad. This point of crossing is at the south easterly limits of development of the community of Chester which occupies the space between the Mica-Dishman Road and the railroad. After crossing the railroad, the creek parallels the west side of the tracks, crossing Bowdish Road, and continuing approximately 3000 feet before recrossing the tracks to the east about 1200 feet from Schafer Road. There is an extensive low area west of the railroad tracks at the recrossing. After recrossing the railroad, the creek swings north toward the Mica-Dishman Road, paralleling the road, crossing Schafer Road and then turning west again toward the tracks. The creek begins to parallel the track about 700 feet north of Schafer Road where there is another sink on the west side of the track. The creek continues north between the road and tracks to 26th Avenue where it crosses westerly under the tracks in two culverts. The path of the creek north of 26th Avenue west of the tracks is at a very flat gradient, about 1 foot per 1000, becoming indistinct and essentially disappearing before reaching 16th Avenue. Between 16th Avenue and 8th Avenue, the grade diminishes further and the area between the tracks and the edge of the valley is occupied by a development along Dishman Road.

The tributary drainage area of Chester Creek upstream from Schafer Road is larger than that of Liberty Lake but the creek has no surface outlet to the Spokane River and does not result in a lake. The entire flow percolates into the valley gravel. The locations at which the percolation takes place are not known but the surface flow does not appear to extend north of 26th Avenue. There has been little damage from flooding by Chester Creek to date. Bowdish Road has been inundated. There has been inconvenience flooding of a few residential lots in

Chester. When flows are high and in excess of percolative capacity by the waters pond and spread out over adjoining low land from south of Schafer Road to the vicinity of 26th Avenue. There is concern by the County that percolative areas will be blocked by filling, as now taking place both north and south of Schafer Road or that development itself will take place in the ponding areas. At present the lands are private property and there are no drainage easements or zoning restrictions on use or development.

The foregoing specific examples of growing concern in Pasadena Park, Trentwood, and Chester creek call for the formulation of a general policy to deal with these situations before they become critical problems. A recommended plan of action is as follows:

1. Develop a master drainage plan for the bordering slopes of the entire valley which recognizes the present and forecast runoff and provides for its disposal by one or more of the following alternatives:

   a. Restriction of development on the historic percolation area.

   b. Substitution of an alternative percolation area or subsurface leaching.

   c. Extension of drainage conduit to the river.

2. Develop a policy for storm drainage of slope areas that recognizes the requirements for capacity in these systems to accommodate forecast runoff.

3. Investigate the legal problems that are inherent in both the structural and non-structural aspects of these policies. For example:

   a. To what extent is a downhill developer obligated to provide excess capacity in his system to accommodate flows due to future development.

   b. How can property owners be obligated to reserve certain areas for percolation of runoff flows generated off of their property that may or may not have percolated in that specific site.

Evaluation of Urban Runoff Pollution

General. Elemental alternative measures for urban runoff pollution abatement are summarized in Table 12 under two categories, non structural and structural. These elements may be combined in various ways to arrive at a basic formulation of urban runoff water quality abatement management alternatives. These elemental measures, both structural and non structural may be considered as plan components which may be assembled in various combinations to yield a variety of management alternatives. Not all of these elemental concepts are equally effective for reduction of all pollution constituents; some are specific to only one or a few pollutants. The following evaluation of urban runoff treatment elements is presented as an aid in understanding the relative effectiveness of these elements, which is necessary in determining effective combinations thereof which may be considered as urban runoff plan alternatives.

Abatement Alternative Elements. It should be stated prior to venturing into a discussion of the relative merits of various urban runoff treatment technologies that this area of interest is the subject of continuing research and development which to date has resulted in limited success in terms of physical or chemical treatment methods. It should be recognized that solutions to the problem of preventing the degradation of water quality by urban runoff have not been demonstrated to any significant degree with regard to either efficiency or reliability. Many technical concepts consist of theoretically feasible ideas on how the problems might be solved. This and the lack of clear regulatory guidelines on the subject severely limit the feasibility of recommending any definite plan for urban runoff water quality control plan at this time. This is in keeping with the current EPA policies.

The following evaluation of the methodologies outlined in Table 12 is intended to generally compare effectiveness of these various plan elements:

Non-Structural Methods

1. Land Use Control affords opportunities to effect limited URO quality control in newly developing areas and areas of redevelopment. Land use control is not a primary strategy in abating URO water quality control problems. It is more accurate to recommend that consideration of URO problems should influence land use control policies.

2. Impervious Surface Connection Regulation, whereby some control of the extent of impervious surfaces is exercised, is very difficult to evaluate, except to observe that some control is better than no control. The physical concepts involved are

based on the idea of providing urban runoff maximum opportunity to percolate to soils and to contact plants and root systems which are capable of effecting nutrient removals. This concept has obvious limitations with regard to roadways, except in cases where grassy median strips might be used. It has more applicability to parking areas where dividing landscaping features would also be an esthetic benefit. It could apply in the form of impervious area setbacks around buildings where roof drainage could be spread prior to discharge to a storm drain.

There are limited opportunities, particularly in the City of Spokane, for reduction of flow or quality impacts of urban runoff by diversion of impervious area drainage to local percolation. Social impacts of this concept are negligible. Environmental impact is positive both from a water quality aspect, as well as the potential for enhancement of the landscape.

3. Regulation of Construction Operations should be carried out to the extent of requiring diking around earthmoving operations which would be susceptible to significant erosion. Consideration of limiting operations during wet periods should also be considered where a particular hazard is recognized. Due to the gravelly and rocky nature of soils in the Spokane urban area, this water quality degradation source is limited.

4. Litter Laws and their enforcement provide an opportunity for significant source control of URO water quality as an adjunct to a good surface housekeeping program. Difficulty of

enforcement limits the effectiveness of this concept and requires that effectiveness be based primarily on a good public education program.

5. Surface Housekeeping is by far the most effective non structural URO water quality impact control technique. Street sweeping and related surface housekeeping measures are considered to be the most effective method in comparison with most structural alternatives other than complete storage and ultimate complete wastewater treatment. The cost of surface housekeeping is normally considered to be justified by the related esthetic benefit. Efficiency and reliability of this method of URO quality impact abatement is considered to be very good relative to mechanical and chemical treatment systems.

6. Use of Unleaded Gasoline for automobile fuel is effective in removing surface deposits of lead. The degree of effectiveness relates directly to the proportionate required usage of unleaded fuels.

Structural Methods

1. In-System Storage, as with all storage alternatives provides for treatment by sedimentation which removes contaminants by gravity separation and prevents them from being carried into the receiving surface water. This method is most cost effective where natural storage is available or where other structures can be modified to provide storage as a secondary function at little increase in cost. In-system

storage cost and efficiency depend on the type of system used, which may include the following:

a. Ponding in streets and parking areas is limited in applicability since this limits the primary use which is normally considered to be of much greater benefit. Effectiveness depends on design and frequency of surface cleaning.

b. Rooftop ponding does not interfere with the primary function of a roof and is cost effective unless major structural revisions are required. It is limited to utilization with flat roofs and is limited to the beneficial effects of reduction in peak flow. Roof drainage in itself is not a major source of urban runoff pollution.

c. Ponding structures afford reliable removals at reasonable cost if good sites are available where earthen structures can be utilized or constructed at reasonable cost. If natural sites are not available, the cost of concrete or other structures of significant size to provide adequate detention to accomplish good removals, is relatively high. Natural earthern structures will have a more desirable impact on visual quality of the landscape than concrete structures and can be incorporated into water features of park or other open space development.

d. Oversized conveyance systems are of limited usefulness in providing storage due to the limited volume and high unit cost of sediment removal limits the realistic application of this option.

e. Conveyance system regulating structures are utilized to make the most of available system storage capacity to minimize the overflow from combined storm, sanitary systems. Effectiveness of this system is limited to relatively low intensity storm events except where gross oversizing is accomplished. This method is of somewhat limited effectiveness and requires careful operation and control to avoid compounding the problems of overflow bypass resulting from excessive detention at the wrong time. At lower flows, utilization of this storage prevents overloading of treatment facilities by dampening peak flow characteristics. This method is normally a stop-gap solution where total storm water separation is considered too costly.

2. Terminal Storage offers the most effective functional means of controlling quality impact of urban runoff. Terminal storage with post-storm-peak treatment with sanitary wastes provides maximum reliability, contaminant removal and disinfection. Utilization of off-peak sewage treatment capacity is cost effective. The major problem with this alternative is the requirement for total conveyance and storage at a single point of concentration which may require very large peak conveyance capacity, large pumping capacity, and an adequate site to develop the necessary storage facility. Terminal storage may provide for storage of excess combined flows or for separated urban runoff flows. Costs of this alternative are heavily dependent on complications of conveyance and the availability

of a storage site, both of which are very difficult considerations for the City of Spokane.

3. Groundwater Recharge of urban runoff to the maximum extent possible is generally regarded as an optimum goal in urban runoff management, particularly with regard to recharge of runoff before significant quality degradation takes place in terms of retention on the land nearest the point of rainfall. Recharge of contaminated runoff affords a reasonably effective and economical means of nutrient, BOD, and bacteria removal. The primary concerns relate to possible degradation of groundwater with dissolved minerals, stable organics, virus and the combined effect of accellerating the leaching of sanitary wastes. The effects of the leaching of lead and other toxicants are relatively unknown and are dependent on soil chemistry. Groundwater recharge of urban runoff, where permeable soils are available to make this technique feasible on a large scale, such as in the Spokane Valley, is very cost effective and will result in minimum impact on surface water quality.

4. Treatment of Separate Urban Runoff to date is the subject of considerable experimentation with less than conclusive results. Urban runoff, free of the problems associated with combined sewage systems, does not constitute a major water quality impact, and, to date, has not been the subject of definitive guidelines. Technological approaches to separate URO treatment include the following:

a. Sedimentation provides reliable removal of a substantial amount (up to 50%) of the BOD and suspended solids content of urban runoff. Sedimentation is reliable because of the lack of complex equipment. The major drawback of sedimentation is the requirement for large detention volumes to permit sedimentation. This can be costly unless natural basins can be utilized.

b. Skimming is a mechanical process of removing floatable matter which is visually offensive. This does not effect a major overall quality improvement and is usually accomplished in conjunction with other mechanical methods such as sedimentation. Effective skimming of floatables requires almost the same degree of quiescent flow as for sedimentation to permit a high degree of removal.

c. Screening has been the subject of a great deal of research with regard to urban runoff treatment since it can be accomplished in smaller structures without the need of the large detention structures that are required for sedimentation and skimming. Screening is not very effective and is not reliable due to the vulnerability to clogging with screened matter and biological slimes. Screening is normally utilized for the removal of larger particulate matter. Screening can be accomplished fairly economically, but does not accomplish a very high level of removal. It is normally utilized in conjunction with other treatment.

d. Flotation is employed to increase the efficiency of removal of floatable materials, particularly oil and grease which are brought to the surface more rapidly by flotation. Flotation requires quiescent flow. This is a fairly costly process, particularly at the scale required to treat large volumes of urban runoff. This technique is more appropriate to treatment at locations subject to high localized levels of oil and grease contamination.

e. High rate filtration provides for a higher degree of removal than is effected by screening or sedimentation and normally would follow these processes to effect additional removal of fine suspended and dissolved matter. Even at high rates, the process has limited applicability to the large volumes of urban runoff flow and is therefore costly.

f. Microstraining provides physical removal of particulate matter by straining, utilizing equipment designed to remove particles of smaller size than is normally removed by screening. Microstraining is intended as a substitute for removal of particulate matter which would be removed by sedimentation without the need for the large basins required for detention. Microstraining generally falls well short of this goal and is subject to the problems of clogging and biological growths which reduce efficiency and are the cause of maintenance problems. Microstraining has been applied most commonly to installations designed to improve the quality of bypass overflow of combined sewers.

g. Chlorination of urban runoff flows for control of bacteria contamination is very difficult because of control problems and the dosage rates required to disinfect large flow quantities. In order to raise chlorine concentrations to disinfection levels, large dosages are required over a short period of time which require large and costly chlorination installations, subject to reliability problems resulting from intermittent usage. This practice is fundamentally questionable due to the problems of toxicity from the large dosage required.

5. Treatment of Urban Runoff with Sanitary Sewage

a. Treatment of combined urban runoff and sanitary flows without storage requires the installation of treatment facilities sized to meet storm water generated peak flows or the acceptance of greatly reduced treatment efficiency at peak flow in facilities sized for the sanitary component. The former is not cost effective and the latter is generally not acceptable. Storage of combined flows, other than in conveyance structures subject to flushing, is subject to severe odor problems due to settled sewage or requires that sludge removal, mixing and/or aeration be provided in storage facilities. These factors and the large storage volume required are quite costly and must be weighed against other systems.

b. Treatment of stored separate urban runoff utilizing off peak sewage treatment capacity would improve quality only to the extent of removals by secondary treatment, since storage would provide primary treatment. Storage needs are substantial and total water quality impacts are of questionable benefit due to the reduced effectiveness of secondary treatment as a result of dilution of sanitary wastes and the fact that post-storm discharge at a lower stage of flow in the receiving water would be more critical. Costs are high with questionable benefit.

6. Stormwater Separation eliminates the water quality impacts resulting from combined flow bypass overflow or backup.

a. Separation of new facilities prevents further complication of problems caused by combined sewerage systems. This policy is questioned only on the basis of speculation that separate treatment of urban runoff may be required, and that combined treatment of wastes may be more efficient.

b. Separation of existing combined systems would eliminate bypass overflow and would reduce water quality impact from urban runoff to the level of urban runoff alone, without the compounded impact of bypassed raw sanitary sewage. Separation of sewerage systems would involve extensive construction throughout 70% of the City of Spokane. Economic justification relates to the cost and effectiveness of other combined treatment alternatives and the extent to which reconstruction of old combined sewers is justified to replace deteriorated facilities and recognition that regardless of separation needs, there is a need for greater combined or separate flow capacity in those areas subject to backup of raw sewage onto public streets or into basements.

Social and Environmental Impacts of Urban Runoff Pollution Abatement Measures

The potential social impacts of the preceding described non-structural urban runoff measures have been mentioned and are limited to potential indirect social impacts relating to land use policies which are responsive to urban runoff pollution abatement measures. The identifiable social impacts related to this land use consideration is not expected to be significant. The potential social impacts of considered structural URO treatment measures is limited to those options which would require dedication of large areas of land for storage or spreading. Extensive relocations for this purpose are not likely in consideration of specific sites available at this time. Otherwise social impacts of considered structural URO treatment measures are considered to be positive. Certainly the potential to eliminate the hazard of sewage overflows and backflows into streets and basements will be a positive social influence in neighborhoods presently afflicted in this manner.

The potential environmental impacts of all measures described is positive in terms of pollution abatement. The relative effectiveness of measures in this regard is previously described. Added environmental impact of non-structural measures is limited to the positive environmental impacts associated with concepts such as interspersing paved areas with landscaped median strips and good housekeeping practices which also improve the appearance of the community. Other than structural measures involving large detention structures, non-water quality environmental impacts of structural measures are negligible. Large concrete storage structures could have a major visual impact which would be mitigated by selection of site locations away from public view. Large earthen storage structures can be designed to provide a beneficial environmental impact. The major visual problem with these structures will be associated with zones of surface fluctuation and sedimentation deposits.

Alternative Responses to Urban Runoff Pollution Abatement Needs

City Service Area. Since the City is committed to a detailed plan of study for solution of the combined sewer and associated internal flooding problems, the objectives here are to point out the implications of urban runoff pollution potential that should be considered in these studies. As shown above, the primary abatement needs relative to the urban runoff component of City wastewater flows are:

1. Removal of unsightly floating materials and scums.
2. A small reduction in BOD impact.
3. Disinfection.
4. Reduction in lead content.

The impact from the sanitary component of combined flow, particularly grease which forms floating scum, BOD due to stranded solids and high coliform content are judged to be more serious than the urban runoff component and continue to deserve highest priority in the alternatives for dealing with combined sewer problems. There appears to be no incentive to route urban runoff flows through complete treatment for their own sake.

The alternatives mentioned for consideration in The City Plan of Study are evaluated as follows for their respective values in meeting urban runoff pollution abatement needs:

1. Storm relief sewers with satellite treatment facilities, no storage.

   This alternative would treat unregulated combined flow by one of the several methods feasible for highly varying flow and highly intermittant operation. The feasible treatment alternatives are:

   a. Screening

   b. Flotation

   c. Chlorination

   This alternative could satisfy the need for removal of unsightly floating materials and for disinfection. It probably could not achieve any reduction in BOD below that which would be obtained in completely separated untreated urban runoff, due to the inclusion of a significant sanitary component. The lack of storage to regulate flow would provide poor control of chlorination and introduce risks of toxicity due to overchlorination or excape of coliforms due to underchlorination and the fact that many coliforms would be carried through with particulate matter. This alternative would provide no opportunity for phosphorous reduction if needed and would do nothing for toxic material control.

This alternative is rated as the least satisfactory of the four.

2. Storm relief sewers with storage so that all potential overflows can be stored for later conveyance to the sewage treatment plant through existing interceptors.

3. Storm relief sewers combined with relief interceptors and further enlargement of the City treatment plant.

   These alternatives would produce the maximum reduction in urban runoff pollution impact by giving it full treatment or at least primary treatment along with sanitary flow. The only defect of this alternative is that it provides a higher degree of treatment than is necessary from a functional standpoint and perhaps more than may be required under regulations for urban runoff when promulgated.

4. Complete storm and sanitary separation with direct untreated discharge of storm waters.

   From an overall pollution abatement standpoint, this alternative has high value since it gives the most complete treatment to the sanitary component which is the more significant load. It does not of course provide any abatement of urban runoff pollution potential but has the advantage of making these flows separately available for the appropriate level of treatment to be added.

It is recommended that the complete separation alternative where used consider location of the termination at places where treatment and/or storage could be added and where the underflow from treatment could be pumped into the sanitary collection system for ultimate disposal.

A fifth alternative that should be considered is the addition of storage to alternative 1. This would remove most of the disadvantages of 1 and raise it to a high degree of acceptability.

From a functional urban runoff pollution abatement standpoint, alternative 5 and alternative 4 with storage and treatment added would be leading candidates. The ideal treatment would result in effective removal of floating materials and scums, a moderate reduction in BOD, and sufficient flow regulation and removal of particulate matter to make chlorination a well controlled process.

Where large volumes of storage are not feasible, even token storage to catch the first flush for selected treatment or later diversion to the sanitary system would be very beneficial.

Non structural measures should not be neglected. Of prime importance where combined sewers are retained is the possibility of keeping the sewers cleaned during dry weather so that the impact of a storm is not heightened by the flush of accumulated materials. Likewise, consideration should be given to the potential for urban load reduction through housekeeping reduction of surface loading through street sweeping and other controlled cleaning measures.

One of the most critical design needs for the City study is a means of sizing storage in full recognition of statistical requirements. It is recommended that a computerized statistical analysis similar to that outlined in Section 406.3 be implemented for this purpose.

<u>North Spokane Service Area</u>. North Spokane is started on a separated system of storm and sanitary sewers. It is recommended that all future construction follow this criterion so that the appropriate level of treatment can be applied in a most cost effective manner to each component.

The most cost effective adjunct to urban runoff pollution control where space is available is storage. The natural point for such a storage facility or facilities is in the lowlands bordering on the Little Spokane River. Use of a portion of these lands for temporary storage and/or percolation of urban runoff would be compatible with land use planning.

Adequate storage and particularly storage with percolation would provide the following benefits:

1. Protect the lower Little Spokane River from dissolved oxygen sag due to BOD from urban runoff.
2. Protect the recreational use of the Little Spokane River from coliform discharges from urban runoff.
3. Remove the phosphorus potential by percolation to further reduce Long Lake enrichment.
4. Reduce any possible impact of ammonia through attenuation by time.
5. Reduce lead escape through percolation and/or spreading impact over longer time.

Adequate storage would probably preclude the need for any further treatment other than provision for surface skimming and possibly chlorination. If the storage can be made large enough and percolation adequate, it is possible that the ponds could be operated on a non-overflow basis.

In addition to flow control alternatives summarized in Appendix II, the possible plan amendments to the North Spokane storm drainage plan to provide supplemental storage primarily directed towards water quality improvement are shown on Figure A. This plan indicates the possible storage and infiltration/percolation sites which could be utilized to provide storage and sedimentation, which will effect for water quality improvement and peak flow reduction as a result of routing through storage. These sites include the Cedar Rd.-Francis Ave., the Country Home Blvd.-Excell Dr. and Wall St.-Price Rd. areas previously mentioned in storm drainage alternative Concept No. 8. In addition, the existing low area immediately north of Whitworth College (area No. 3) and sites adjacent to the Little Spokane River could be utilized as detention treatment facilities. The Whitworth sites would require diversion piping to be constructed, which would divert all or a portion of storm drainage flow through an essentially natural storage/sink area. Estimated costs of providing supplemental storage facilities as outlined could range between 0.5 to 1.0 million dollars depending on the size of facilities ultimately selected.

Spokane Valley Service Area. The major alternative consideration for the Spokane Valley service is whether to continue local disposal to percolation, taking advantage of removals provided by the soil, or to construct a collection system prior to either surface water or limited locations for percolation.

It is recommended that urban drainage continue to be disposed of to the largest possible extent by percolation to groundwater in small increments as near to the place of origin as possible. This obviously protects the Spokane River from BOD, coliform and phosphorus impacts. The soil depth to groundwater is expected to protect the groundwater from BOD, coliform and phosphorus impacts. The only groundwater quality concern not directly addressed by the method is possible mineral or organic toxics. Since the extent to which these items are removed by the soil are uncertain, it is recommended that vigilance against these items be maintained by non-structural methods including monitoring and control of the use of these materials in the community and industry. At present, the only mineral toxicant of concern is lead from motor fuels, and its identification is from literature sources only. Available data for the groundwater of the study area does not indicate any percolation impact of lead.

Generally the water quality concerns of Spokane Valley urban runoff can best be served by protecting the natural storage and infiltration characteristics of natural sink areas which could be functionally augmented as necessary by development of supplemental spreading areas or by extension of open joint pipelines into permeable soil areas.

The representative application of this concept to the Pasadena Park area problem previously described is indicated on Figure B. This concept provides for conveyance of drainage from existing and newly developing subdivisions to be conveyed to a common storage, infiltration/percolation site on the valley floor. Costs of such a plan specifically applied to this area are estimated to be of the order of .25 to .4 million dollars, depending on final determination of spreading area requirements and actual sizing of pipe required.

TABLE 1

BASIS FOR URBAN RUNOFF FORECASTS

	Forecast by Years 1980	1990	2000	2020
Forecast Sewered Population				
City	177,945	182,506	189,282	204,315
North Spokane	17,220	38,561	44,627	62,482
Spokane Valley	52,227	63,166	74,061	91,021
Forecast Impervious Area, Acres				
City, max (1)	8,008	8,213	8,518	9,194
min (1)	5,694	5,840	6,057	6,538
North Spokane, max (2)	620	1,388	1,607	2,249
min (2)	396	887	1,026	1,437
Spokane Valley, max (3)	2,141	2,590	3,037	3,732
min (3)	1,462	1,769	2,074	2,549
Forecast Annual Runoff, Ac.Ft.				
City, max (4)	8,504	8,722	9,046	9,764
min (4)	6,047	6,202	6,433	6,943
North Spokane, max (5)	698	1,563	1,809	2,532
min (5)	446	999	1,155	1,618
Spokane Valley, max (6)	2,436	2,947	3,456	4,247
min (6)	1,664	2,013	2,360	2,901

NOTES: (1) Range 0.045 Ac/cap. to 0.032 Ac/cap.
(2) " 0.036 Ac/cap. to 0.023 Ac/cap.
(3) " 0.041 Ac/cap. to 0.028 Ac/cap.
(4) At mean rainfall 18.2 in/yr and 0.7 coef. (1.062 Ac.ft/Ac.yr)
(5) " " " 19.3 " " " (1.126 Ac.ft/Ac.yr)
(6) " " " 19.5 " " " (1.138 Ac.ft/Ac.yr)

TABLE 2

OCCURRENCE OF TYPICAL RAINFALL EVENTS
SPOKANE WBAS - 1971

MONTH	NO. EVENTS	PRECIP.-IN.
January	4	2.11
February	5	0.88
March	5	2.11
April	4	1.85
May	5	1.39
June	5	2.46
July	1	0.50
August	2	0.59
September	4	1.37
October	3	0.82
November	4	1.51
December	7	2.89
	49	18.48

SEASON	NO. EVENTS	AVERAGE DAYS BETWEEN EVENTS	AVERAGE PRECIP. PER EVENT - IN.
Winter	14	6.4	0.36
Spring	14	6.5	0.41
Summer	7	13.1	0.35
Fall	14	6.6	0.37
June-Sept.	12		

TABLE 3

CALCULATED SEASONAL POLLUTANT YIELD
FOR UNIT IMPERVIOUS AREA
SPOKANE RAINFALL PATTERN

Pollutant	Season	Pollutant Yield Pounds per Impervious Acre	
BOD	Winter	8.2	
	Spring	13.6	
	Summer	8.8	
	Fall	14.3	
	Annual	44.9	
		Kjeldahl N	Total N
Nitrogen	Winter	1.26	1.68
	Spring	1.36	1.81
	Summer	.88	1.17
	Fall	1.30	1.73
	Annual	4.80	6.39
		Ortho P	Total P
Phosphorous	Winter	.56	2.43
	Spring	.62	2.70
	Summer	.40	1.74
	Fall	.59	2.57
	Annual	2.17	9.44

TABLE 4

SELECTED RANGE OF POLLUTANT YIELDS
FROM URBAN RUNOFF FOR
SPOKANE VICINITY EVALUATION

Parameter	Range of Pollutant Yield, Pounds Per Impervious Acre					
	Annual		Summer Season*		Typical Summer Event	
	High	Low	High	Low	High	Low
BOD	90	45	27	13.5	2.52	1.26
Total N	12.8	6.4	3.4	1.7	.34	.17
Total P	9.4	2.35	2.6	.65	.77	.19

*June 1 through September 30

TABLE 5

FORECAST URBAN RUNOFF AND TREATED SANITARY EFFLUENT, YEAR 2020

	CITY OF SPOKANE				NORTH SPOKANE				SPOKANE VALLEY			
	Annual	Summer Season (2)	24hr-2yr Event (3)	Typ Sum. Event (4)	Annual	Summer Season (2)	24hr-2yr Event (3)	Typ Sum. Event (4)	Annual	Summer Season (2)	24hr-2yr Event (3)	Typ Sum. Event (4)
URBAN RUNOFF												
Volume, Acre Feet (1)	6,943	1,389	404	134	1,618	324	88.9	29.3	2,901	580	158	52.0
Volume, Million Gallons (1)	2,263	453	132	44	527	106	29.0	9.6	946	189	51.4	17.0
BOD, Range (5)												
Max 10^3 Pounds	588	176	41.5	16.6	129	38.8	9.05	3.62	230	69.0	16.1	6.44
Min 10^3 Pounds	294	88	20.8	8.3	64.7	19.4	4.53	1.81	115	34.5	8.05	3.22
Midrange conc. mg/l	23.4	35.0	28.3	34.0	22.1	33.0	28.1	34.0	21.9	32.9	28.2	34.1
Total N, Range (5)												
Max 10^3 Pounds	83.6	22.2	5.55	2.22	18.4	4.90	1.20	.48	32.8	8.72	2.20	.88
Min 10^3 Pounds	41.8	11.1	2.78	1.11	9.21	2.45	.60	.24	16.4	4.36	1.10	.44
Midrange conc. mg/l	3.3	4.4	3.8	4.5	3.1	4.2	3.7	4.5	3.1	4.2	3.9	4.7
Total P Range (5)												
Max 10^3 Pounds	61.6	17.0	12.6	5.03	13.5	3.72	2.77	1.11	24.0	6.64	4.90	1.96
Min 10^3 Pounds	15.4	4.25	3.10	1.24	3.38	0.93	.68	.27	6.01	1.66	1.23	.49
Midrange conc. mg/l	2.0	2.8	7.1	8.6	1.9	2.6	7.1	8.6	1.9	2.6	7.2	8.7
SANITARY EFFLUENT (6)												
Volume, Million Gallons	13,452	4,484	37	9.21	2,904	968	8.0	1.99	4,449	1,483	12.2	3.05
BOD, 10^3 Pounds (7)	2,330	680	5.6	1.4	603	176	1.4	0.35	930	272	2.16	.54
Total N, 10^3 Pounds (7)	1,720	570	4.8	1.2	472	157	1.24	0.31	714	238	1.92	.48
Total P, 10^3 Pounds (7)	520	41	.34	.08	144	11.4	.09	0.022	217	17.2	.13	.033

NOTES:
(1) Runoff volume corresponding to connected impervious area.
(2) June 1 through September 30 during which 20% of annual rainfall occurs and 12 of 49 events occur.
(3) Total event rainfall 1.06 inches, average rate .044 inches/hr.
(4) Total event rainfall 0.35 inches, 13.1 day average between events.
(5) Refer to Table 4 for criteria.
(6) Treated effluent to 1983 standards of activated sludge secondary and with seasonal P removal.
(7) Sanitary pollutant quantities are accumulated for periods corresponding to URO periods, respectively: 1 year, 4 months, 1 day and 6 hours.

TABLE 6

URBAN RUNOFF POLLUTION EVALUATION, CITY - YEAR 2020

Urban Runoff Parameter	ANNUAL Flow - cfs and Average Load-pounds	ANNUAL Dilution[6] and conc. mg/1[1]	SUMMER SEASON Flow - cfs and Average Load-pounds	SUMMER SEASON Dilution[6] and conc. mg-1[2]	24 HR 2 YR EVENT Flow - cfs and Average Load-pounds	24 HR 2 YR EVENT Dilution[6] and conc. mg/1[3]	TYPICAL EVENT Flow - cfs and Average Load-Pounds	TYPICAL EVENT Dilution[6] and conc. mg/1[4]	TYPICAL EVENT Dilution[6] and conc. mg/1[3]
Runoff Volume	9.59	.00138	5.75	.00120	204	.10350	269	.2383	.1321
BOD[7]	441,000	.03	132,000	.04	31,150	2.93	12,450	8.1	4.5
Total N[7]	62,700	.005	16,650	.005	4,165	.39	1,665	1.07	.59
Nitrate [8]	-	-	-	-	-	.09	-	.25	.14
Ammonia [9]	-	-	-	-	-	.05	-	.13	.07
Total P[7]	38,500	.003	10,625	.003	7,850	.73	3,135	2.05	1.14
Total Coliform[5]	-	-	-	-	-	10,000	-	24,000	13,000
Lead[10]		.0004		.0004		.03		.07	0.04

NOTES:
(1) In mean annual flow of Spokane River per Spokane gage - 6,927 cfs.
(2) In mean flow for the summer season, June 1 through September 30 per Spokane gage 4770 cfs.
(3) In mean flow for lowest month of the summer season, September at 1,767 cfs per Spokane gage.
(4) In 10 year - 7 day low flow of Spokane River at Spokane of 860 cfs.
(5) Based on average conc. in urban runoff of 100,000 org/ml.
(6) Dilution factor = $\frac{\text{URO}}{\text{URO and Receiving Stream}}$
(7) Midrange values from Table 5.
(8) At 23% of Total N per Seattle data.
(9) At 12% of Total N per Seattle data.
(10) Based on average conc. 0.30 mg/1 per Seattle data.

TABLE 7

URBAN RUNOFF POLLUTION EVALUATION, NORTH SPOKANE - YEAR 2020

	ANNUAL		SUMMER SEASON		24 HR - 2 YR EVENT		TYPICAL EVENT		
Urban Runoff Parameter	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(1)	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(2)	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(3)	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(4)	Dilution(6) and Conc. mg/1(3)
Runoff Volume	2.23	.00701	1.34	.00739	44.76	.248	59.01	.391	.3026
BOD(7)	96,850	.15	29,100	.24	6,790	6.97	2,715	13.29	10.29
Total N (7)	13,805	.02	3,675	.03	900	.92	360	1.76	1.36
Nitrate(8)	-	-	-	-	-	.21	-	.40	.31
Ammonia(9)	-	-	-	-	-	.11	-	.21	.16
Total P (7)	8,440	.01	2,325	.02	1,725	1.76	690	3.36	2.60
Total Coliform(5)	-	-	-	-	-	25,000	-	39,000	30,000
Lead(10)	-	.002	-	.002	-	.074	-	.117	.091

NOTES:
(1) In mean annual flow of Little Spokane River per Dartford gage - 316 cfs.
(2) In mean flow for the summer season, June 1 through September 30 of LSR per Dartford gage - 180 cfs.
(3) In mean monthly flow for lowest month of the summer season, August 136 cfs plus URO.
(4) In 10 year - 7 day low flow of LSR per Dartford gage - 92 cfs plus URO.
(5) Based on average conc. in urban runoff of 10^5 org/100 ml.
(6) Dilution factor = URO mean flow / (receiving water mean flow and URO).
(7) Midrange values from Table 5.
(8) At 23% of total N per Seattle data.
(9) At 12% of total N per Seattle data.
(10) Based on average conc. of 0.30 mg/1 from Seattle data.

TABLE 8

URBAN RUNOFF POLLUTION EVALUATION, SPOKANE VALLEY - YEAR 2020

Urban Runoff Parameter	ANNUAL		SUMMER SEASON		24 HR - 2 YR EVENT		TYPICAL EVENT		
	Flow - cfs and Average Load-Pounds	Dilution(6) and conc. mg/1(1)	Flow - cfs and Average Load-Pounds	Dilution(6) and conc. mg/1(2)	Flow - cfs and Average Load-Pounds	Dilution(6) and conc. mg/1(3)	Flow - cfs and Average Load-Pounds	Dilution(6) and conc. mg/1(4)	Dilution(6) and conc. mg/1(3)
Runoff Volume	4.01	.00058	2.40	.00050	79.5	.0431	105.2	.109	.056
BOD(7)	172,500	.013	51,750	.016	12,080	1.22	4,830	3.72	1.92
Total N(7)	24,600	.0018	6,540	.0021	1,650	.17	660	.51	.26
Nitrate(8)	-	-	-	-	-	.04	-	.12	.06
Ammonia(9)	-	-	-	-	-	.02	-	.06	.03
Total P(7)	15,000	.0011	4,150	.0013	3,065	.31	1,225	.95	.49
Total Coliform(5)	-	-	-	-	-	4,000	-	11,000	6,000
Lead(10)	-	.00017	-	.00015	-	.013	-	.033	.017

NOTES:
(1) In mean flow of Spokane River per Spokane gage - 6927 cfs.
(2) In mean flow for the summer season June 1 through September 30 per Spokane gage - 4770 cfs.
(3) In mean flow for the lowest month of the summer season, September at 1767 cfs per Spokane gage.
(4) In 10 year - 7 day low flow per Spokane gage at 860 cfs.
(5) Based on average conc. in urban runoff of 10^5 org/100 ml.
(6) Dilution factor = $\frac{\text{URO}}{\text{URO \& Receiving Water}}$
(7) Midrange values from Table 5.
(8) At 23% of total N per Seattle data.
(9) At 12% of total N per Seattle data.
(10) Based on average conc. of 0.30 mg/1 per Seattle data.

TABLE 9

URBAN RUNOFF POLLUTION EVALUATION, COMBINED EFFECT CITY AND NORTH SPOKANE - YEAR 2020

Urban Runoff Parameter	ANNUAL		SUMMER SEASON		24 HR - 2 YR EVENT		TYPICAL EVENT		
	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(1)	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(2)	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(3)	Flow - cfs and Average Load-Pounds	Dilution(6) and Conc. mg/1(4)	Dilution(6) and Conc. mg/1(3)
Runoff Volume	11.83	.00141	7.11	.00126	249	.0856	332	.2418	.1109
BOD(7)	537,850	.03	161,100	.04	37,940	2.42	15,165	8.22	3.77
Total N(7)	76,505	.005	20,325	.006	5,065	.32	2,025	1.09	.50
Nitrate(8)	-	-	-	-	-	.07	-	.25	.11
Ammonia(9)	-	-	-	-	-	.04	-	.13	.06
Total P(7)	46,940	.003	12,950	.004	9,575	.61	3,825	2.08	.95
Total Coliform(5)	-	-	-	-	-	9,000	-	24,000	11,000
Lead(10)	-	.0004	-	.0004	-	.026	-	.073	.033

NOTES:
(1) In mean annual flow of Spokane River below LSR confluence per Long Lake gage, 8381 cfs.
(2) In mean flow for the summer season June 1 through September 30 per Long Lake gage, 5630 cfs.
(3) In mean flow for the lowest month of the summer season, August, at 2,661 cfs per Long Lake gage.
(4) In approximated 10 year 7 day low flow at Long Lake gage, 1041 cfs.
(5) Based on average conc. in urban runoff of 10^5 org/100 ml.
(6) Dilution factor = $\frac{\text{URO}}{\text{URO and Receiving Water}}$
(7) Midrange value composited from Table 5.
(8) At 23% of Total N per Seattle data.
(9) At 12% of Total N per Seattle data.
(10) Based on average conc. of 0.30 mg/1 per Seattle data.

TABLE 10

URBAN RUNOFF POLLUTION EVALUATION, COMBINED EFFECT ALL SERVICE AREAS - YEAR 2020

Urban Runoff Parameter	ANNUAL Flow - cfs and Average Load-Pounds	ANNUAL Dilution(6) and Conc. mg/1(1)	SUMMER SEASON Flow - cfs and Average Load-Pounds	SUMMER SEASON Dilution(6) and Conc. mg/1(2)	24 HR - 2 YR EVENT Flow - cfs and Average Load-Pounds	24 HR - 2 YR EVENT Dilution(6) and Conc. mg/1(3)	TYPICAL EVENT Flow - cfs and Average Load-Pounds	TYPICAL EVENT Dilution(6) and Conc. mg/1(4)	TYPICAL EVENT Dilution(6) and Conc. mg/1(3)
Runoff Volume	15.84	.00189	9.51	.00169	328	.1097	437	.2957	.1411
BOD(7)	710,350	.04	212,850	.06	50,015	3.1	19,995	10.1	4.8
Total N(7)	101,105	.006	26,865	.007	6,715	.42	2,685	1.36	.65
Nitrate(8)	-	-	-	-	-	.10	-	.31	.15
Ammonia(9)	-	-	-	-	-	.05	-	.16	.08
Total P(7)	61,945	.004	17,100	.005	12,640	.78	5,050	2.54	1.21
Total Coliform(5)	-	-	-	-	-	11,000	-	30,000	14,000
Lead(10)	-	.0006	-	.0005	-	.033	-	.089	.042

NOTES:
(1) In mean annual flow of Spokane River below LSR confluence per Long Lake gage, 8381 cfs.
(2) In mean flow for the summer season June 1 through September 30 per Long Lake gage, 5630 cfs.
(3) In mean flow for the lowest month of the summer season, August per Long Lake gage, 2661 cfs.
(4) In approximated 10 year 7 day low flow at Long Lake gage, 1041 cfs.
(5) Based on average conc. in urban runoff of 10^5 org./100 mg.
(6) Dilution factor = $\frac{\text{URO}}{\text{URO and Receiving Water}}$
(7) Midrange value composited from Table 5.
(8) At 23% of Total N per Seattle data.
(9) At 12% of Total N per Seattle data.
(10) Based on average conc. of 0.3 mg/1 per Seattle data.

TABLE 11

BACKGROUND QUALITY OF RECEIVING WATERS

LOCATION: SPOKANE RIVER AT BOUNDARY (RM 96.5)

		MEAN VALUES			
PARAMETER	UNITS	JAN-MAR	APR-JUNE	JULY-SEPT	OCT-DEC
Temp.	°C	3.2	10.8	19.0	9.1
D.O.	mg/1	12.1	11.4	8.8	10.2
BOD	mg/1	1.1	2.5	1.9	1.0
Tot. PO_4-P	mg/1	0.048	0.130	0.024	0.024
NH_3-N	mg/1	0.037	0.086	0.051	0.019
Tot. N	mg/1	0.25	0.30	0.29	0.21
Tot. Colif.	No./100ml	518	251	1398	684
Zn. Diss.	ug/1	392	318	168	261

LOCATION: LITTLE SPOKANE AT MOUTH (RM 1.1)

		MEAN VALUES			
PARAMETER	UNITS	JAN-MAR	APR-JUNE	JULY-SEPT	OCT-DEC
Temp.	°C	5.2	12.4	13.5	7.0
D.O.	mg/1	10.5	8.9	8.8	10.5
BOD	mg/1	1.1	0.8	0.5	-
Tot. PO_4-P	mg/1	0.086	0.084	0.039	0.030
NH_3-N	mg/1	0.077	0.042	0.064	0.042
Tot. N	mg/1	1.300	1.105	1.530	1.206
Tot. Colif.	No./100ml	1802	1012	1776	880
Zn. Diss.	ug/1	42	43	4	15

GROUNDWATER, PRIMARY AQUIFER

		MEAN VALUES, YEAR AROUND
Temp.	°C	10.7
BOD	mg/1	Negligible
Total P	mg/1	.014
NH_3-N	mg/1	.015
NO_3-N	mg/1	1.521
Total N	mg/1	1.649
Lead	mg/1	.019
Tot. Colif.	No./100ml	None

TABLE 12

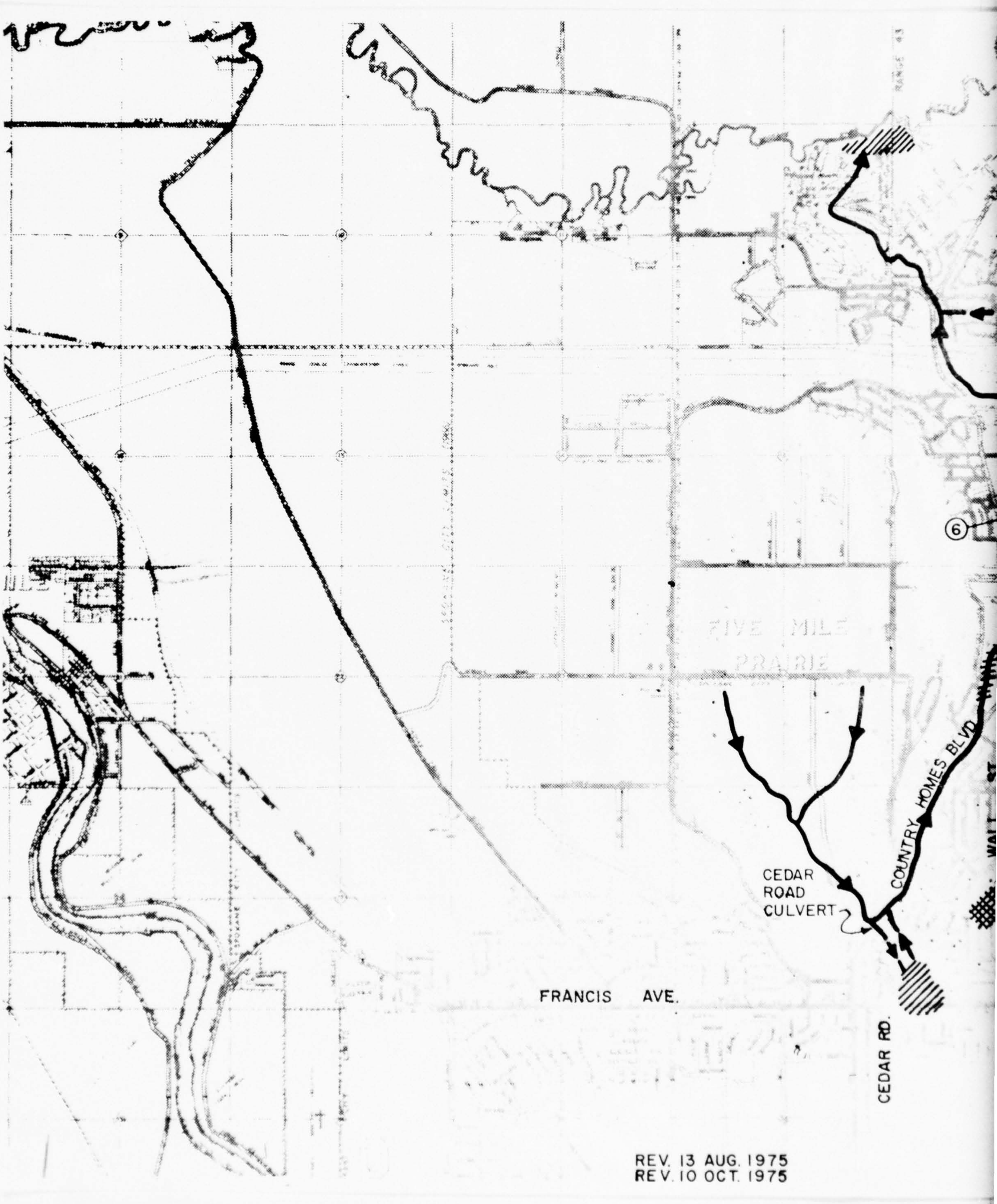
URBAN RUNOFF POLLUTION ABATEMENT ALTERNATIVE ELEMENTS

NON-STRUCTURAL

1. Land use control
2. Impervious surface connection regulation
3. Regulation of construction operations
4. Litter laws and enforcement
5. Surface housekeeping (street sweeping, etc.)
6. Use of unleaded gasoline

STRUCTURAL

1. In-system storage
    a. Ponding in streets and parking areas
    b. Rooftop ponding
    c. Ponding structures
    d. Oversized conveyance systems
    e. Conveyance system regulating structures
2. Terminal storage
3. Groundwater recharge
4. Treatment, separate
    a. Sedimentation
    b. Skimming
    c. Screening
    d. Flotation
    e. High rate filtration
    f. Microstraining
    g. Chlorination
5. Treatment with sanitary sewage
    a. Treatment of combined flow
    b. Treatment of stored separate urban runoff
6. Stormwater separation
    a. Separation of new facilities
    b. Separation of existing combined systems


FIVE MILE
PRAIRIE
6
COUNTRY HOMES BLVD
CEDAR
ROAD
CULVERT
FRANCIS AVE.
CEDAR RD.
REV. 13 AUG. 1975
REV. 10 OCT. 1975

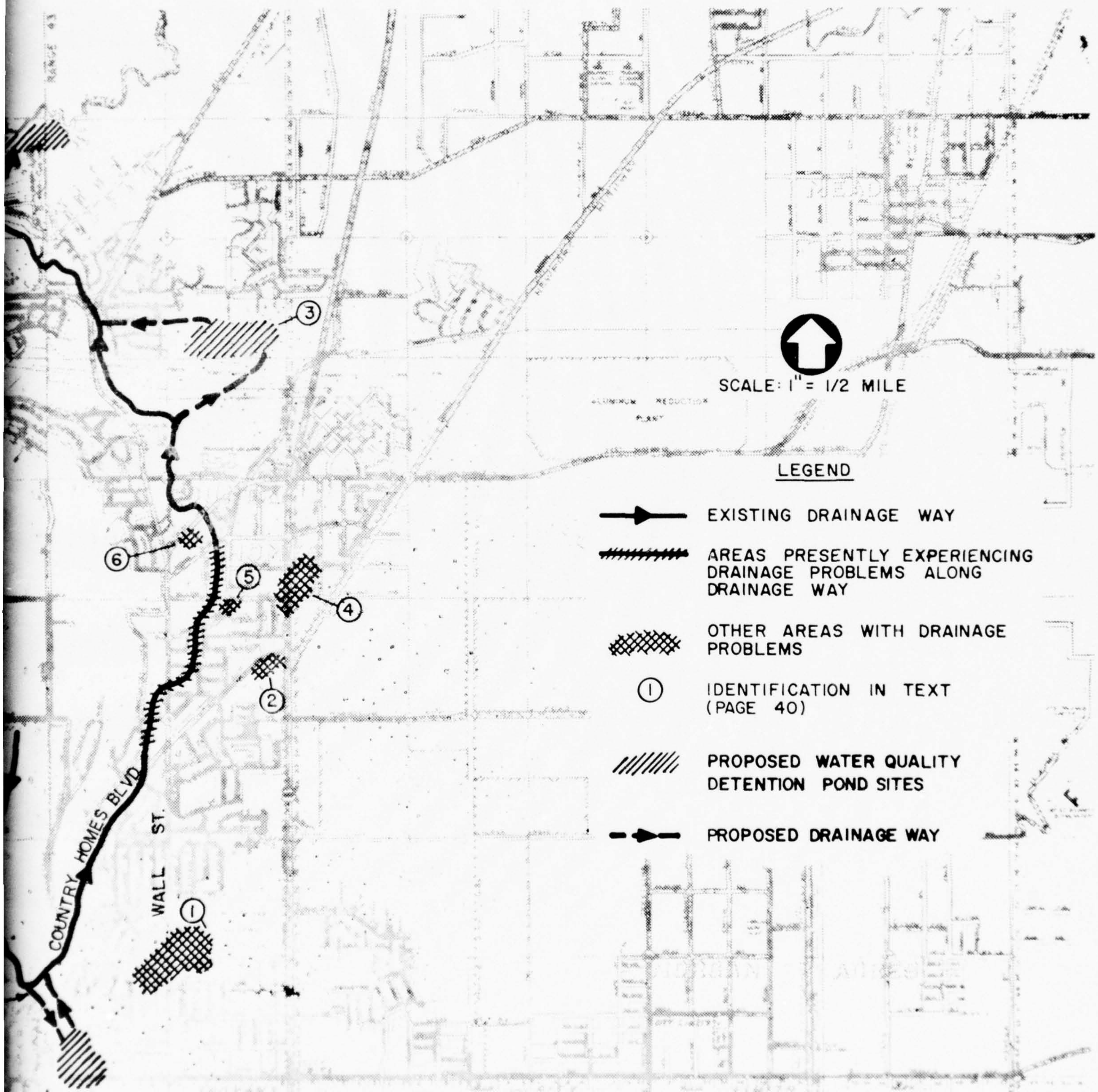
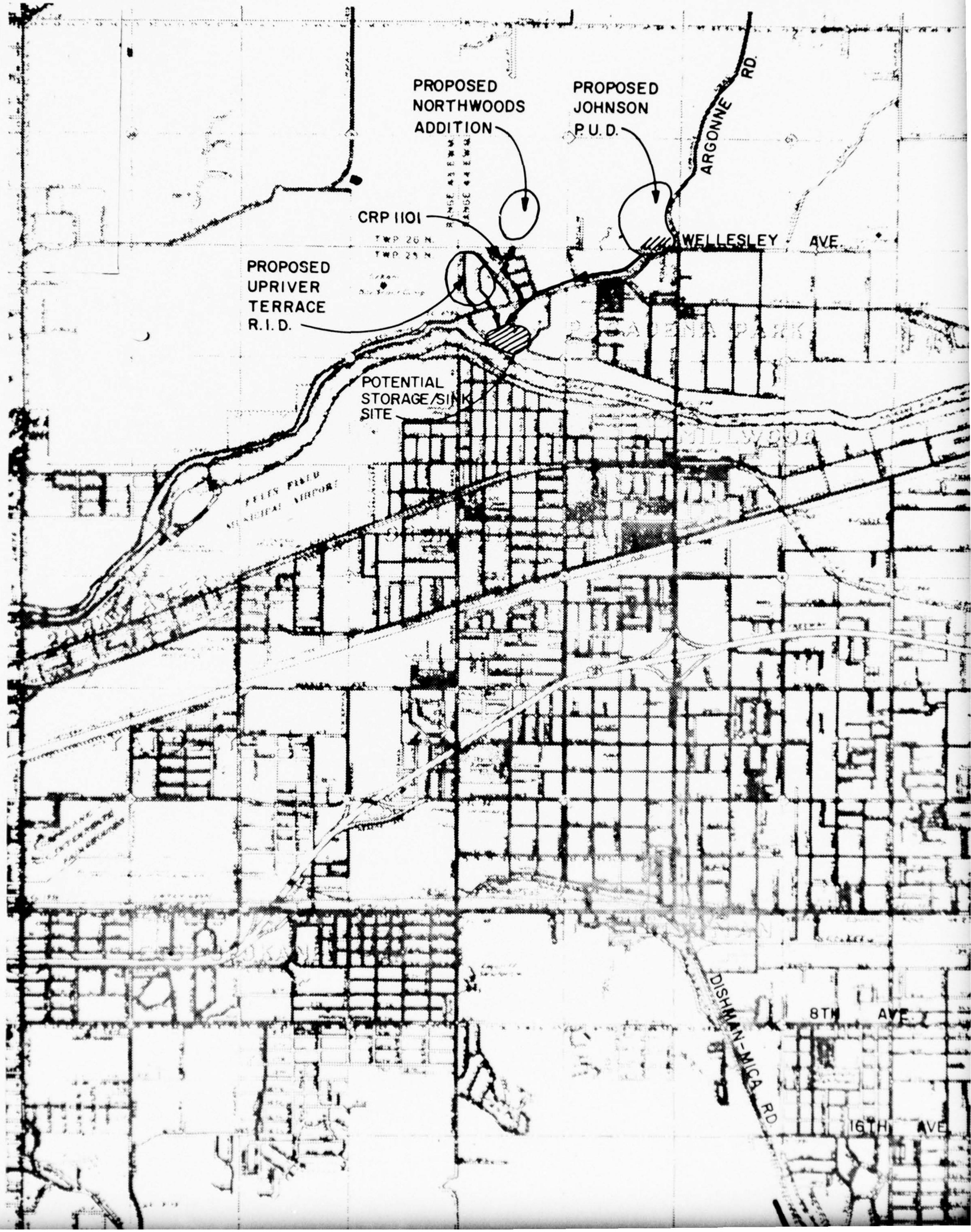
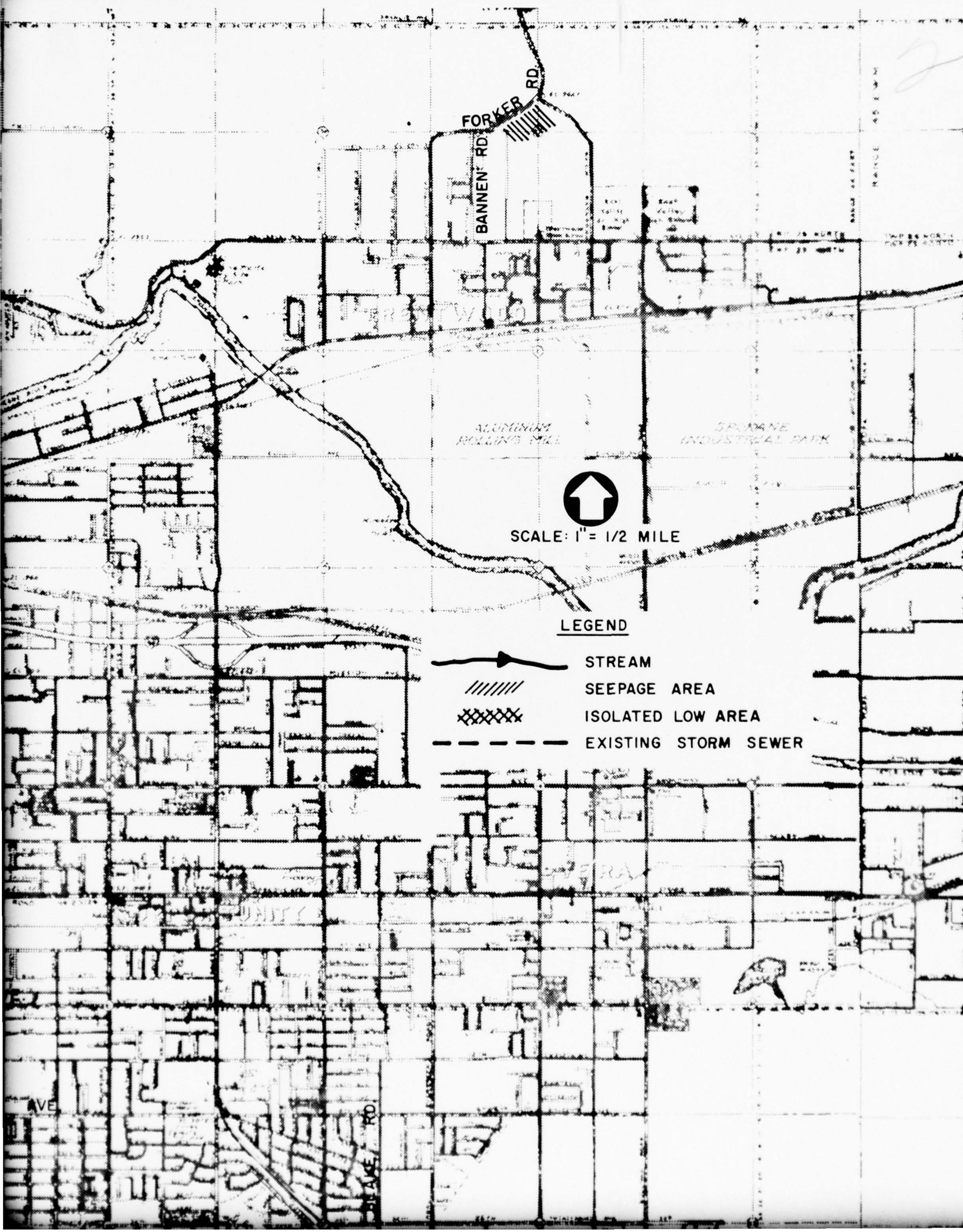


FIGURE A

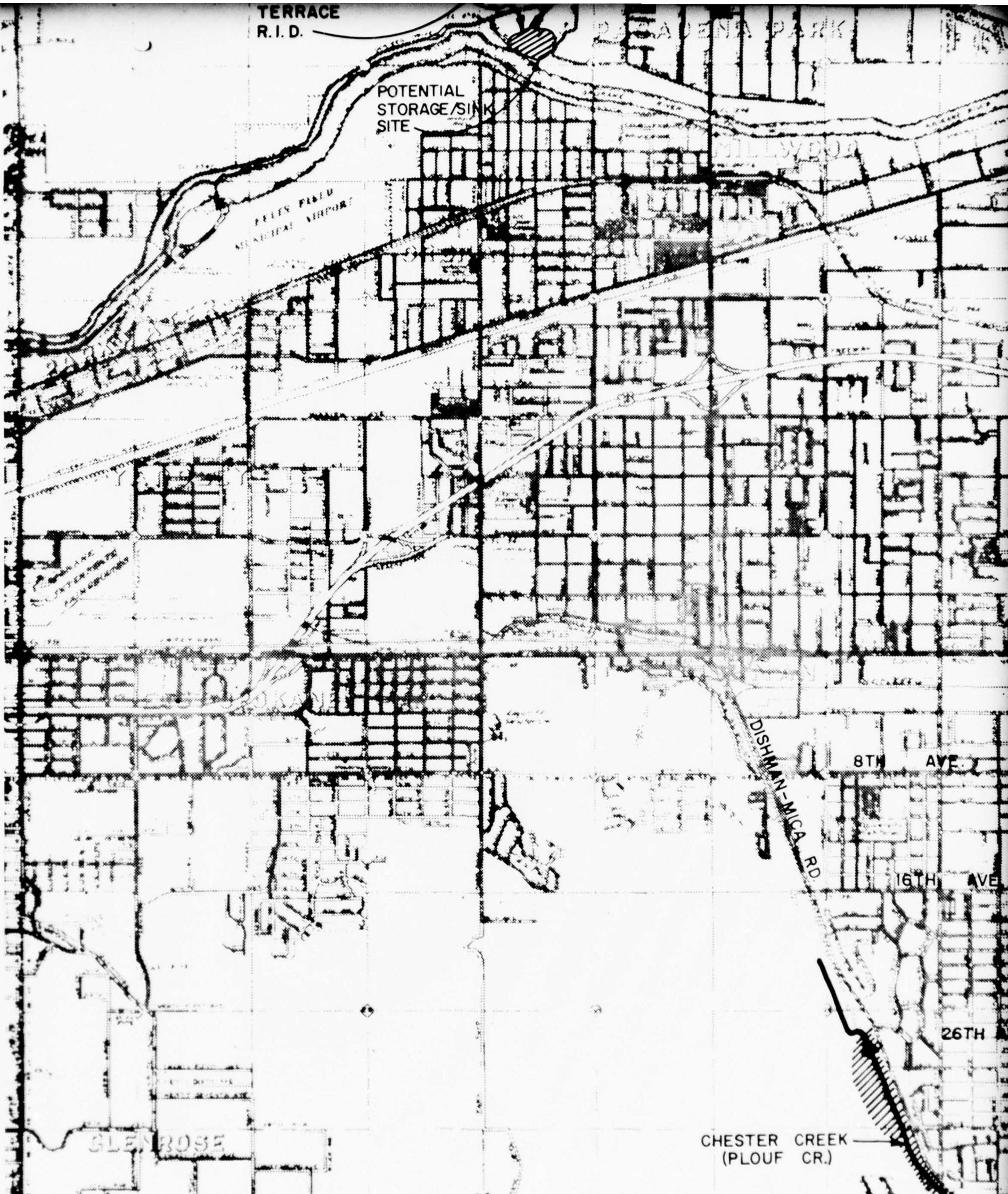
NORTH SPOKANE
URBAN DRAINAGE PROBLEMS

604.5-81


PROPOSED
NORTHWOODS
ADDITION
PROPOSED
JOHNSON
P.U.D.
ARGONNE RD.
CRP 1101
TWP 26 N.
TWP 25 N.
WELLESLEY AVE.
PROPOSED
UPRIVER
TERRACE
R.I.D.
POTENTIAL
STORAGE/SINK
SITE
8TH AVE.
16TH AVE.
DISHMAN-MICA RD.



FORKER RD.
BANNEN RD.
ALUMINUM ROLLING MILL
SPOKANE INDUSTRIAL PARK
SCALE: 1" = 1/2 MILE
LEGEND
STREAM
SEEPAGE AREA
ISOLATED LOW AREA
EXISTING STORM SEWER
AVE.
BLAKE RD.



REV. 13 AUG. 1975
REV. 10 OCT. 1975

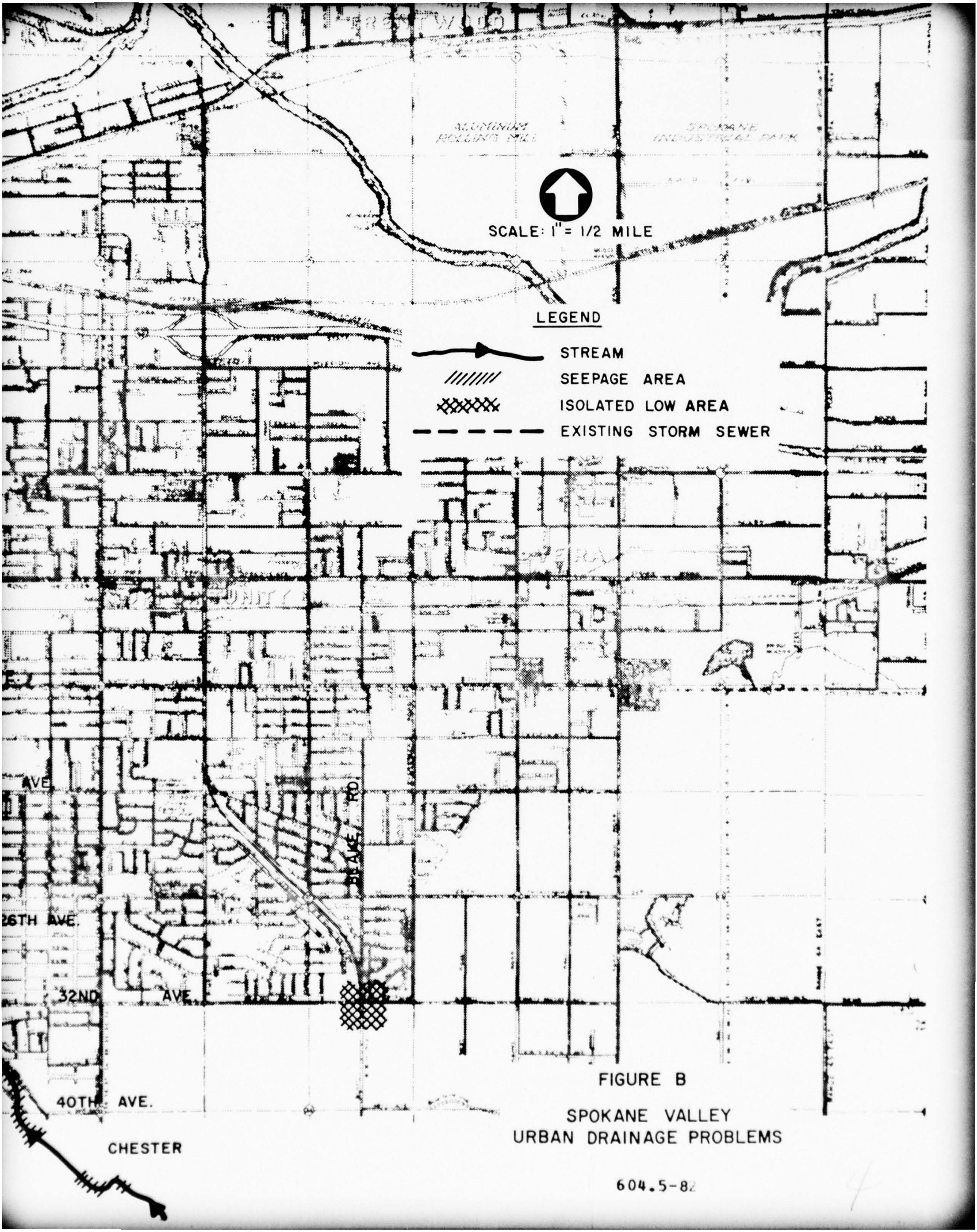


FIGURE B

SPOKANE VALLEY
URBAN DRAINAGE PROBLEMS

604.5-82

List of References

American Process Equipment Corporation. 1970. Ultrasonic filtration of combined sewer overflows. U.S. Environmental Protection Agency. K-T #551

American Public Works Association. 1970. Combined sewer regulation and management. A manual of practice. Federal Water Quality Administration. K-T #552

American Public Works Association. 1970. Combined sewer regulator overflow facilities. Federal Water Quality Administration. K-T #557

American Society of Civil Engineers, 1974. Proceedings of Research Conference Urban Runoff Quantity and Quality (Franklin Pierce College, Rindge, N.H. Aug. 1974)

Black, Crow and Eidsness, Inc. 1971. Storm and combined sewer pollution sources and abatement--Atlanta, Georgia. U.S. Environmental Protection Agency. K-T #554

Bovay Engineers, Inc. 1973. Report on additions and modifications to the wastewater treatment plant, City of Spokane, Washington. K-T #365

Cornell, Howland, Hayes and Merryfield. 1970. Rotary vibratory fine screening of combined sewer overflows. Federal Water Qualtiy Administration. K-T #549

The Dow Chemical Company. 1970. Chemical treatment of combined sewer overflows. U.S. Environmental Protection Agency. K-T #555

Enviro Control, Inc. 1974. Total Urban Water Pollution Loads: The Impact of Storm Water. For Council on Environmental Quality PB-231-730. K-T #596

Federal Water Pollution Control Administration, 1968.[1] Report of the Committee on Water Quality Criteria. K-T #271.

Federal Water Quality Administration. 1970. "Combined sewer overflow abatement technology." Symposium on Storm and Combined Sewer Overflows. Chicago, Illinois. K-T #548

---

[1] Cited as "FWPCA 1968".

Glover, George E., and Herbert, George R. 1973. Microstraining and disinfection of combined sewer overflows--Phase II. U.S. Environmental Protection Agency. K-T #599

Leclerc, G. and Schaake, J. 1973. Methodology for Assessing the Potential Impact of Urban Development on Urban Runoff and the Relative Efficiency of Runoff Control Alternatives. Report No. 167, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology. K-T #468

Melpar. 1970. Combined sewer temporary underwater storage facility. Federal Water Quality Administration. K-T #558

Minneapolis-Saint Paul Sanitary District. 1971. Dispatching system for control of combined sewer losses. U.S. Environmental Protection Agency. K-T #556

Nebolsine, Ross, Harvey, Patrick J. and Fan, Chi-Yuan. 1972. High rate filtration of combined sewer overflows. U.S. Environmental Protection Agency. K-T #553

Pontius, Uwe R., Pavia, Edgar H., and Crowder, Donald G. 1973. Hypochlorination of polluted stormwater pumpage at New Orleans. U.S. Environmental Protection Agency. K-T #547

Portland (City), Oregon Department of Public Works. 1971. Demonstration of rotary screening for combined sewer overflows. U.S. Environmental Protection Agency. K-T #550

Rosenkranz, William A. 1970. Storm and combined sewer demonstration projects. Federal Water Pollution Control Administration. K-T #559

Soltero, Raymond A., Gasparino, Anthony F., and Graham, William C., 1973. An Investigation of the Cause and Effect of Eutrophication in Long Lake, Washington, Eastern Washington State University. K-T #87

Soltero, Raymond A., Gasparino, Anthony F., and Graham, William C. 1974. Further Investigations as to the Cause and Effect of Eutrophication in Long Lake, Washington. Eastern Washington State University. K-T #592

Shuckrow, Alan J., Dawson, Gaynor W., and Bonner, William F. 1973. Physical-chemical treatment of combined and municipal sewage. U.S. Environmental Protection Agency. K-T #598

U.S. Army Corps of Engineers, 1974.[2] Urban Runoff and Basin Drainage Study, Green and Cedar River Basins of Washington, Appendix C.

U.S. Environmental Protection Agency. 1971. Environmental impact of highway deicing. K-T #546

U.S. Public Health Service, 1962. Drinking Water Standards. K-T #347

Water Resources Engineers and The Hydrologic Engineering Center, Sacramento Dist., U.S.A. Corp of Engineers, 1974.[3] Management of Urban Storm Runoff. ASCE Urban Water Resources Research Program, Technical Memorandum No. 24, K-T #642

---

[2]Cited as "USCOE 1974".
[3]Cited as "Water Resources Eng. 1974".

APPENDIX I

PLAN OF STUDY

Facilities Planning for the City of Spokane Sewer Upgrading and Overflow Corrections - September 1974

The intent of facilities planning studies proposed by the City of Spokane is to arrive at cost effective solutions for correcting deficiencies in the City's Sewer System. Deteriorating sewers, overloaded sewers, and combined storm and sanitary overflows to the Spokane River are typical deficiencies to be corrected.

To accomplish these objectives the City has been divided up into ten zones with each zone encompassing one or more sewage drainage basins. Subsequently, these ten zones have been incorporated into nine separate proposed projects of about equal cost. The reason for nine projects is to divide the total problem into segments that the City can handle on a phased planning, design, and construction basis. Attached is a list of the nine projects showing proposed dates for facilities plans, design and construction assuming 90 percent grant money is available. In addition, a flow chart is attached showing anticipated dates for the above mentioned planning, design, and construction and nine maps showing the location of each project.

The facilities planning to be performed by the City will consist of evaluating, using an annual cost analysis, alternate solutions for correcting the above mentioned deficiencies in the City's Sewer System. The alternate that proves to be the best solution will then be presented in detail with the reasons for the selection listed. The four alternates proposed for study are as follows:

1. Storm relief sewers with satellite treatment facilities at various overflow points to the Spokane River.

2. Storm relief sewers with storage facilities so that all storm water can be conveyed to the sewer treatment plant without requiring any capacity increase in the existing interceptor sewers or the new sewer treatment plant.

3. Storm relief sewers combined with new relief interceptor sewers to the City's sewer treatment plant and further enlargement of the new sewer treatment plant to treat all storm water.

4. Complete storm and sanitary sewer separation with direct discharge of storm waters to the Spokane River.

To accomplish the facilities planning, the City will rely mainly on existing data in City files plus information included in the following two reports by Bovay Engineers Incorporated: "Report on Excessive Infiltration/Inflow," June 1974 and "Spokane Waste Water Study," July 1972. Some additional field work will be required to supplement the above information.

Planning costs are anticipated to be about $100,000 per project based on Washington State Department of Ecology guidelines of 2 percent of construction costs. Construction costs are anticipated to be about $5,000,000 per project. A more specific breakdown of planning costs and planning tasks will be included in the final grant application.

PROJECT LIST

The following schedule assumes that 90 percent grant money is available for all steps. The location of the basin zones referred to on the following project list and schedule are shown on the attached maps.

PROJECT #	SCHEDULE	ZONES	PROJECT DESCRIPTION
1.	BFP June 1975 CFP July 1976 BD June 1977 CD May 1979 BC June 1980	II	Erie Street Complex - Correct bypass of dry weather flow to river during periods of high water.
		III	Area Tributary to Erie Street Complex - Sewer back-ups occur. Area has some separate storm sewers.
2.	BFP June 1975 CFP May 1976 BD June 1977 CD June 1978 BC June 1979	I	Mallon Street Overflow - Correct bypass of dry weather flow to river during periods of high water.
		VI	North Central Area - Chronic sewer back-ups occur. There are 3 overflows to the river from this area.
		X	Assembly Street Area - Chronic sewer back-ups occur. There are 5 overflows to the river from this area.
3.	BFP June 1976 CFP June 1977 BD June 1978 CD June 1979 BC June 1980	IV	Central Business District Relief - Relieve sewers in CBD by constructing intercepting storm relief line along southern fringe of CBD.
		IV & V	South Hill - Area is tributary to CBD Relief Sewer. Sewer back-ups occur during wet weather.

PROJECT #	SCHEDULE		ZONES	PROJECT DESCRIPTION
4.	BFP	June 1977	VII	Zone VII North of River - Area has very old sewers. Back-ups frequently occur.
	CFP	June 1978		
	BD	June 1979		
	CD	June 1980		
	BC	June 1981	IX	Shadle Park Area - Some sewer back-ups occur.
5.	BFP	June 1978	VIII	West Half of Zone VIII - Area has some back-up problems, is tributary to 5th Ward No. 10 Sewer.
	CFP	June 1979		
	BD	June 1980		
	CD	June 1981		
	BC	June 1982		
6.	BFP	June 1979	VIII	Portion of East Half of Zone VIII - Area has some back-up problems. Proposed North-South Freeway will have significant effect on area sewers.
	CFP	June 1980		
	BD	June 1981		
	CD	June 1982		
	BC	June 1983		
7.	BFP	June 1980	VIII	Portion of East Half of Zone VIII - Area has some back-up problems. Construction of proposed North-South Freeway may provide means.
	CFP	June 1981		
	BD	June 1982		
	CD	June 1983		
	BC	June 1984		
			II	Portion of S.E. City (Lincoln Heights) Area is tributary to Erie Street Complex.
8.	BFP	June 1981	II	Portion of S.E. City (Lincoln Heights) Area is tributary to Erie Street Complex.
	CFP	June 1982		
	BD	June 1983		
	CD	June 1984		
	BC	June 1985	VII	Zone VII South of River - Area is served by combined sewers with sypons under Hangman Creek.
			I	Parkwater - Area is partially unsewered and partially separated - Tributary to 8 overflows.

PROJECT #	SCHEDULE	ZONES	PROJECT DESCRIPTION
9.	BFP June 1982 CFP June 1983 BD June 1984 CD June 1985 BC June 1986	IV	Central Business District - Sewers are in poor condition. Separation and rehabilitation are needed.

LEGEND:

BFP	Begin Facilities Plan
CFP	Complete Facilities Plan
BD	Begin Design
CD	Complete Design
BC	Begin Construction

APPENDIX II
NORTH SPOKANE
WALL STREET DRAINAGE INVESTIGATION[1]

Concept No. 1

A. Divert 253 c.f.s. of 5-mile Prairie drainage from the Cedar Road Culvert into the City Pits at Francis and Maple.

B. Provide emergency overflow of 50% of the contribution to the City Pits, from a 5-year flood, into the paved ditch along Country Homes Blvd., as follows:

From 5-mile Prairie	253 c.f.s.
From Cannon Bowl	72 c.f.s.
	325

50% = 325/2 = 163 c.f.s.

C. Provide underground piping from the outlet culvert on Country Homes Blvd. into Wall Street at Price Road and along Wall Street to Mill Road. This structure will carry:

a. 5-mile drainage except the diverted 253 c.f.s.
b. *All local drainage along Country Homes Blvd.*
c. All local Wall Street Drainage from Francis Avenue to Mill Road.
d. Discharge into the natural drainage channel at Mill Road.

D. Emergency overflow from City Pits will surcharge this system.

E. Estimated construction cost $983,000.[2]

Concept No. 2 - Identical to Concept No. 1 except:

A. Drainage from areas south of Hawthorne Avenue will be discharged into the natural channel (east of Wall Street) at a point 400 ft. north of Hawthorne.

B. Local catch basins and outfall pipes, to the natural drainage channel, between Hawthorne Avenue and Mill Road are estimated to cost $11,400.[3]

---

(1) Source: Informal studies made by County Engineer's office in 1971.
(2) All construction costs are adjusted to 1974 price level and are exclusive of right-of-way costs.
(3) Local drainage costs are not included in concept cost.

C. Estimated construction cost $747,000.

Concept No. 3

A. Provide facilities, principally under Wall Street, based on 5-year flood, to:

   a. Accommodate all local drainage into Wall Street between Francis Avenue and Mill Road.
   b. Discharge into the natural drainage channel at Mill Road.

B. Drainage from 5-Mile and Country Homes Blvd. will be left "as is" through existing culvert at Tieton Avenue, and flowing northeast through natural drainage channel east of Wall Street.

C. A new triple-arch culvert under Tieton Avenue, which can be financed with gas tax funds, is estimated to cost $33,300.[1]

D. Estimated construction cost $462,000.

Concept No. 4 - Identical with Concept No. 3 except:

A. Drainage upstream from Hawthorne Avenue to be discharged into the natural drainage channel at a point 400 ft. north of Hawthorne Ave.

B. Catch basins and discharge pipes, for local drainage between Hawthorne Avenue and Mill Road, are estimated to cost $11,400.[2]

C. A triple-arch culvert at Tieton Avenue, which can be financed with Gas Tax Funds, is estimated to cost $33,300.[1]

D. Estimated construction cost $255,000.

Concept No. 5 - Criteria

A. Divert 253 c.f.s. from Cedar Road to City Pits.

B. Conduct all other drainage through underground piping - to run from Country Homes Blvd. at Carolina Way to Outfall at Hawthorne Avenue.

C. Include diversion facilities.

---

(1) Included in concept total.

D. Provide overflow pipe from City Pits to Country Homes Blvd. Ditch.

E. Overflow from City Pits, based on 5-year flood, should not surcharge this system.

F. Facilities for local drainage between Hawthorne Road and Mill Road have been estimated at $11,400.[1]

G. Estimated construction cost $767,000.

Concept No. 6 - Criteria

A. Divert 253 c.f.s. from culvert on Cedar Road to City Pits.

B. Construct Detention Pond at west side of Country Homes Blvd. just southerly of Excell Drive.

C. Underground pipe from Country Homes Blvd. culvert northerly of Carolina Way to present culvert at Price Road.

D. Construct Detention Pond on north side of Price Road about 200 feet west of Wall Street.

E. Conduct Country Homes Blvd. local drainage into intake northerly of Carolina Way.

F. Conduct Wall Street drainage into intakes at:

   a. Price Road Detention Pond.
   b. Present culvert north of Tieton Avenue.
   c. Catch Basins at Jay Avenue, Mountain View Avenue, Holland Avenue, Whitworth Drive, College Road, and Westover Road.
   d. Discharge into natural channel 400 feet north of Hawthorne Road.

G. Facilities for local drainage between Hawthorne Road and Mill Road have been estimated at $11,400.

H. Estimated construction cost $619,000.

Concept No. 7 - Criteria

A. Divert from Cedar Road, equivalent to:

118 c.f.s.	-	drainage from City area on top of 5-Mile Prairie.
17 c.f.s.	-	drainage from City areas on east slope of 5-Mile Prairie that drains into Country Homes Blvd.
135 c.f.s.		City responsibility

(1) Local drainage not included in concept total

253 Total from 5-Mile Plateau
118 c.f.s. Left to Country Homes Boulevard run-off.

B. All drainage, including this 118 c.f.s. to be piped from Country Homes Blvd. at Carolina Way to outfall at Hawthorne.

C. No estimate of diversion to City Pit is included herein.

D. Local drainage facilities between Hawthorne Road and Mill Road have been estimated to cost $11,400.

E. Estimated construction cost $758,000.

Concept No. 8 - Criteria

A. Divert 253 c.f.s. from Cedar Road to City Pits. (By City of Spokane.)(1)

B. Provide no overflow from City Pits.

C. Construct Detention Pond at Excell Drive.

D. Provide underground piping from Country Homes Blvd., near Carolina Way, to Price Road.

E. Construct Detention Pond on north side of Price Road about 200 feet west of Wall Street.

F. Provide underground piping from Price Road Pond, along Price Road to Wall and thence along Wall Street to culvert at Tieton Avenue (7 plus 00).

G. Divert 111 c.f.s. down natural channel which runs northeasterly from Tieton Avenue. This represents overflow from Price Road Pond, plus 12 c.f.s. in existing 21" pipe under Wall Street.

H. Provide underground piping from Jay Avenue (11 plus 50) to outfall at College Road.

I. The cost of local drainage facilities between College Road and Mill Road has been estimated to be $36,500.

J. Estimated construction cost $295,000.

---

(1)Cost to City not included in concept total.

Concept No. 9 - Criteria

A. Same as Concept No. 8 except that no drainage is diverted down natural channel from Wall at Tieton.

B. From Tieton Avenue, the overflow from Price Road Pond and all local drainage will be piped under Wall Street pavement to the outfall proposed at College Road.

C. The cost of local drainage facilities between College Road and Mill Road has been estimated to be $36,500.

D. Estimated construction cost $461,000.

NOTE: The difference between the estimated costs of Concept Nos. 8 and 9 might reasonably be assessed against property owners along the natural water course between Country Homes Blvd. and Hawthorne Avenue, resulting in the benefits of Concept No. 9 for the cost, from public funds, of Concept No. 8.

Concept No. 10 - Criteria

A. Includes drainage from 5-Mile Prairie into culvert at Cedar Road as follows:

From City areas:	118 c.f.s.;	46.5%
From County areas:	135 c.f.s.;	53.5%

B. Includes drainage from slopes on east and west sides of Country Homes Blvd. between Cedar Road and Carolina Way, as follows:

From City areas:	17 c.f.s.;	19%
From County areas:	71 c.f.s.;	81%

C. Includes local drainage, principally from west side of Wall Street from Francis Avenue to 400 feet north of Hawthorne Avenue.

D. Discharges into natural channel at a point 400 feet north of Hawthorne Avenue.

E. No diversion anywhere south of Hawthorne.

F. Cost of local drainage facilities between Hawthorne Avenue and Mill Road has been estimated to be $11,400.

G. Estimated construction cost $996,000.

Concept No. 11

A. Identical to Concept No. 10, except diversion to take place at College Road instead of at 400 feet north of Hawthorne Avenue.

B. Cost of local drainage facilities between College Road and Mill Road have been estimated to be $36,500.

C. Estimated construction cost $814,000.

Concept No. 12

A. Identical to Concept No. 11, except that 150 c.f.s. is diverted to natural channel at Tieton Avenue.

B. Includes special structure at Tieton Avenue.

C. Cost of local drainage facilities between College Road and Mill Road have been estimated to be $36,500.

D. Estimated construction cost $728,000.

Concept No. 13

A. Identical to Concept No. 10, except 150 c.f.s. to be diverted northeasterly through natural channel from culvert at Tieton Avenue.

B. Includes special structure at Tieton Avenue.

C. Cost of local drainage facilities between Hawthorne Avenue and Mill Road are estimated to be $11,400.

D. Estimated construction cost $855,000.

Concept No. 14 - Criteria

A. Detention ponds at:

   a. Excell Drive
   b. Price Road

B. No diversion at either Cedar Road or Tieton Avenue culvert.

C. All drainage in underground piping beginning at Country Homes Blvd. near Carolina Way and ending at outfall near Hawthorne Avenue.

D. Cost of local drainage facilities between Hawthorne Avenue and Mill Road has been estimated to be $11,400.

E. Estimated construction cost $900,000.

Concept No. 15 - Criteria

A. Identical to Concept No. 14, except that 150 c.f.s. to be diverted down natural channel from culvert at Tieton Avenue.

B. Outfall into natural channel at 400 feet north of Hawthorne Avenue.

C. Include special structure at Tieton Avenue.

D. Cost of local drainage facilities between Hawthorne Avenue and Mill Road has been estimated to be $11,400.

E. Estimated construction cost $791,000.

Concept No. 16 - Criteria

A. Same as Concept No. 14, except that outfall occurs at College Road.

B. Cost of local drainage facilities between College Road and Mill Road has been estimated to be $36,500.

C. Estimated construction cost $750,000.

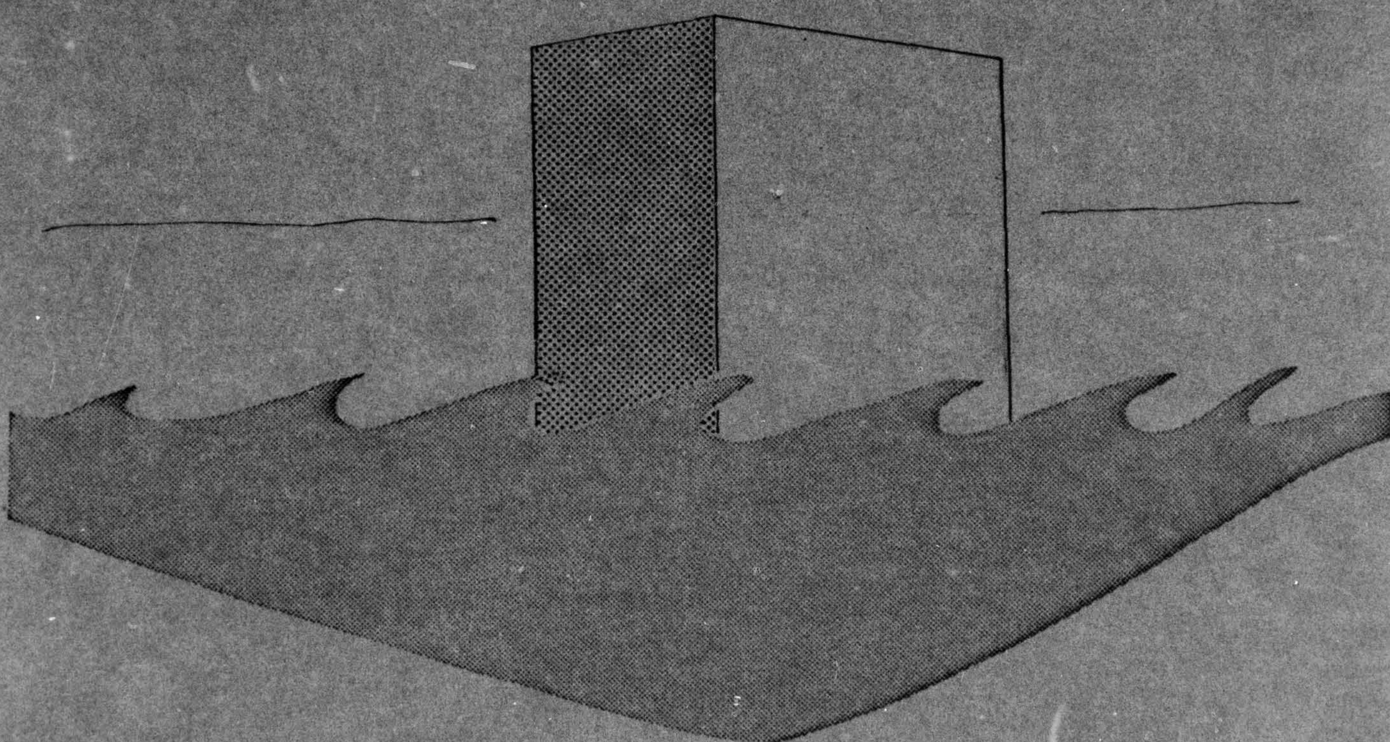
Concept No. 17

A. Canal, lined with asphaltic concrete, and protected by an 8-foot chain-link fence.

B. Includes a triple-arch C.M. culvert at Tieton Avenue.

C. To omit asphaltic concrete lining, deduct $57,200.

D. Estimated construction cost $332,000.



SECTION 604.6

FLOOD CONTROL NEEDS ALTERNATIVES AND EVALUATION

WATER RESOURCES STUDY

METROPOLITAN SPOKANE REGION

SECTION 604.6

FLOOD CONTROL NEEDS

ALTERNATIVES AND EVALUATION

13 October 1975

Department of the Army, Seattle District
Corps of Engineers
Kennedy-Tudor Consulting Engineers

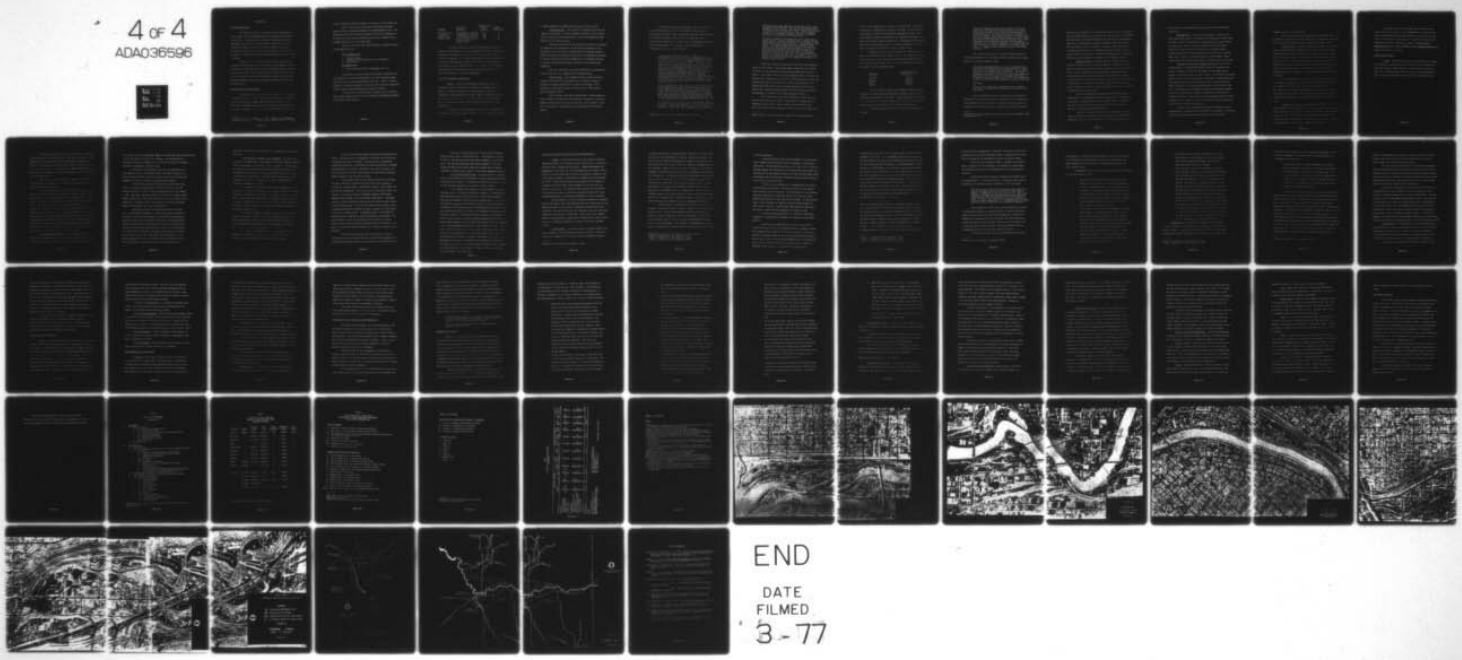
INDEX

INDEX - Continued

AD-A036 596 KENNEDY-TUDOR SPOKANE WASH F/G 8/6
METROPOLITAN SPOKANE REGION WATER RESOURCES STUDY. APPENDIX H. --ETC(U)
JAN 76

UNCLASSIFIED NL

4 OF 4
ADA036596



END
DATE
FILMED
3-77

SECTION 604.6

Scope and Objectives

The 100 year recurrence flood flows for the Spokane River, Little Spokane River and Hangman Creek are determined and reported in Section 410.1. Areas subject to flooding on these same streams are described in Section 410.2. The objectives of this section are to evaluate the impact of potential flooding, formulate alternative structural and nonstructural methods for abatement of flooding damage and hazard, evaluate these alternatives and recommend a selected course of action.

This section is not concerned with internal urban flooding problems caused by rainfall on the urban area or its immediate environs but rather with flooding caused by major streamflows generated remotely from the urban area. Urban flooding problems caused by deficiencies of the City storm and combined sewer systems are covered in Section 500. Flooding problems in suburban areas presently unsewered are discussed in Section 604.5.

Overview of the Flooding Problem

Flooding from non-local runoff has not been a major problem in the Spokane urban area. The few problems that exist effect very small areas with low levels of damage and practically no threat to life. Where future problems could develop, proper zoning could prevent their occurrence. Spokane is cited in a U.S.G.S.[1] nationwide survey of 26

---

[1] Schneider, W.J. and Goddard, J.E. 1974. Extent and Development of Urban Flood Plains. U.S. Geological Survey Circular 601-J. K-T #654.

cities as having the smallest percent, 2.4 percent, in flood plain area.

None of the existing or potential flood control problems impact upon the recommended wastewater or sludge management plans. The existing City STP site has been determined by the City's consultants to be above flood level and the potential site area for a Spokane Valley treatment plant is not in the flood plain.

There are four urban sites which experience flooding and minor flood damage; these are:

<u>On the Spokane River</u>

1. Peaceful Valley
2. Riverpoint (industrial area east of Gonzaga U.)
3. Upriver Drive

<u>On Hangman Creek</u>

1. From 11th Avenue south to approximate R.M. 3.5

An extensive area which regularly experiences flooding is the area adjacent to the Little Spokane River, but with negligible damage since the area is largely undeveloped at this time. There is, however, pressure for suburban expansion in the area on one hand and a significant public reaction favoring maintenance of natural conditions.

To put the total flood problems in perspective the following table roughly summarizes the extent of potentially threatened development at the above cited locations:

Location	Structures Involved	Developed Area Involved Acres	Maximum Depth, Feet
Peaceful Valley	20 residences, 1 industry	11.7	4
Riverpoint	4 industrial/1 post off.	8.8	3
Upriver Drive	2 apartments, 1 residence	NA	4
Hangman Creek	up to 5 residences and farm buildings, a trailer court	NA	NA

It should be noted that Hangman Creek problems involve bank erosion and undercutting as well as inundation. The nature of the flood problems in the Spokane urban area do not call for or justify major structural responses. It is expected that small scale local improvements or non-structural approaches would be most appropriate to abatement of flood damage and flood damage potential. As a first step to formulation of possible specific responses, a brief survey is presented of the general alternatives to flood plain management.

Flood Plain Management Alternatives

General. Flood plain management alternatives include all possible measures for preventing or reducing flood damage where flood damage is defined as including not only the physical losses due to inundation or undermining but the economic impact of emergency measures and loss of economic output. It is also a goal of flood plain management to achieve the optimum economical and environmental use of the flood plain.

Alternative flood plain management involves a broad spectrum of structural and non-structural techniques. Table 1 presents an outline of these techniques as categorized by Burges and Hillmer (1974).

Major Structures. This category is subdivided into four subcategories by function: (1) For reducing flow volume, (2) for controlling the elevation of the water surface, (3) for containing the flood flow and (4) for bank protection.

Dams and reservoirs for flow reduction can almost be eliminated by inspection from consideration for the specific problems in this study due to their great cost in comparison with the damage potential. These alternatives are addressed to the extent of examining the findings of previous studies effecting the Spokane River and Hangman Creek and to consider the applicability under the unique Little Spokane River conditions.

The other three major structural alternatives are essentially local in nature and are considered on an individual basis.

Flood Proofing. This technique includes various structural considerations that may be incorporated in the original design of a structure or added by modification to reduce flood damage. These techniques are described in detail in Sheaffer et al (1967) and U.S. Corps of Engineers (1972).

These techniques have good potential where flooding depths are small and where other measures are economically infeasible, a situation common to several specific cases in this study. This technique is also one of the mandatory considerations for the National Flood Insurance Program.

The National Flood Insurance Program. One of the non-structural alternatives to reduction of the impact of flood damage is a flood insurance program. Such a program has been made available nationally through the National Flood Insurance Program (NFIP) under the Flood Insurance Administration (FIA) of the U.S. Department of Housing and Urban Development. This program is briefly described in the following quotation from a HUD brochure.*

> "Inaugurated in 1968 and broadened in 1969 and 1973, the National Flood Insurance Program is a comprehensive approach to flood damage protection. It enables individual property owners in flood prone areas to acquire for the first time insurance coverage at affordable rates. At the same time, it requires that communities with designated flood prone areas adopt flood plain management measures to protect against the devastation of future flooding. To be eligible for this federally-subsidized insurance protection, the community in which an individual resides must apply to the Federal Insurance Administration (FIA) of the U.S. Department of Housing and Urban Development and meet the minimum requirements established by FIA for participation in this program. Once an area is accepted in the program, local insurance agents will sell the policies.
>
> Since the inception of the program, FIA has notified more than 15,000 communities that they are flood prone and that they should apply for this special coverage. Each has been provided a map tentatively identifying hazardous flood prone areas. To be accepted in the program initially, a community must submit an application, part of which requires the adoption of minimum flood plain management regulations, such as a simple building permit system if one does not already exist.
>
> Once a community has fulfilled this simple procedure and is accepted in the program, individual property owners throughout the entire community can immediately purchase subsidized insurance to cover losses up to $35,000 on a single dwelling;

---

*"Bridge over Troubled Waters" HUD-FIA-79, February 1975.

$100,000 on multi-unit dwellings, and $10,000 on the contents of each unit; and $100,000 on non-residential buildings and $100,000 on their contents. The rate for residential coverage is only $0.25 cents per $100.00 of value. Thus, insurance protection for a residence valued at $20,000, for example, would cost the purchaser only $50.00 per year.

Following acceptance in the program FIA will contract with a federal agency or private engineering firm to provide the community with the flood data necessary to develop adequate additional flood plain management measures to minimize flood damage. The technical information developed will include an actuarial rate map enabling property owners to purchase an equal additional amount of non-subsidized insurance at actuarial rates once the additional flood plain management measures are adopted for their area. The map will be accompanied by a study containing sufficient technical data on the special flood hazard areas of that community to enable it to formulate these measures."

Within the study area, progress has been made toward implementation of this program. Flood Hazard Boundary Maps have been prepared by FIA for the incorporated and unincorporated communities listed in Table 2. Also shown in Table 2 are the communities that are eligible for National Flood Insurance as of July 1975.* Most significant to the flood problems discussed in this section is the fact that both the City of Spokane and Spokane County acting for unincorporated areas have established their eligibility under the NFIP and are therefore committed to establishment of acceptable flood plain management measures.

The FIA mapping of Flood Hazard Boundaries in the study area identifies many more areas subject to potential flood damage than are addressed in this section. Refer to Table 3 which lists the flood hazard area identified by FIA mapping. Within the City of Spokane, four

*Weekly lists of currently eligible communities are published by FIA.

of the 7 areas identified are considered in this section. The identified areas not considered are unoccupied riverbank. Of the identified flood potential in rural areas and small communities, only the lower Little Spokane, Rockford and Tekoa have had significant problems. The lower Little Spokane Valley and Rockford are considered in this section. Tekoa is not included herein since it has been the subject of recent Corps of Engineers reconnaissance studies in 1966 and 1970.

Communities have one year from the date of identification in which to establish eligibility under the NFIP. Five communities in the study area have had their hazard areas identified and mapped but have not established their eligibility. They are listed below together with the date one year from identification:

Community	Date One Year From Identification
Fairfield	11-08-75
Latah	12-06-75
Rockford	12-06-75
Tekoa	08-30-75
Waverly	11-15-75

Since the primary condition of eligibility under the NFIP is adoption of certain flood plain management techniques, they should be understood as defined for this purpose. These requirements, enforceable by federal control of certain financing means in the area such as FHA, make it unnecessary for this study to recommend these measures.

The NFIP provides a definition of flood plain management as follows:

> "Flood plain management means the operation of an overall program of corrective and preventive measures for reducing flood damage including but not limited to emergency preparedness plans and any regulations aimed at the future use of the flood plain. Such regulations refer to specific local codes and ordinances which provide standards for the location and design of new development within flood-prone areas. These regulations may be adopted in any manner that is legally enforceable for a particular community, and typically take the form of portions of zoning, subdivision or building regulations, or a special purpose ordinance such as a flood plain ordinance...."[1]

This same reference goes on to define a minimum standard of flood plain management for the purpose of NFIP qualification as consisting of the following community action:

> "(1) require building permits for all new construction and substantial improvements and (2) review the permit to assure that sites are reasonably free from flooding. For its flood-prone areas, the community must also require: (1) proper anchoring of structures, (2) the use of construction materials and methods that will minimize flood damage, (3) adequate drainage for new subdivisions, and (4) that new or replacement utility systems be located and designed to preclude flood loss."
>
> and further:
>
> "that all new construction in identified areas of special flood hazard be elevated or floodproofed to the level of the base flood."

One of the important tools of the NFIP is the delineation of the special flood hazard area which is defined as the area inundated by the event with one percent chance of occurrence in any one year, also referred to as the 100 year flood. The 100 year flood flow is further

---

(1) From "Questions and Answers, National Flood Insurance Program" in HUD News March 10, 1975.

defined as that determined by the Log-Pearson Type III statistical method. This is the methodology used in Section 410.1 of this study. The profiles and water surface elevations developed in Section 410.2 are approximate since they are developed from existing available profile and cross section data which are not of a quality to satisfy the NFIP requirements to establish actuarial rates. Presumably these more accurate data will become available in the future. The NFIP law requires that the necessary technical data be provided at no expense to the community involved.

Regulatory Control. The NFIP makes the adoption of certain regulatory controls of the flood plain mandatory. Note that the above materials contain the proviso that these regulations be "legally enforceable." To help communities solve the problem of developing legally enforceable statutes, the Water Resources Council (WRC) has sponsored a legal research to develop model statutes. The results of this research are presented in a two volume work titled "Regulation of Flood Hazard Areas to Reduce Flood Losses." Burges and Hillmer (1974) provide further information on flood plain zoning.

Control of development and optimum use of the undeveloped lands subject to flooding along the Little Spokane River will depend on the adoption of appropriate statutes by Spokane Country. Guidance in the field of statutes is beyond the scope of this study except by reference to the WRC sponsored publications.

The goal of regulatory controls is to control the uses and kinds of construction in the flood plain to minimize flood damage while leaving the lands in private ownership. The primary consideration is that this goal be accomplished within constitutional and legislative constraints.

Non-regulatory. One of the alternatives to control of privately owned lands subject to flooding is the acquisition of those lands by a public agency for dedication to flood tolerant uses such as parks and open spaces. There is also the possibility of the land being acquired by a public agency for conversion to developable land by structural means such as filling, bank protection or levees for either public use or return to the private sector for redevelopment. These considerations have general applicability to several sites in this study.

Warning and Evacuation or Emergency Protection. One of the responsibilities of the National Weather Service is continuous monitoring of weather conditions for the purpose of developing advance warning of conditions likely to produce floods. The warning from National Weather Service River Forecast Center (in Portland) is disseminated over the communications network of the National Civil Preparedness system which is tapped by local agencies including the City and County of Spokane. The Washington State Emergency Services has management responsibilities for coordination of effort in responding to notification of emergency conditions. Thus there is a well established system for flood warning and the initiation of action for emergency response, whether it be evacuation or temporary protections.

Within certain constraints, the Corps of Engineers also has responsibility for emergency flood protection to the extent of protecting existing and maintained levees, and other actions where there is "imminent danger" to public property.

For areas threatened by the Spokane River advance warning based on conditions in Idaho has provided ample notice of high water conditions which has permitted emergency preparations such as sandbag levees.

Land Treatment. A number of alternative measures for decreasing runoff and increasing infiltration or retention are shown in Table 1 under three general kinds of land use, agricultural, forest and urban. For this study, the amount of urban land contribution to major streamflow is negligible. Refer to Section 604.5. For the watershed of the Spokane River in Idaho, the portion in agricultural lands is also negligible, leaving forest lands as the primary concern. Both forest and agricultural lands are tributary to the Little Spokane and Hangman Creek watersheds.

The watershed with greatest need for increased infiltration or retention is Hangman Creek. This stream is extremely flashy due to the combination of slope, soil type and agricultural practices. Far more critical to the area than flood control is reduction in erosion of the valuable Palouse soils. For discussion of possible improvements in retention in connection with agricultural practices refer to Section 312.6.

Application of Alternatives to Specific Problems. The foregoing alternatives are considered for their applicability and appropriateness to solution of the specific problems in the study in the remainder of this section. Table 4 provides a checklist of alternatives considered and their applicability to each specific site. Refer to Figure F for orientation of specific sites on Figures A through E.

The mandatory actions to be taken under the NFIP are key actions and are all or part of the recommended plan of action in many cases. These mandatory actions are assumed to be taking place in any case so that the focus in this study is on additional actions not required under the NFIP. Therefore, in Table 4, Flood Insurance, Flood Proofing and flood plain management through Regulatory Control are assumed to be given in all cases.

Spokane River Problems

General. The Spokane River is well contained in its channels, with substantial freeboard even at the 100 year flood, throughout the study area except at three locations. These three locations are at R.M. 73.6 at Peaceful Valley, R.M. 75.5 to 76.2 designated Riverpoint (east of Gonzaga University) and R.M. 76.8-78.0 along Upriver Drive.

The flood of January 1974 was created by flows of 46,100 cfs which approaches the calculated 100 year flood flow of 52,000 cfs. The channel section is such that the calculated additional depth at the 100 year flood ranges from 0.6 feet in the vicinity of Peaceful Valley to 1.5 feet above R.M. 75. Thus the level of damage sustained during the January 1974 flooding is a substantial measure of that to be expected by the 100 year flood.

There are no official economic loss reports for the January 1974 experience. The impacts described below are based primarily on news coverage and aerial photos.

At least three days warning were available in advance of the January 1974 peak and similar advance warning would be expected for all major floods due to the routing effect of Coeur D'Alene Lake. All major floods on the Spokane River originate in runoff from the Coeur D'Alene and St. Joe Rivers in Idaho and are reflected as increases in the Spokane River caused by increase in stage at Coeur D'Alene Lake. Monitoring of the Coeur D'Alene and St. Joe gages provides timely warning of the coming increase in Coeur D'Alene stage. This practice was in effect during January 1974 with the result that the City of Spokane had warned citizens in the flood prone areas and had provided sand and sandbags for temporary protections in advance. The result is less damage than the river stage and theoretical flood plain would indicate.

R.M. 73.6, Peaceful Valley. The total area potentially affected is approximately 11.7 acres containing 20 single family residences and one industrial structure. Refer to Figure A. These homes are on Water Street from just below Cedar to the river bank and on Main from Ash to the river bank, all in the City of Spokane. The maximum depth of potential flooding is estimated to be 4 feet and the length of riverbank involved is approximately 1500 feet long.

The January 1974 flooding of this area is estimated to have been within 0.6 feet of the 100 year flood. The damage experienced in January 1974 was confined largely to flooded streets plus the yards and basements of about 12 residences and an industrial building.

The estimated potential damage with the 100 year flood and failure of temporary sandbag dikes is extension of street, yard and basement flooding to a total of about 20 homes with first floor damage to some. The single industrial facility in the area is a casket factory whose concrete floor is above the flood plain, the flood potential being primarily to the storage yard. The residences in the area are single family wood structures, most over forty years old.

The assessed valuation of the casket factory is $41,000, land, and $104,000, improvements. Typical single family residences in the portion of Peaceful Valley subject to flood threat have assessed valuation of $450, land, and $2,900, improvements. With approximately twenty residences and the casket factory in the flood threatened area, the total assessed value of improvements in the area is $162,000 equal to a market value of $205,000. The damage potential due to flooding is only a small part of the total value of the improvements. If the maximum damage were 10 percent of market value, the damage would be of the order $20,000. There are no records of actual damage due to historical floods but it is estimated that the damage was far less than this level.

R.M. 75.5-76.2 Riverpoint (near Gonzaga U). The total area affected on the right bank is approximately 24.2 acres of which 8.8 acres contain development, all industrial. Refer to Figure B. The developed area affected is on Columbus Street between Trent and Springfield, on Springfield from Cincinnati to the river, Superior Street on both sides of Springfield, the west side of the Post Office and the river side of buildings at the foot of Cincinnati and Columbus. Maximum depth of flooding is estimated to be 3 feet.

The January 1974 flooding of this area is estimated to have been within 1.5 feet of the 100 year flood. Damage was limited to street flooding in the areas described above including the west side of the Post Office. The railroad embankment marked the limit of flooding along the west side of Gonzaga University. Lake Arthur became a part of the river when the flood flow crossed over the roadway which normally separates Lake Arthur from the river.

The extent of damage as compared with the January 1974 flood caused by addition of another 1 to 1.5 feet of depth at the 100 year flood is impossible to evaluate without precise floor elevations. The area involved would not be expected to be much greater but the added depth would certainly restrict access to the Post Office.

The length of riverbank involved is approximately 1800 feet adjacent to the developed industrial area. A total of 4800 feet is involved if the overbank adjacent to Lake Arthur is included.

The two parcels facing Superior Street have the maximum flood threat. The parcel north of Springfield (17534-0216) is vacant and has an assessed land value of $11,680. The parcel south of Springfield, occupied by Dorsey Bros. (17534-0215) has assessed land value of $32,000 and improvements of $159,520. The Dorsey Bros. parcel contains a concrete block wall open-sided vehicle shelter and some smaller buildings. Damage potential to the structures is small.

The occupancy south of Trent Avenue is described as follows: The parcel southeast of Hamilton and Trent, with river frontage, is occupied by Corrugated Metals (517534-0563) assessed values $3,880, land, and $49,440, improvements. The parcel south of Front Avenue, with river frontage, is occupied by Taylor and Edwards Warehouse (TI754-0501), assessed values $36,000, land, and $115,040, improvements. The damage potential to both structures is small since the floors are high relative to the adjoining ground. The only other improved parcel south of Trent, occupied by M. Mikelson Equipment and Supply, appears to be high enough to be free of flooding threat. The Mikelson parcel (TI7534-0502) has assessed values of $30,320 for land and $134,080 for improvements. The area southwest of Trent and Cincinnati Street extended is railroad property and was about 40 percent inundated by the 1974 flooding. It is part of the operating railroad property and a separate valuation is not available.

The Post Office structure west of Cincinnati and north of Trent Avenue is above the flood level but the surrounding ground on the southwest and northwest appears to be floodable up to the building line.

There are no improvements south of the railroad embankment along the south edge of Gonzaga University. The high water observed on the left bank in January 1974 was limited primarily to undeveloped land. Some limited flooding was experienced adjacent to the river between the Upper Trent Avenue bridge and Broadway, and at a marina upstream of Division Street, however no structural damage was reported.

R.M. 76.8-78.0 Upriver Drive. The area affected is approximately one mile long on the north bank of the river between the Mission and Greene Street bridges. In addition to Upriver Drive itself, a house and two apartment buildings are threatened. Refer to Figure C.

In the January 1974 flooding, the road pavement was flooded throughout most of its length, particularly adjacent to Washington Water Power Building and east from Granite Court to Smith Street (extended). These sections remained flooded until flow dropped below 40,000 cfs. The 1974 flooding approached the foundation lines of the two new apartment buildings east of the intersection of Crestline Street and Upriver Drive. The approach was closest to the new 67 unit Edgewater Village where some diking and removal of carpets and furniture was done in anticipation of possibly higher levels. The most seriously threatened structure was the single family residence at E 2315 Upriver Drive where a four foot high wall of earth and sandbags was constructed on three sides of the lot. The home is recently constructed and in the over $30,000 class. The 100-year flood which is estimated to be 1.5 feet higher stage than the 1974 flood could be expected to begin encroaching on the ground floor level of the apartments and threaten the residence with flooding about 4 feet deep. The additional 1.5 feet of depth would approach several smaller dwellings but probably would not cause significant damage. There was no actual structure damage in the 1974 flood.

Spokane River Alternatives, Evaluation and Recommendations

General. For all three locations, the feasible structural alternatives appear to be limited to levee construction, or in the case of Upriver Drive, raising the road itself. Channel improvements and management of river flows out of Coeur D'Alene Lake as a means of flood reduction for the Spokane River have been investigated in depth by previous Corps of Engineers studies which are summarized in House Document No. 531[(1)]. These previous studies conclude that neither channel improvements nor Coeur D'Alene Lake management are cost effective and feasible alternatives. The conditions which caused these alternatives to be rejected in 1950 are essentially unchanged and there are no new considerations which would justify reexamination of these conclusions.

House Document No. 531 also includes consideration of impoundments on the Coeur D'Alene River upstream from Coeur D'Alene Lake for the multiple purposes of flood control, irrigation, power generation and recreation. The flood control benefits below Post Falls are a very minor element in the evaluation of these dams. Since none of these impoundments are currently under consideration for implementation, this alternative is not considered significant to current flood control problem solving.

Peaceful Valley. At Peaceful Valley a straightforward structural solution to prevent flooding is physically feasible. This would consist of a combination of flood wall and levee extending from under

---

(1) Refer to U.S. Army Corps of Engineers (1950).

the Maple Street Bridge west approximately 1500 feet to tie into higher ground beyond the City sewage lift station. There is an existing concrete wall about 300 feet long between the casket factory and the river but this wall was too low by at least two courses of sandbags during the 1974 flooding. There is insufficient space to construct a levee from the Maple Street Bridge west about 700 feet, including the section with the existing wall. A permanent structural solution would consist of 700 feet of concrete flood wall, up to 10* feet high but averaging 7 feet, and 800 feet of earth levee with slope protection, up to 8* feet high and averaging 6 feet high. The estimated construction cost of this improvement is $150,000 exclusive of right-of-way. The observed damage potential appears to be significantly less than the proposed improvement and can not be justified on a cost-benefit basis. The decision to take action would have to be based on social or planning considerations.

Peaceful Valley is presently zoned R-3,[1] multiple family residence, although the present occupancy is single family and one light industrial unit. The 1965 comprehensive plan[2] calls for Peaceful Valley to become an element in a major riverside park. The 1974 riverfront development plan[3] calls for private redevelopment of Peaceful Valley to garden apartments. The decisions for implementation of flood control improvements are dependent upon the planning goals and the timing

---

*All protective structure heights include 3 feet freeboard.
(1)Refer to Spokane City Plan Commission (1972).
(2)Refer to Spokane City Plan Commission (1965).
(3)Refer to Spokane City Plan Commission (1973).

of their achievement.

Eventual park use, which could be designed to tolerate infrequent flooding, would indicate no need to implement a flood control improvement. Redevelopment which implies the removal of the industrial building suggest that construction in the restricted space between the building and the bank would be premature and that the improvement should be designed after the building is removed and would include filling the entire area to above flood level.

If the area is to remain as it is indefinitely, the plan as described above is functional. An interim solution to the Peaceful Valley problem could be considered. The levee portion of the permanent structural improvement is about one third of the total cost, about $60,000, but would protect more than half the length. If this part were built it would minimize the temporary protections needed where the costly wall is required. With the usual ample warning of high water, this shorter length should be manageable for temporary works.

A diking and drainage district is a possible institutional arrangement to implement the improvement if acceptable to the owners involved.

Protection of Peaceful Valley by a wall or levee is not economically justifiable for the damages sustained. Although a diking and drainage district formed by the present occupants of the area is possible it is highly doubtful that such a plan would meet with public approval due to cost for even partial implementation as described above. Also, the local residents should not be asked to make a long-term commitment in the absence of a confirmed City planning policy.

If anything is to be done, it would probably have to be done with the assistance of the City. It is recommended that the City clarify its long term goals for this area with recognition for both the flood control implications and the displacement of individuals which is always inherent in a redevelopment. Only with goals set and an approximate time schedule could the justification of City participation be evaluated. The implementation of flood control for the Peaceful Valley area is not separable from overall planning decisions. The first prerequisite to any action is the formulation by the City of a definite policy and time schedule for the status of the area. The second prerequisite is the necessary earth foundation explorations to determine the physical constraints on levee construction and make possible a refined cost estimate based on construction conditions.

Riverfront (Trent Avenue Indust[illegible]

south of the railroad track (located at Broadway extended) is zoned M-1, light industrial.[1] The 1965 comprehensive plan[2] designates the Riverfront area as a riverfront conservation area to be developed by acquisitions, easements or zoning. The 1974 development plan for the Spokane River[3] designates this area for upgrading to industrial park and recommends extension of public ownership of the riverbank through the area. Public acquisition of the riverbank and including removal of structures on the riverbank would greatly affect

---

(1)Refer to Spokane City Plan Commission (1972).
(2)Refer to Spokane City Plan Commission (1965).
(3)Refer to Spokane City Plan Commission (1973).

any flood control implementation. Therefore, City goals for river front acquisition and open space development require consideration in formulation of alternatives for Riverpoint as they do for Peaceful Valley.

Since there are no specific plans or timetables to undertake public acquisition of the riverbank or for general area redevelopment, the discussions herein must be conditioned with these planning uncertainties.

The Riverpoint area experienced flooding in 1933 which led to the consideration of a levee for protection. The levee project and its feasibility are described in House Document No. 531[1] as follows:

> "The levee project for flood protection along the right river bank of the Spokane River in the vicinity of Trent Avenue, Spokane, was adopted June 28, 1938, but was never constructed. Subsequent investigations disclosed unsatisfactory foundation conditions that make the construction of the levee impracticable. Because of this and the fact that local interests consider the project undesirable, it is recommended that the authorized levee project within the city of Spokane be abandoned."

House Document No. 531[1] also covered consideration of specific channel improvements as a possible means of reducing the flooding depth in the vicinity of the Trent Street bridges and concluded that a combination of lowering the sill of the Upper Falls Dam and upstream channel improvements would succeed in lowering the flood stage by only 9 inches at the Trent Street bridges. Channel improvements were not recommended because of the high costs and small benefits.

The rejection of levee and channel improvements as possible

---

[1] Refer to U.S. Army Corps of Engineers (1950).

alternatives by a previous study would appear to preclude any solution to the flooding problem other than to vacate the affected areas and their designation as flood plain or to redevelop the area with fill above the flood plain.

Recommended actions are as follows, considering the riverfront by sections from west to east.

1. No action is recommended for the section between Lake Arthur and the river east to the railroad embankment on Broadway extended since there is no development subject to damage. If an element of the linear waterfront park is developed here, the road between Lake Arthur and the river could be built above flood level but with culverts to allow flooding through so that the road would not have to function as a structural levee.

2. In the section from the railroad embankment to the West Trent Bridge, it is recommended that some filling be done on the southwest and northwest side of the Post Office to protect continuous access to this important facility. Again, there is no justification from a damage abatement viewpoint. A more permanent solution can await riverfront development for open space. In the meantime, development in the large area northwest of the Post Office should not be permitted without prior solution of the flooding problem.

3. In the section from the West Trent Bridge to the East Trent Bridge it is recommended that no action be taken other than to prohibit development in the railroad operating property subject to flooding.

4. In the section from the East Trent Bridge to the Railroad at Broadway extended it is recommended that development in vacant parcel 17534-0216 be prohibited and that any additional development in parcel 17534-0215 be prohibited. The flooding of Springfield Avenue by waters entering the east end of the street between parcels 0215 and 0216 should be investigated for possible improvement west of Columbus Street by raising the street grade to provide a dry approach to the Post Office. Consideration should be given by the City to acquisition of the presently vacant parcel 17534-0216 with later acquisition of the lot occupied by Dorsey Bros. on the east side of Superior St. With the full width of the lots to work on it may be possible to construct a broad fill which would serve as a levee on the unsatisfactory foundation material.

Upriver Drive. The north side of Upriver Drive from Center to Stone is zoned R-4, large multi-family residences, and from Stone to Greene is zoned R-3, small multi-family residences.(1) The 1965 comprehensive plan(2) shows the Upriver Drive area from the riverfront back to

---

(1)Refer to Spokane City Plan Commission (1972).
(2)Refer to Spokane City Plan Commission (1965).

Illinois Street as conservation lands by easements and zoning. The 1973 plan for development of the Spokane River[3] is quoted below on its recommendation for this area:

> "Upriver Drive should be further improved into a parkway. The area, bounded by Perry Street, the river, Greene Street, and the GN tracks to the north, is an isolated area. The trend to apartments, retirement homes and non-residential use of WWP quality (of comparable quality as the WWP facilities in this location) is expected to continue and zoning should be modified accordingly as needed."

At Upriver Drive, the road itself is so close to the bank that there would not be room to build a separate levee; the road itself would have to become the levee. The proximity of development on the land side puts constraints on the amount that the road can be raised without developing an awkward relation with the fronting building. Approximately 4,000 feet of improvement would be required of completely rebuilt road with elevations increased by up to 6 feet with an estimated average of 3 feet. The estimated cost of the complete improvement including associated work to register the new elevation with adjoining private property is $300,000. The cost is far in excess of the apparent damage potential to either the the present road or the few present adjoining structures. Unlike the flooding problems at Pleasant Valley or Riverpoint, where the flood

---

(3) Refer to Spokane City Plan Commission (1973).

protection improvements are largely on a number of parcels of private property, the only feasible location at Upriver Drive is the City street itself, thus involving the City directly.

The only structural alternative for the buildings themselves other than raising Upriver Drive would be to provide flood proofing by permanent structural walls around the few threatened buildings. Removable sections would be required to provide for driveways and other access. Raising and/or moving the individual house which is in greatest danger onto a new foundation appears feasible and practical.

The primary recommendation for the Upriver Drive area east of the WWP building is the prevention of further development on sites subject to flooding pending solution of the flooding problem. This will be taken care of by the mandatory requirements of NFIP. Reconstruction of Upriver Drive at a grade above flood plain cannot be recommended on a cost benefit basis. It is recommended that the City make a policy decision as to whether they plan to modify the grade of Upriver Drive for any reason, such as upgrading to parkway status. If this is not imminent, the individual home owner should be encouraged to raise and/or move back his home and the apartment owners to proceed with flood proofing.

Non-structural. At most problem areas on the Spokane River, the opportunity for dealing with flood plain areas by zoning to prevent development has passed, but not completely. Further development in areas as described above must and will be prevented unless concurrent protection is provided in order to conform with NFIP requirements.

Non-structural alternatives to control the volume of runoff such as land use in the watershed are not productive since the Idaho watershed is at present in large measure in natural condition with the protection of national forest status and wild river status. This subject is also covered in House Document No. 531. This document points out that there are some lands in the watershed which could be improved in water retention capability by such measures as terracing, reforestation and grass planting on logged-off lands, primarily through U.S. Department of Agriculture programs, but that these efforts would have negligible effect on flood flow volumes.

A most effective non-structural measure for minimizing flood hazard on the Spokane River is already in existence, namely, the monitoring of flows on the Coeur D'Alene and St. Joe Rivers so that timely warning can be given impending flood stage. It is recommended that this monitoring and warning system be continued.

Little Spokane River Problems

General. If flooding is defined as flow outside of the channel defined in nature, the Little Spokane River is not guilty of flooding. Man's impact on the watershed has not significantly increased runoff and man's impact on the river channel has not significantly hindered flow (except in the last mile due to backwater from Long Lake). The river gradient is relatively flat in its lower reaches, below Chattaroy at approximate RM 22, and has developed a characteristic meandering configuration with a small channel. At higher flows, the river goes overbank throughout a large part of this lower reach as it has been doing since before the white man's arrival. The river flows are unusually well regulated without any artificial upstream impoundments due to a large groundwater interflow. The overbank flows are not due to high peak flows but to well attenuated peaks, and are of frequent occurrence rather than associated with infrequent extremes.

At present few improvements are threatened by overbank conditions. The overbank areas are in small private ownerships and are subject to development unless protected by zoning.

R.M. 9.9 Fairwood Lagoons. These interim facility sewage lagoons are constructed with earth dikes on land which would have been inundated by the flood of December 1973 which was 1,540 cfs as compared with the 100 year flood at 4,700 cf. Flood waters encroach on these earth dikes. The recommended wastewater plan will eliminate the need for these lagoons.

R.M. 10.8 Dartford. Several residences and approximately 11 acres of potential residential land are threatened. Approximately 1200 feet of riverbank are involved.

R.M. 18.0 Buckeye. Several residences and a stretch of county road are threatened by a reach of 1700 feet of riverbank.

Little Spokane River Alternatives

Structural. The calculated 100 year flood flow of 4700 cfs is a low peak for a drainage area of 700 square miles. Achievement of a further reduction through storage impoundments would be very costly. More important is the fact that overbank flows on the Little Spokane River takes place at much lower flows and the depth of overbank flow is not significantly increased at the 100 year flood due to the width of effective channel in the overbank condition. For example, the December 1973 flow of only 1540 cfs was sufficient to develop overbank conditions throughout most of the reach from the mouth to Chattaroy. The flat valley bottom extended these low flow overbank conditions "wall-to-wall". Consequently, a flow reduction to less than one third of the calculated 100 year peak would be required to eliminate overbank flooding. Conversely, the area inundated at 100 year flood would not be substantially greater than that which occurs at lower flows. These conditions all point to the impracticality of storage as a flood control measure on the lower reaches of the Little Spokane River.

The normal summer flow channel of the Little Spokane River is relatively small and is an extreme example of the meandering configuration. Both enlargement and straightening would have potential for greatly increased channel capacity and elimination of overbank conditions.

Levees following the existing alignment and channel size would have two structural disadvantages. The length of levee would be very long, and the height would be increased by the narrow channel to achieve the needed cross section.

No cost estimates are made for either of these channel structural alternatives since they could not be supported economically by any significant damage prevention and further, as discussed below, are environmentally unacceptable.

Non-structural. The watershed of the Little Spokane River has been changed by man's activity to the extent that most of the flat-lands now in forage crops or pasture were once forested. Most of the upland areas are still forested in natural and second growth. There has undoubtedly been some change in the rate of runoff from natural conditions in the farmlands. Due to the kind of agricultural use, however, this change is judged to be small and not amenable to significant change through different land managment techniques.

The primary non-structural alternative concerns the use of the overbank lands themselves. Zoning to prevent incompatible development would obviate the need to prevent overbank flows.

Little Spokane River Evaluation and Recommendation

The areas along both banks of the Little Spokane River from the mouth to Chattaroy are at present largely areas essentially in natural condition and of interest for preservation of natural habitat and vegetation. Any structural modification such as channel straightening or levees would destroy these natural conditions. Refer to goals selected by local citizens for shoreline management. Structural measures along the stream are not recommended.

Upstream storage is not recommended for consideration to attenuate peak flows since the overbank flow condition occurs at relatively low flows. For the same reason, and the fact that farm areas in general provide good cover, there is negligible opportunity for flooding reduction through watershed management.

The foregoing leads to the conclusion that there is no physically feasible method of preventing overbank conditions throughout the lower reach of the Little Spokane that is environmentally acceptable. It is recommended that the stream be allowed to continue its natural overflow regime and that the areas involved be zoned to prevent incompatible development which would be subject to damage. This recommendation is in keeping with the expressed public interest as recorded by the Department of Ecology as a result of a series of public meetings on this subject held in conjunction with State water plan development activities. Public interest findings relative to the Little Spokane River as contained in Chung (1975) are as follows:

> "Localized flood problems occur along the river from Chattaroy to the confluence with the Spokane River. Misuse of lands adjacent to the streams causes flood damage."
>
> "Nonstructural flood control measures are preferred over structural flood control."

Hangman Creek Problems

General. In contrast to the Little Spokane River which has low peak flows and the Spokane River for which there is ample warning time for high flows, Hangman Creek has extremely high peak flows that can be generated with little advance warning. Most of Hangman Creek is through rural area where there are few improvements which encroach on potentially flooded areas. These rural locations of minor flooding with negligible structural involvement are shown in Section 410.2 but are not considered further herein. Areas in or adjacent to the urban area with more significant structural involvement are discussed below.

Experience in the 1974 Flood. Hangman Creek between R.M. 1.1 and R.M. 3.5 suffered a variety of flood and erosion problems in the January 1974 flooding which was caused by peak flows of 18,300 cfs. The

100 year flood flow is 28,000 cfs. Therefore these 1974 episodes are only symtomatic of potentially more severe problems. The problems encountered during the 1974 flooding as observed by representatives of the Corps of Engineers are as follows, beginning at the downstream end and working upstream. Refer to Figure D for location of these incidents.

1. Downstream from a point beginning approximately 300 feet north of the 11th Avenue Bridge the channel is well protected by rock and did not experience any notable difficulties. Severe erosion was experienced on the west bank downstream from the west bridge abutment to the beginning of the rock protection and on the east bank from the east abutment about 300 feet upstream. These conditions were judged to be ineligible for remedial action by the Corps because north of the bridge the public road was not in "imminent danger" and south of the bridge only private property was threatened. The Corps is not empowered to take corrective action for private property and can take action for public property only if it is in imminent danger.
2. On the east bank north of 16th Street a levee was eroded to the extent that about 50 percent was washed away. The problem was made the subject of a Corps study, designated HAG 74-2, to evaluate the feasibility of slope protection to correct the problem. The estimated cost of $50,800

was determined to be in excess of possible benefits and the project was declared not justified. No action was taken.

3. On the west bank south of 18th Street a low area containing one home was inundated with minor damage to the home. The east bank on the outside of the bend of the stream opposite the low area suffered erosion. There was no authority for Corps action since only private property was threatened.

4. At the north abutment of the Inland Empire Way Bridge on the east bank there was severe erosion of the bank for a distance of about 300 feet. Corps assistance was declined by the City with the understanding that the state highway department would take corrective action.

5. The west bank between 23rd and 25th Streets was undercut threatening one private residence. The bank at this point is over 50 feet high. No study was made to evaluate protection since there is no authority for Corps action to protect private property.

6. The existing levee on the west bank between 30th and 31st Streets was washed out flooding the low areas to the north. The resultant damages included silt and debris deposited on farm lands, the erosion of farm lands, complete undercutting of a small shed and partial undercutting of a barn. The existing levee had been

constructed to an elevation to protect from floods of 30 year recurrence and appeared to have failed because of inadequate face protection against the high stream velocities estimated at between 11 and 14 feet per second. The project was studied by the Corps, found eligible and repaired in the spring of 1974, project HAG 4-74 under Public Law 99. The repair consisted of replacement to an elevation to protect against 30 year recurrence flooding but with Corps standard quality of face protection.

7. On the east bank between 30th and 31st Streets the bank was eroded threatening a Washington Water Power substation and some power poles. There is a need for bank protection. Corps action to remedy the situation was not authorized since the protection would serve a private owner.

8. On the west bank, the trailer court located in a low area at approximately 1500 feet south of the point where Highway 195 crosses the railroad was threatened with flooding but not actually reached by the 1974 water level. The east abutment of the private foot bridge at the trailer park was threatened by erosion.

In addition to the above described problem based on Corps observation there was another significant incident on the lower part of Hangman Creek, not, however, in the urban area.

9. Hangman Valley (County) Golf Course, at approximately R.M. 14.4, suffered extensive damage in the January 1974 flood. Inundation of fairways which were covered with silt and complete destruction of two pedestrian bridges caused damage estimated by the County at $150,000. The silt load carried by Hangman Creek in flood stage is an important component to its damage potential since inundation means not only water damage but also a layer of mud.

In the vicinity of Hangman Valley Golf Course, the County also suffered damage to County roads.

Forecast Flood Problems. The forecast water surface for the 100 year flood indicates a potential problem at R.M. 3.2 where no damage occurred in 1974.

The computed 100 year flood is estimated to have a water surface approximately 2.6 feet higher at this point than the January 1974 flood and would threaten the homes north of the NPRR bridge.

For the 100 year flood the erosion problems for the lower reach of Hangman Creek will undoubtedly be more severe than reported in 1974 and could well pose a greater threat than inundation.

Hangman Creek Alternatives and Recommendations

Storage and Land Treatment. Studies made by the Corps of Engineers in 1966 regarding flood control at Tensed, Idaho and Tekoa, Washington in the upstream end of the Hangman Creek watershed concluded that storage projects for flood control were not economically feasible. One of the reservoirs studied would have controlled 17.5 percent of the basin watershed. The feasibility of utilizing storage as a flood control measure for the lower reaches of Hangman Creek, involving the entire watershed with many tributaries and no significant storage sites, is judged to be even less feasible than the upstream proposals. Storage as a structural alternative is not considered further.

Upstream alternatives for land management to prevent high runoff and erosion are related to farming practices on the Palouse soils which cover a large proportion of the Hangman Creek watershed. Adoption of recommended farming practices are not expected to substantially affect peak flows which are often associated with frozen ground conditions. The primary goal of these management techniques is reduction of erosion and consequent reduction in silt load. These measures are expected to be pursued by the U.S. Soil Conservation Service independently of flood control concerns.

Flood peak reduction of the extremely "flashy" flow of Hangman Creek by either construction of impoundments or watershed management is judged to be infeasible in connection with alleviation of the minor flood damage problems addressed in the downstream areas. Watershed management for erosion control is a major concern addressed elsewhere which would have some long term minor flow reduction benefits, but insufficient to impact most flooding problems.

Flood Insurance and Regulatory Land Use Control. Relatively few residences are involved in Hangman Creek flooding problems since the threatened areas are presently at low density in semi-rural development. Since the NFIP will require regulatory land use control, the damage exposure will be prevented from increasing. It is recommended that the areas threatened by flood damage be defined to include not only those areas subject to inundation but also those areas that are threatened by erosion.

Other Structural Measures. Except at the trailer court, all flood and erosion threats to residences involve only one or several structures at any one location. The low loss potential makes any kind of structural correction not cost effective and the fact that the improvement benefits only private property precludes protection by Corps projects. The only feasible damage reduction technique open to these individuals is to encourage removal of the existing structures from the threatened areas. In some cases raising the floor level by a new foundation may be satisfactory where inundation is the threat. More precise definition of the flood elevation than available at present would be required. Most single family residences cannot be flood proofed except by raising the floor level. Where the threat is from erosion, moving back from the threatened land is the only alternative.

Where bridge abutments, roads and other non-residential improvements providing public service are threatened by erosion, bank protection is ultimately required either in anticipation of critical flows or on an emergency basis. At present, reliance is being placed on an emergency response. The very flashy flow condition of Hangman Creek and high flow and velocity potential make long term permanent bank protection to meet the most critical condition very costly. It is beyond the scope of this study to make the individual evaluations for each potentially threatened structure. Leaving the protections for emergency response appears to be the only feasible action unless a structure is declared of such critical importance by the responsible agency that permanent protection should be provided.

In general channel improvement is infeasible at most locations since the stream is relatively straight and the channel occupies all available space. Velocities are already high. Only at the bend and divided channel downstream from R.M. 3.2 would improvements be functionally feasible. An improvement at this point would benefit only the single residence in the pocket southwest of the railroad bridge.

Specific Location Recommendations. The following paragraphs correspond to the numbered paragraphs describing the problem locations and as identified on Figure D. Findings are summarized in Table 4.

Items 1, 4 and 7. These sites all represent erosion threats to public bridges and roads and to facilities of a privately owned public utility. At present reliance is being placed on emergency bank protection. It is the responsibility of these agencies to evaluate the criticality of the facilities to decide whether they should take permanent remedial action regardless of cost effectiveness.

Item 5. The erosion threat to a private residence on a high bluff cannot be remedied by any cost effective bank protection. The owner should be encouraged to vacate the dangerous site by moving the threatened structure. No public agency action is recommended.

Item 2. Repair and protection of this levee threatened by erosion has been declared not justified by a Corps study. No action is recommended other than those mandatory under NFIP.

Items 3 and 10. These are flood threats to isolated residences by forecast floods. No structural flood protection of the areas could be justified on the basis of damage potential. The owners should be encouraged to raise or remove the structures. No public agency action is recommended other than those mandatory under NFIP.

Item 6. The levee has been repaired with added erosion protection by Corps action. The area protected has low development and should be kept that way by the mandatory requirements of NFIP. Building the levee to a higher level of protection than the 30 year flood is not recommended.

Item 8. Trailer courts where the units are truly mobile and ample warning can be given are a permitted use in regulatory flood plains. Ample warning on Hangman Creek is marginal and trailer homes on blocks are not truly mobile. Further levee construction, even if cost effective, should not be permitted in the floodway to protect non-permanent construction. It is recommended that the site be vacated.

Item 9. A golf course is a permitted use in a regulatory flood plain. In this case the silt damage from the flood waters makes for high recovery costs by the golf course. Levee protection of the golf course would be an encroachment on the floodway. No action is recommended other than that which the golf course management wishes to take to reduce their recovery costs such as relocating part of the course.

Rock Creek at Rockford

The flooding problem at this community has been studied periodically since 1933. The potential flood plain for the 100 year flood flow is approximately 18 acres all on the east side of the stream. Refer to Figure E. The area is occupied by much of the community's commercial and public structures. A levee approximately 1700 feet long from the Emma Street bridge south was constructed following the 1933 flood and improved by the Corps of Engineers in 1965. A study was made in 1970 by the Corps of Engineers to evaluate the needs for improvement of the levee and to make a cost-benefit comparison. The need was determined to be to raise 700 feet of levee by 3 feet and to rebuild the remaining 1000 feet. The cost-benefit ratio was determined to be 0.9. No action has been taken to implement the plan.

Reevaluation of the 100 year flood profile in this study confirms that the levee is marginal in height and probably inadequate considering the backwater potential of the Emma Street bridge. An earth dike of questionable security was constructed in 1974 to prevent flood waters from backing into the area from between the Emma Street bridge and the railroad embankment to the north.

The unmet need remains as defined by the Corps of Engineers study in 1970 plus reconstruction of the emergency dike between the bridge and the railroad.

Rockford has until December 6, 1975 to quality for NFIP. Qualification for the benefits of this program is recommended. No other action is recommended except as initiated by the community of Rockford.

TABLE 1

FLOOD PLAIN MANAGEMENT ALTERNATIVES[1]

I. STRUCTURAL
- A. Major Structures
  - 1. For reducing the volume of flow
    - a. Dams and reservoirs
  - 2. For controlling the elevation of the water surface
    - a. Channel improvements
  - 3. Containing the flood flow
    - a. Levees and flood walls
  - 4. Bank protections
- B. Flood Proofing

II. NON STRUCTURAL
- A. Flood Insurance
- B. Land Use Adjustment (changes in use to reduce damage potential)
  - 1. Regulatory
    - a. Statutes controlling channel encroachment
    - b. Zoning ordinances defining type of land use
    - c. Subdivision regulations
    - d. Building codes
  - 2. Non-regulatory
    - a. Government acquisition
    - b. Control of loans for building construction
    - c. Urban renewal
    - d. Permanent evacuation
    - e. Tax adjustment to encourage open-space use or other non-intensive use compatible with flood areas
- C. Warning and Evacuation or Emergency Protection
- D. Land Treatment (measures to decrease runoff and increase infiltration or retention)
  - 1. On agricultural lands
    - a. Contour plowing
    - b. Brush control
    - c. Range seeding
    - d. Cropping practices
  - 2. On forest lands
    - a. Tree management
    - b. Fire control
  - 3. Urban areas
    - a. Rooftop retention
    - b. Paved surface retention
    - c. Conveyance structure retention
  - 4. Wet lands retention

[1] Adapted from a similar table and from text references in Burges and Hillmer (1974).

TABLE 2

STATUS OF CITIES, TOWNS AND
COUNTIES IN THE NATIONAL FLOOD
INSURANCE PROGRAM*

City/Town	County	Eligible Date	Ident. Date	Map Available	Community Number	Type Program
Cheney	Spokane	05/01/75	06/07/74	Yes	530175	Emerg.
Deer Park	"	07/03/75	04/05/74	"	Unk.	"
Fairfield	"	Not Elig.	11/08/74	"	530177	"
Latah	"	" "	12/06/74	"	530178	"
Medical Lake	"	07/02/75	06/07/74	"	530179	"
Millwood	"	03/03/75	08/16/74	"	530180	"
Rockford	"	Not Elig.	12/06/74	"	530181	"
Spokane	"	01/15/73	05/24/74	"	530183	"
Tekoa	Whitman	Not Elig.	08/30/74	"	530215	"
Waverly	Spokane	" "	11/15/74	"	530184	"
Unincorp.	Lincoln	04/02/75	Unk.	No	530106	"
"	Pend Oreille	05/27/75	"	"	530131	"
"	Spokane	05/30/75	01/17/75	Yes	530174	"
"	Stevens	Not Listed				
"	Whitman	07/01/74	12/27/74	Yes	530205	"

*As of July 1975, subject to weekly revision.

TABLE 3

FLOOD HAZARD AREAS IDENTIFIED BY
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
FLOOD HAZARD BOUNDARY MAPS

City of Spokane

1. West end of Felts Field near Upriver Dam (H-01)**
2. South bank of Spokane River at Havana Street (H-03)
*3. The Riverpoint area at the two Trent Bridges including some area on the south bank (H-08, 09 and 13)
*4. Upriver Drive (H-08)
*5. Pleasant Valley (H-14 and 19)
*6. Hangman Creek (H-14, 15, 19 and 20)
7. Downriver Area (H-18 and 23)

Spokane County, Unincorporated Areas

1. Little Spokane River at Elk (H-02)
2. Little Spokane River at Milan (H-03 and 04)
*3. Little Spokane River at Chattaroy (H-05 and 06)
*4. Little Spokane River and Little Deep Creek at Colbert (H-07)
*5. Little Spokane River and Sheep Cr. at Dartford (H-08)
6. Borders of Newman Lake and Thompson Creek (H-09 and 10)
7. Peone Creek at Mead (H-11)
8. Spokane River at Trentwood (H-12)
9. Spokane River at Greenacres (H-13)
10. Spokane River at Veradale (H-15)
11. Borders of Liberty Lake and Liberty Creek (H-17)
12. Felts R. and 4th Avenue at Opportunity (H-18)
***13. Chester Creek at Opportunity (Mica-Dishman Road) (H-19)

---

*Indicates locations addressed in this section.
**Map numbers, typical.
***Addressed under urban flooding problems in Section 604.

TABLE 3 - Continued

Spokane County, Unincorporated Areas - Continued

14. Borders of Badger Lakes (H-20 and 21)****
15. Borders of Williams Lake (H-22)****
16. Borders of Chapman Lake (H-24)****
17. Valleyford along California Creek

Incorporated Areas

1. Fairfield
2. Deer Park
3. Cheney
*4. Rockford
5. Tekoa
6. Millwood
7. Medical Lake
8. Latah

*Indicates locations addressed in this section.
****Outside the study area.

TABLE 4

APPLICABILITY OF FLOOD PLAIN MANAGEMENT
ALTERNATIVES

Alternatives	Spokane River Problems: Pleasant Valley	Spokane River Problems: Riverpoint	Spokane River Problems: Upriver Drive	Little Spokane River	Hangman Creek Problems (11): Erosion Non Resident [1][4][7]	Hangman Creek Problems (11): Erosion Resident [5]	Hangman Creek Problems (11): Erosion Levee [2]	Hangman Creek Problems (11): Flood Resident [3][10]	Hangman Creek Problems (11): Levee Repair [6]	Hangman Creek Problems (11): Trailer Court [8]	Hangman Creek Problems (11): Golf Course [9]	Rock Creek at Rockford
STRUCTURAL												
Dams and Reservoirs	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NCE
Channel Improvements	NFE	NFE	NFE	UNP	NA	NCE	NA	NCE	NCE	NCE	NCE	NFE
Levees and Floodwalls	2ND ALT NCE	NFE (2)	2ND ALT NCE (6)	UNP	NA	NA	NA	NCE	NR (12)	NR (13)	NR (14)	NCE
Bank Protection	NA	NA	NA	NA	(8)	NCE	NCE	NA	NA	NA	NA	NA
Flood proofing	MR	MR	MR*	MR	NA	NA	MR	MR	MR	NA	NA	MR
NON STRUCTURAL												
Flood insurance	MR	MR	MR	MR	NA	MR	MR	MR	MR	NA	NA	MR
Regulatory Land Use Control	MR	MR	MR*	MR*	NA	MR	MR	MR	MR	MR	NA	MR
Public acquisition	2ND ALT	2ND (4)	NR	NR	NA	NR	NR	NR	NR	NR	NA	NR
Warning & emergency protection	SEC-R	SEC-R	SEC-R	NA	(8)	SEC-R	SEC-R	SEC-R	SEC-R	NR (13)	NA	SEC-R
Agricultural land treatment	NA	NA	NA	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE
Forest land treatment	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE	NFE
Urban land treatment	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NO ACTION (7)	NR	1ST	1ST	1ST	(8)	2ND	1ST	2ND	1ST	NR	1ST	1ST (15)
OTHER PER NOTE	1ST (1)	(3)	2ND (5)	-	-	1ST (9)	-	1ST (10)	-	1ST (13)	-	-

LEGEND

NA = Not applicable
NFE = Not functionally effective
NCE = Not cost effective
MR = Mandatory requirement under NFIP
SEC-R = Secondary defense - recommended

1ST = First choice recommended action
2ND = Second choice recommended action
ALT = Alternative action
NR = Not recommended
UNP = Unacceptable to public

See page 47 for Notes.

TABLE 4 - Continued

NOTES

(1) Establish City planning policy as to desired use of the area. Proceed to 2nd Alts as indicated by this decision.

(2) Poor foundation for levee. Area fill may be feasible.

(3) Fill to protect access to Post Office and raise Springfield Avenue.

(4) Consider acquiring the unoccupied lot North of Springfield on Superior.

(5) Establish City policy regarding status of Upriver Drive.

(6) Consider raising Upriver Drive to act as levee if in conformance with City plans.

(7) No action refers to optional actions only. Mandatory actions under NFIP must be taken and in cases marked * are the key immediate action or actions.

(8) Choice of continuing no action and relying on emergency measures versus permanent protection to be determined by agency owning facility to be protected.

(9) Relocation of structure to safe location recommended.

(10) Relocation or raising of residences recommended.

(11) Identifier numbers [ ] refer to corresponding paragraphs in text.

(12) Increased level of protection beyond 30 year flood not recommended.

(13) Reliance on warning and evacuation of trailers not recommended due to rapid rise rate. Recommend vacating site. Levee not recommended as an encroachment on floodway.

(14) Construction of levees not recommended without analysis to determine if they would be an encroachment on the floodway.

(15) In the absence of initiative on the part of Rockford, no action is recommended.


x75
x72
x49
1850
1800
1750
RIVER

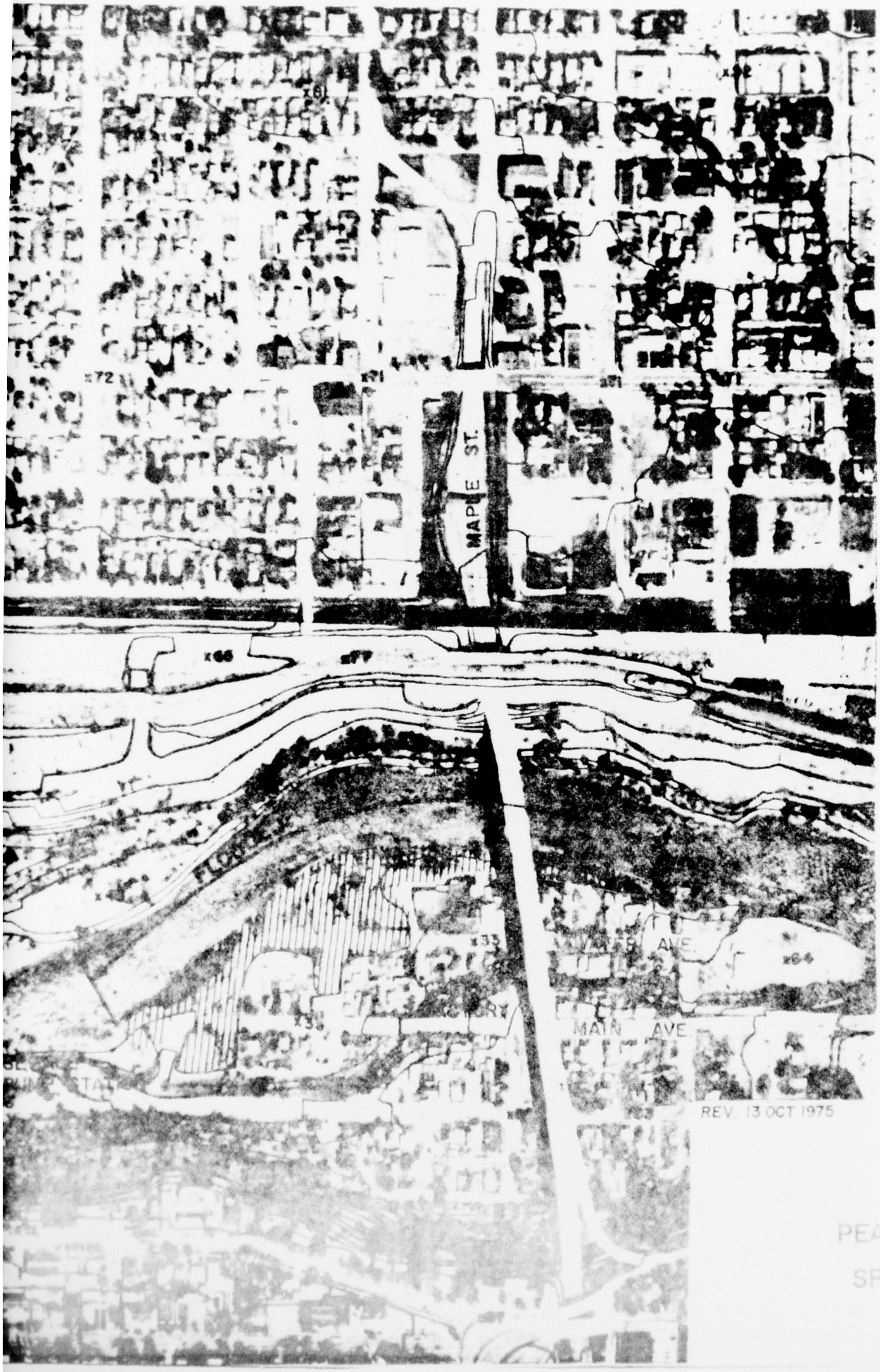
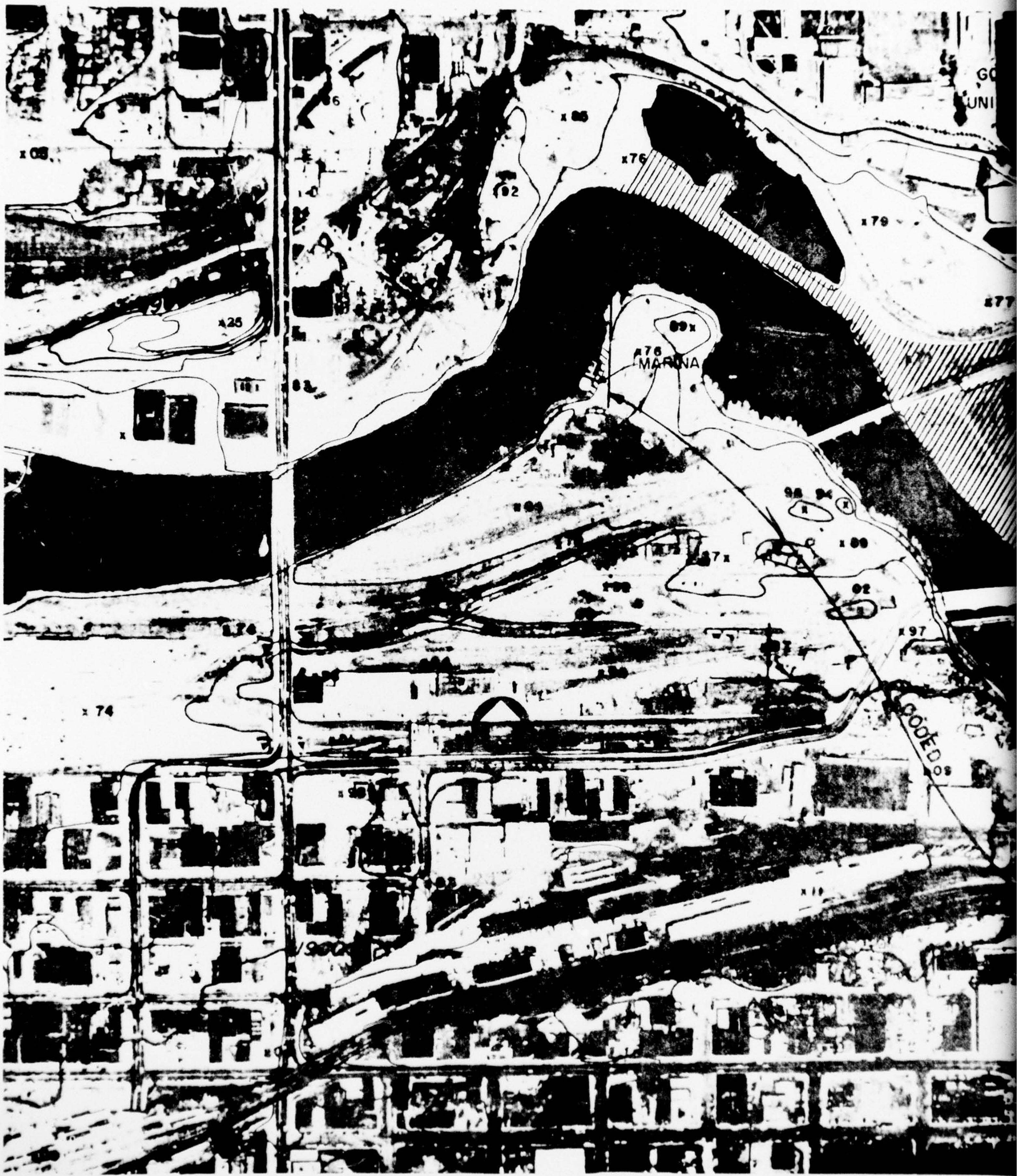
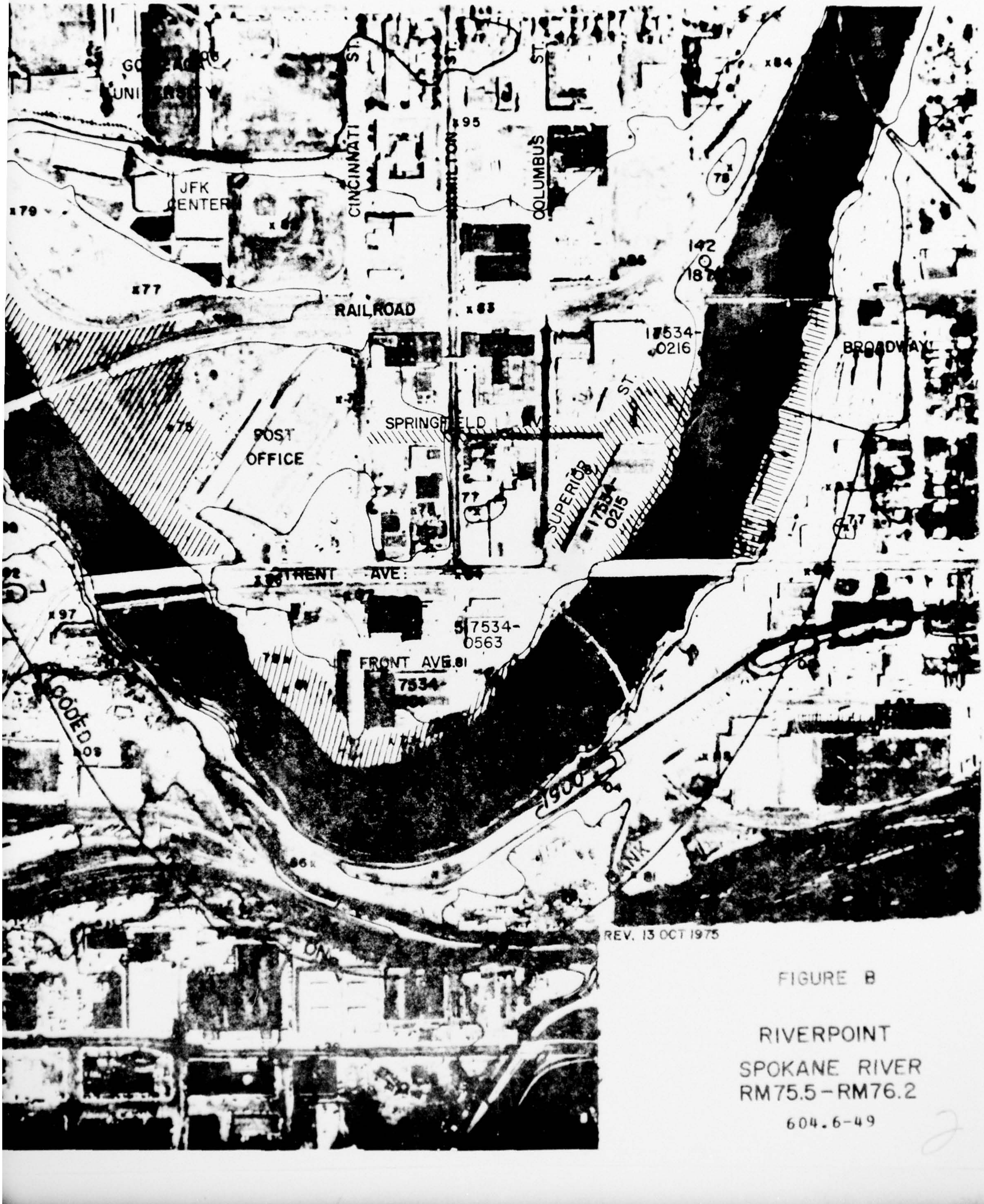


FIGURE A

PEACEFUL VALLEY

SPOKANE RIVER
RM73.6
604.6-48


MARINA
x 74
x76
x79
x 85
x97



REV. 13 OCT 1975

FIGURE B

RIVERPOINT
SPOKANE RIVER
RM75.5 – RM76.2

604.6-49

CENTER ST
GRANITE ST
WWP
1900
SPOK
UPRIVER DRIVE
MISSION ST
1900
FLOODED

FIGURE C

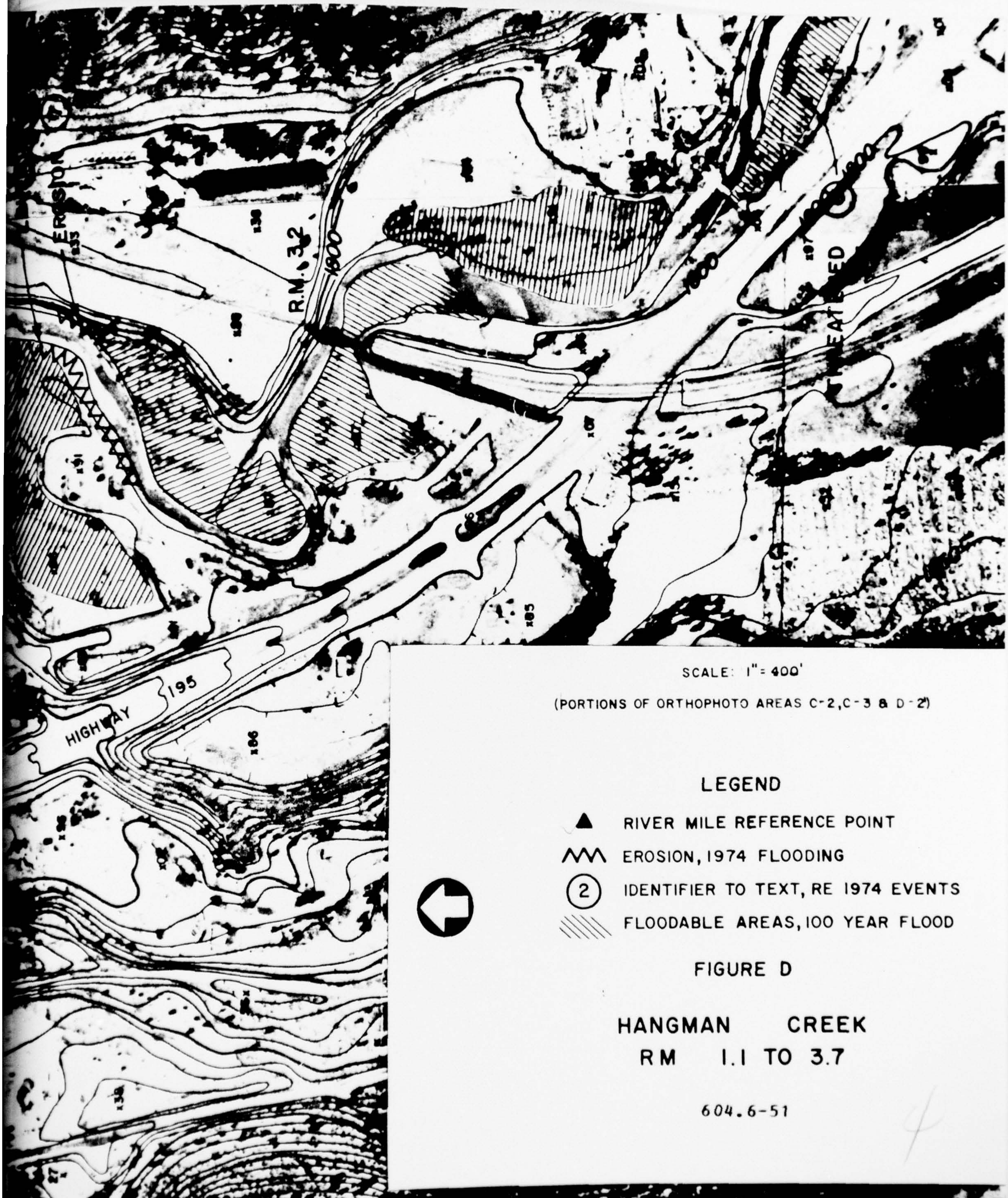
UPRIVER DRIVE

SPOKANE RIVER
RM76.8 - RM78.0
604.6-50


11TH. AVE.
EROSION
1
EROSION
2
16TH. AVE.
CHESTNUT
FLOODED
3
1850
1750

HANGMAN CREEK
2000
1950
1900
1850
1800
EROSION
FLOODED
R.M. 1
16TH. AVE.
51ST. AVE.
CHERRY ST.
1900
1750

HIGHWAY 195
28TH AVE
R.M. 32
1900



SCALE: 1" = 400'

(PORTIONS OF ORTHOPHOTO AREAS C-2, C-3 & D-2)

LEGEND

▲ RIVER MILE REFERENCE POINT

EROSION, 1974 FLOODING

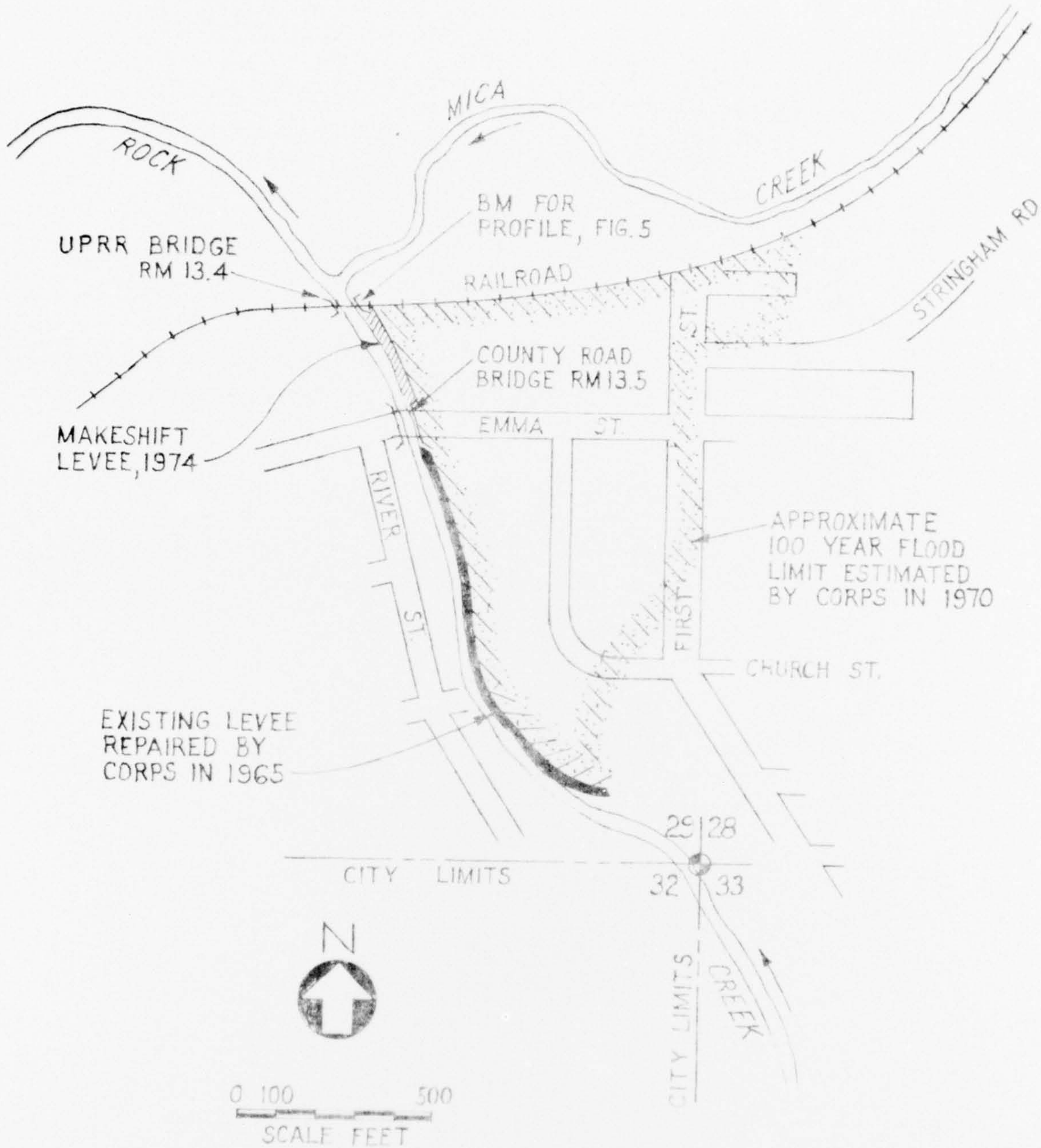
(2) IDENTIFIER TO TEXT, RE 1974 EVENTS

FLOODABLE AREAS, 100 YEAR FLOOD

FIGURE D

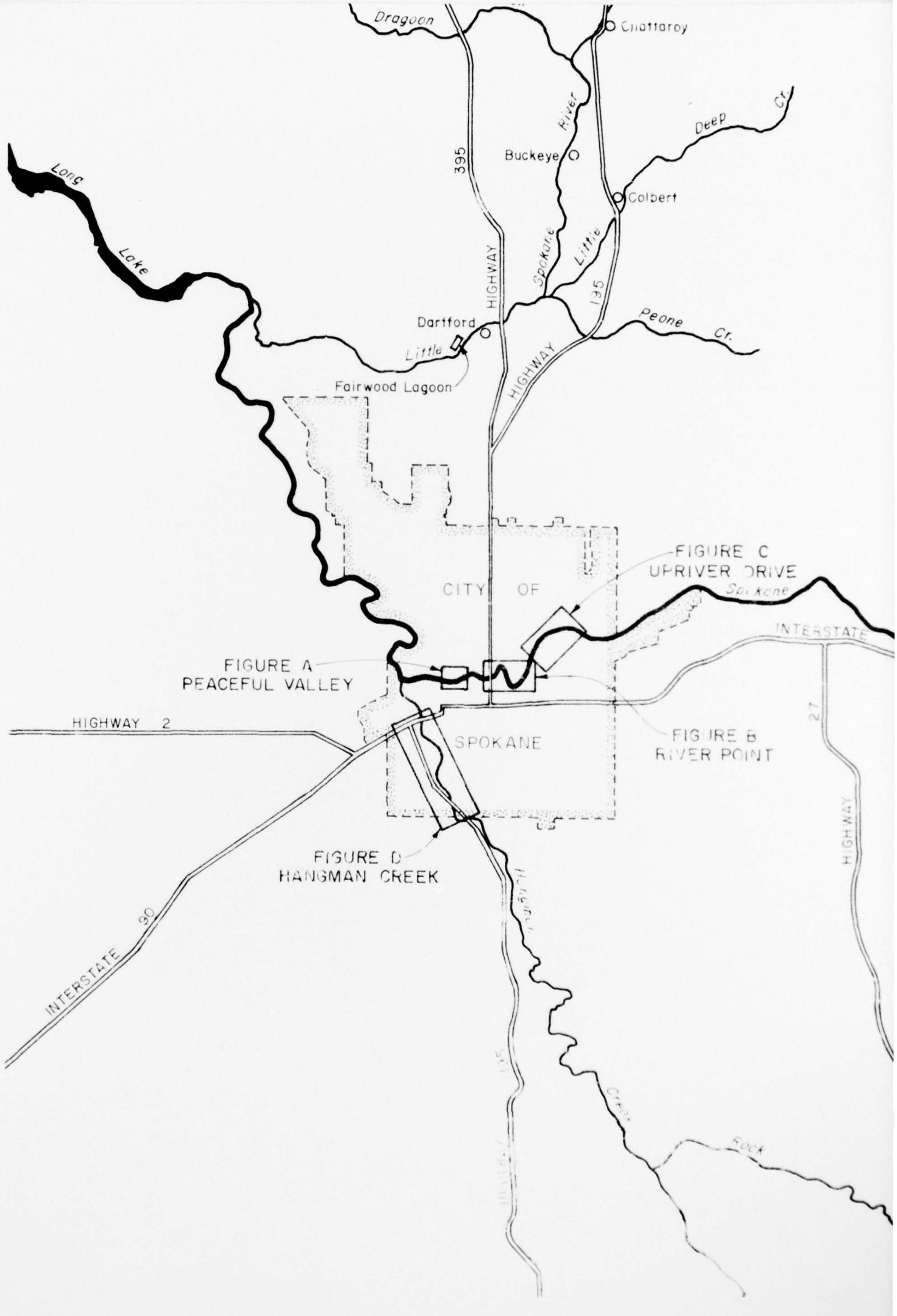
HANGMAN CREEK
RM 1.1 TO 3.7

604.6-51



ROCK CREEK AT
ROCKFORD, WASHINGTON
RM 13.4 TO 13.7

FIGURE E



Dragoon
Chattaroy
Spokane River
Deep Cr.
Buckeye
Colbert
Little
Long Lake
HIGHWAY 395
HIGHWAY 195
Dartford
Little
Peone Cr.
Fairwood Lagoon
CITY OF SPOKANE
FIGURE C
UPRIVER DRIVE
Spokane
INTERSTATE
FIGURE A
PEACEFUL VALLEY
FIGURE B
RIVER POINT
HIGHWAY 2
HIGHWAY 27
FIGURE D
HANGMAN CREEK
INTERSTATE 90
Rock

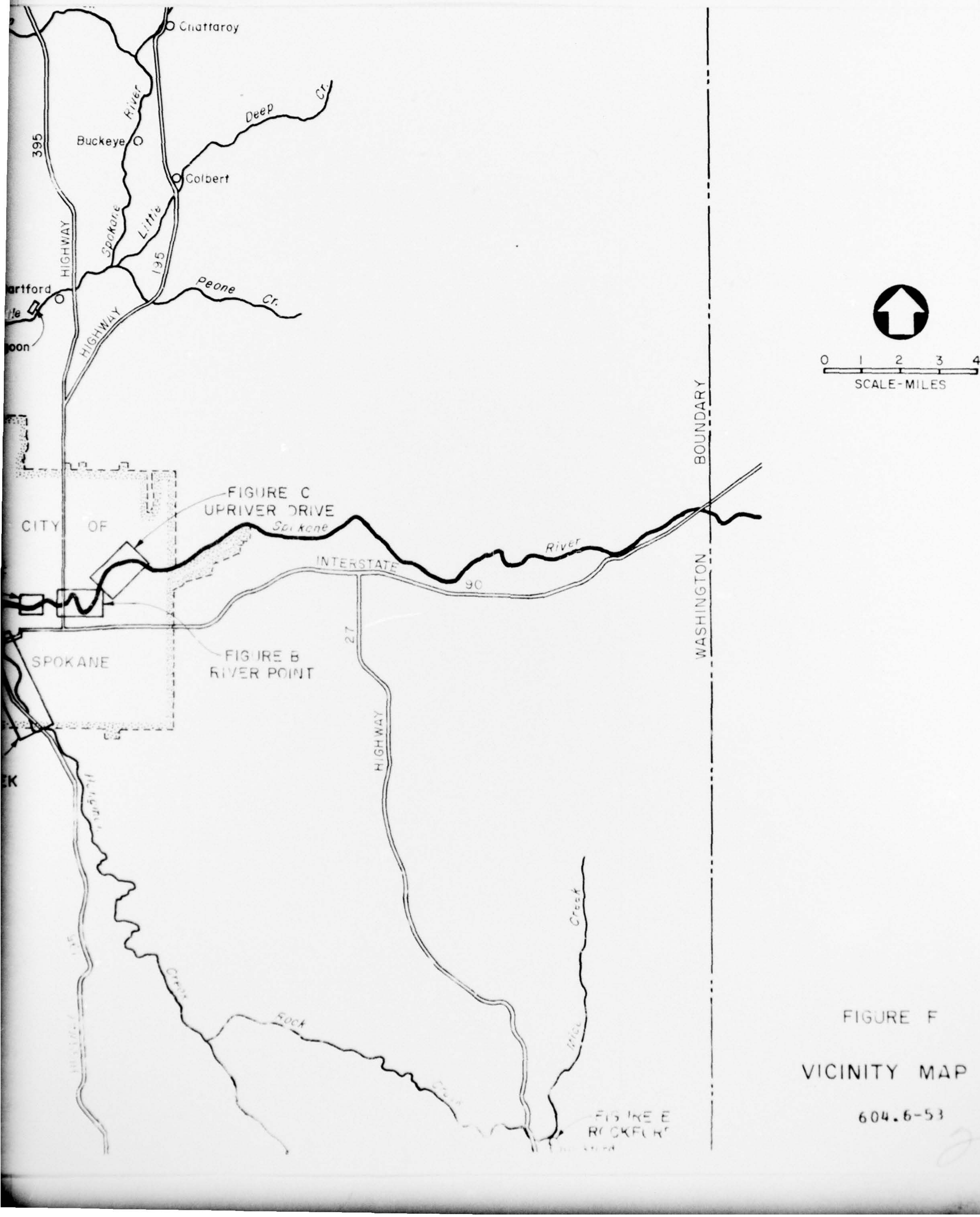


FIGURE F

VICINITY MAP

604.6-53

LIST OF REFERENCES

Burges, S. J. and Hillmer, J. S., 1974. Data and Administrative Considerations for Two District Flood Plain Zoning. *State of Washington* Department of Ecology. WRIS Tech. Bulletin No. 2.

Chung, S. K., 1975. Water Resources Management Program, Little Spokane River Basin, State of Washington Department of Ecology.

Schneider, W. J. and Goddard, J. E., 1974. Extent and Development of Urban Flood Plains. U.S. Geological Survey Circular 601-J. K-T #654.

Sheaffer, J. R. et al, 1967. Introduction to Flood Proofing, An Outline of Principles and Methods. Center for Urban Studies, University of Chicago.

Spokane City Plan Commission, 1965. Park and Open Space Plan.

, 1972. The Comprehensive Zoning Ordinance of the City of Spokane.

, 1973. Detailed Plans for Development of the Spokane River, Phase II.

U.S. Army Corps of Engineers, 1950. Columbia River and Tributaries, Northwestern United States, Volume III. House Document No. 531, Washington, D.C.

U.S. Army Corps of Engineers, 1972. Flood Proofing Regulations, K-T #746.

U.S. Army Corps of Engineers, 1974. Flood Plain-Handle With Care, Publication EP 1105-2-4. K-T #745.

U.S. Department of Housing and Urban Development, 1975. "Questions and Answers, National Flood Insurance Program" in HUD News No. 75-67, March 10, 1975. K-T #752.

U.S. Water Resources Council, (No date, est. 1971), Regulation of Flood Hazard Areas to reduce flood losses, in two volumes.