BULLETIN NO. LR-4

SITE ENGINEERING

one of a series of

HOUSING DESIGN NOTES

P H A LOW-RENT HOUSING
BULLETIN

U.S. PUBLIC HOUSING ADMINISTRATION
HOUSING AND HOME FINANCE AGENCY WASHINGTON 25, D.C.

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LIST OF BULLETINS

WHICH HAVE BEEN PUBLISHED

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NOTE: Some bulletins will be issued in Parts, of which one or more will be contained in the initial release of each bulletin; other parts will be issued subsequently, from time to time as they are completed.

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SITE ENGINEERING

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Bulletin No. LR-4

SITE ENGINEERING

INTRODUCTION

This Bulletin is one of a series of eight technical bulletins, designated as Housing Design Notes. These Bulletins are divided into parts, each of which will deal with some element of technical design.

PART I, PROJECT GRADE DESIGN, is issued with this Introduction. Other parts, such as Sanitary Sewer Design, Roadway and Parking Pavements, and related subjects, will be issued, from time to time, as they are completed.

This connected series of Housing Design Notes will contain technical data, notes, observations and recommendations relating to the design problems which are concerned with low-rent housing based on the continuing observation and intensive study of public housing projects which have been in operation for more than ten years. It should be noted that all recommendations are advisory only, except to the extent that they refer to or reflect the mandatory requirements of the current, published PHA Minimum Physical Standards and Criteria.

These bulletins are not offered as textbook material, or with any pretense that they deal exhaustively with any particular subject. In many instances they express opinions which may be subject to challenge, and they are written with a frank acknowledgment that many readers - particularly professionals - may be as well informed in specific fields as the writers - perhaps more so. The PHA believes, however, that careful consideration of the experience recorded and the suggestions offered should result in the avoidance of certain shortcomings which have been noted in existing projects and in profiting from the knowledge of the many good characteristics which have been observed and studied.

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PART I - PROJECT GRADE DESIGN

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NOTE: This Part supersedes Part 0 dated February 1964. It is up to date through Transmittal No. 223.

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SITE ENGINEERING

(Supplementary Information and Modification Notes)

Since some of the recommended planning criteria and statements included in this Bulletin, published in 1950, are inconsistent with current PHA thinking and in some instances, are at variance with present PHA Standards, the following notes are prepared to amend or emphasize the referenced items.

1. Dedication of Project Streets and Drives. Paragraphs 1 and 7(g), Part II of Bulletin No. LR-4, and paragraph 15, "Streets and Drives," Part I of Bulletin No. LR-3 do not sufficiently emphasize the necessity for dedication of project streets and drives to relieve the project of future maintenance expense. Present Low-Rent Housing Manual Section 207.1, paragraph 3b(1), states that, "To the greatest extent possible all streets, parking, and service access facilities shall be designed to meet mandatory local regulations for dedication to the city for maintenance." This requires that an early and factual investigation be made of applicable local regulations and that the basic street and service system be determined with these requirements in mind. Actual dedication of these facilities should be accomplished at the earliest possible date.

In line with Low-Rent Housing Manual Section 207.1, paragraph 5a, where local regulations are considered excessive to project needs, effort should be made to obtain a waiver to permit adequate and more economical construction.

2. Project Grade Design. (Walks, steps, banks, yard, and ground areas.) Low-Rent Housing Manual Section 207.1, paragraph 4a, "Grading," and paragraph 3b(2); Bulletin No. LR-4 Part I, "Project Grade Design," especially item 14, third paragraph; and Bulletin No. LR-3, Part I, item 8, are considered adequate information on this subject. However, many projects continue to show single riser steps in walks, and treat the 2% MINIMUM grade requirement as though it were a maximum. This inevitably results in numerous minor step and bank changes in grade where a steeper walk grade and yard grades would produce a safer, more economical and easier maintained condition.

3. Paved Areas at Entrances. Paragraph 21(e) of Bulletin No. LR-3, Part I, should not be treated as a "Miscellaneous Detail." The entrance platform and walk expansion areas, as generally designed, are recurring development and maintenance problems. In many cases, such paved areas are inadequate in size for the free movement of tenants and service at these critical locations. It should be emphasized that special care be taken to provide adequate platforms at twin and row house type units and expanded walks or other paved areas at main entrances to apartment type dwellings. Adequacy of these areas should be predicated on the ample accommodation of the expected concentration of people and activities for the widely varying types of use expected.

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SITE ENGINEERING
PART I - PROJECT GRADE DESIGN

1. OBJECTIVES. The grade design for a housing project consists of the detailed fitting, in elevation, of the site plan to the topography. Basic objectives are effective drainage and erosion control. If these are attained, economy in maintenance should follow. Other considerations include economy in first cost, the convenience of tenants, and good appearances.

Unsatisfactory grade and drainage conditions have been experienced in many existing low-rent projects. Some of the difficulties have come from inaccurate construction, poor compaction of fill and backfill, and ineffective planting for erosion control; but often the grade design has been faulty. The results have been increased maintenance expense, additional capital expenditures, and permanent defects in the projects.

This bulletin outlines design practice which, based on construction and maintenance experience, can be recommended as safe and satisfactory. Appendix I is a check list which summarizes the means of achieving the above-mentioned objectives.

2. PROJECT GRADES AND THE SITE PLAN. In planning a housing project, the grade design follows immediately the preparation of the site plan, and the two design operations are closely interdependent. If the site plan is not well adapted to the topography, the defect will be reflected in undesirable grade conditions; and if project grades are not worked out to best advantage, some merits of the site plan will be lost. Faulty design in either respect may result in unwarranted costs of site grading, drainage facilities and building foundations.

Even though the site planner visualizes project grades constantly as his plan is developed, he can hardly foresee whether it will prove satisfactory as regards grades and drainage in every detail. Therefore, the plan should not be "frozen" until the grade design is completed. The grade designer may discover changes, minor ones at least, that will improve drainage, eliminate earth banks, or reduce storm sewer costs. He should be alert to these possibilities.

While a discussion of site planning is beyond the scope of this bulletin, one consideration related to drainage merits mention; it is preferable generally in low-rent projects, to locate roadways in "valleys" rather than on "ridges". Yard areas will then pitch toward the roads, and if the latter are given continuous downward slopes to site boundaries they will serve as emergency drainage channels. Storm sewers are rarely designed to handle <u>maximum</u> storm flows.

3. UNDERGROUND DRAINS. For high density projects, complete systems of storm sewers are always necessary and their per-DU cost generally is quite low. But as project density decreases, this cost rises rapidly and economy in the storm sewer installation becomes increasingly important.

The grade designer must visualize project storm sewers -- those that his grades will necessitate -- in much the same way that the site planner visualizes project grades. In fact, the project grade study and the storm sewer design are both basically concerned with site drainage, and may be treated more or less as a single design operation.

To a certain extent, storm water may be carried away either over the surface or underground. For example, a given area may be drained by providing fill so as to shed the water to a site boundary or by installing an underground drain and inlet. But where storm water must be conducted across the site for any distance, the best place for it is underground.

The following text contains some discussion of the conditions under which storm sewers and inlets become necessary. However, site conditions, such as soil erosibility, slopes and rainfall intensity, vary tremendously and decisions finally must be based on the designer's judgment. In some existing low-rent projects, judgment in this regard was unwisely influenced by pressure for economy in first cost, rather than in maintenance.

4. PREREQUISITES TO GRADE DESIGN. Before undertaking project grade studies, comprehensive information on site conditions must be obtained and decisions reached regarding certain design policies and details. Needed are:

a. An accurate topographic map of the site.

b. Established grades of city streets bordering or crossing the site. (If such grades are not established or changes appear desirable, the local authority should request appropriate action by the city.)

c. Grade elevations and information regarding the adequacy of existing sewers at the site, and regarding off-site sewer extensions necessary or proposed.

d. High water elevations, if any part of the site is subject to flooding, either from streams, tides, or surcharged storm sewers.

e. Subsurface soil investigation data.

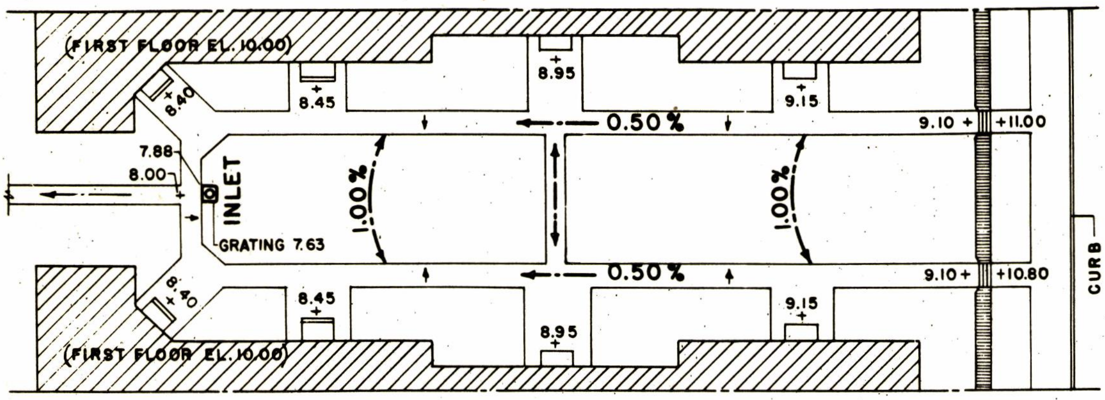
f. Information on drainage conditions of adjoining properties, especially if any such properties drain onto the site or if any part of the site has natural drainage onto adjoining property. (This information should be obtained or verified by the designing engineer).

g. Range of permissible heights of first floors above finished grade; heights of crawl spaces (if any) and proposed methods of grading and draining them; and requisite depths of foundations below present grade.

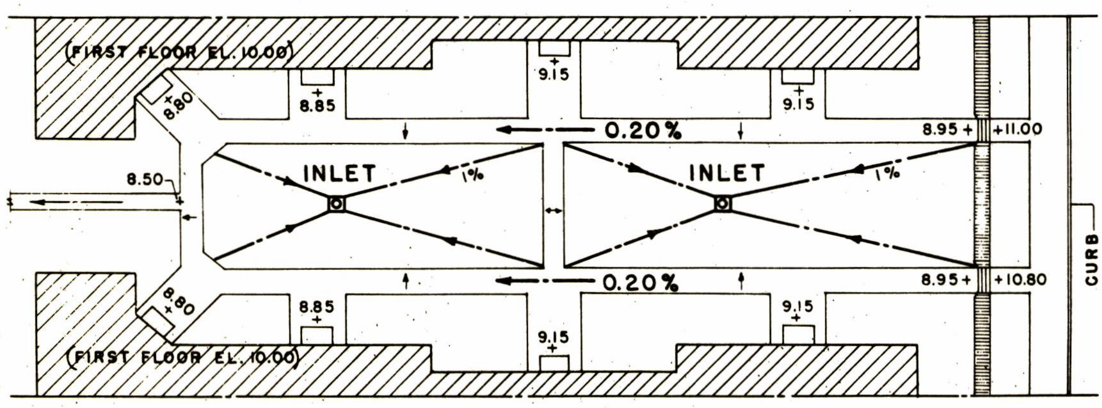
h. Cross sections of new streets and drives.

i. Determination as to the general extent of storm sewers to be provided. (See preceding section.)

5. DIRECT DRAINAGE TO STREETS. The ideal means of grounds drainage consists of continuous easy slopes, downward from buildings to adjacent streets, drives, and parking areas. This method of drainage tends to prevent any concentration of storm water flow on grassed or planted areas, and generally obviates the need for storm sewer inlets elsewhere than in pavements. The method is that commonly used for draining the yards of private houses, and it should be employed in project design to the extent (generally limited) that the site plan and topography permit.



(A) DRAINAGE ALONG WALKS



(B) DRAINAGE FROM WALKS ONTO GRASSED AREA

FIGURE I ALTERNATIVE METHODS OF DRAINING COURT AREA

6. DRAINAGE TO WALKS VS. DRAINAGE TO GRASSED AREAS. There are two basically differing methods of draining project grounds. Figure 1 shows the application of each to a court between two small apartment buildings. In both schemes the storm water is drained away from the buildings to the cross-sloped main walks. Under Scheme A, the water from the grassed central area is also drained toward the walks, and the latter are given sufficient slope to conduct the water along their outer edge (partly on the walk and partly on the grass) to the sewer inlet at the lower end of the court. Under Scheme B the storm water is expected to cross the walks and reach inlets in the center of the grassed areas.

As a general proposition, it is preferable not to use walks as drainage-ways. The storm water flow in some instances may be a nuisance to pedestrians and until turf is formed, silt may be carried onto the walks, causing trouble for pedestrians and management. Nevertheless, walks have been widely used in public housing projects in the manner shown in Scheme A, and in the vast majority of cases no serious objections has been raised to that method of drainage.

The difficulty experienced in draining walks onto grassed areas, as illustrated in Scheme B, has lain in effective drainage. Light ground slopes, inaccuracies in topsoil grading, and expansion of the turf above original finished grade have contributed to the unsatisfactory result. Therefore, this method of drainage is not considered as safe as that shown in Scheme A. Moreover, the dished center panels of Scheme B present a less pleasing appearance than the crowned panels of Scheme A.

As a variation in Scheme A, storm water might be conducted to the inlet through very shallow depressions (swales) centered about two feet from the outer edge of the walks, and carried under the cross walk in small culverts. However, the drainage area between the buildings is quite small and the walks are fairly wide (6 feet), so the storm water flow along one side of them should cause little inconvenience.

7. LIMITING STORM WATER FLOW ON WALKS. It is essential that walks be cross-sloped (or crowned) properly (1/4 or 3/8 inch per foot), that they have adequate longitudinal slope, and that they be built accurately to grade. It is important, further, that storm sewer inlets be provided at points of concentrated flow. A shallow swale paralleling the walk is desirable where there are no cross-walks to interfere and when the flow may reach objectionable proportions.

Walkways should be limited generally to draining yard areas of not more than 10,000 to 20,000 square feet, adhering to the lower figure for 4-foot walks and slopes not exceeding 1 per cent, and approaching the upper limit for wider walks and steeper slopes. (These areas should be reduced by 50 per cent when they are comprised mainly of roofs or surfacing. Somewhat lower limits also should be used for tight soil.)

8. **DRAINAGE BETWEEN ROW-HOUSE BUILDINGS.** Figure 2 shows in section three schemes for handling storm water along a centrally located approach walk between two row-house buildings which have approximately the same elevation. Scheme A utilizes the central walk (one side and the adjoining lawn) as a drainage channel; Scheme B keeps the walk comparatively free from water by means of a concrete gutter; and Scheme C accomplishes the same result by means of a swale (with culverts under entrance walks) located adjacent to the central walk.

Scheme A is the one usually employed in low-rent housing, since it is the simplest, least expensive, and generally is satisfactory. The paved gutter adds to cost, is a slight hazard to children at play, and tenants generally, and culverts are objectionable, to a less extent, for similar reasons.

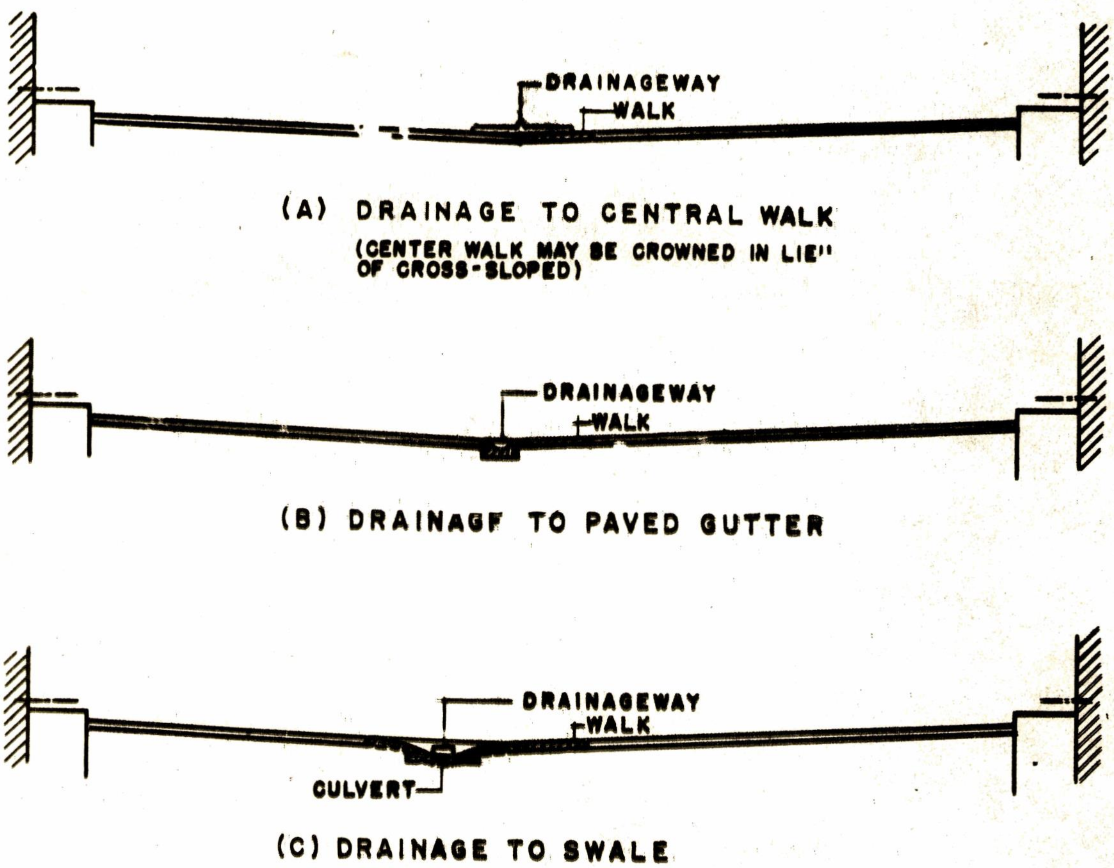


FIGURE 2 ALTERNATIVE METHODS OF DRAINAGE BETWEEN ROW-HOUSE BUILDINGS

Figure 3 shows yard grading and drainage methods for moderate to steep cross slopes between row buildings.

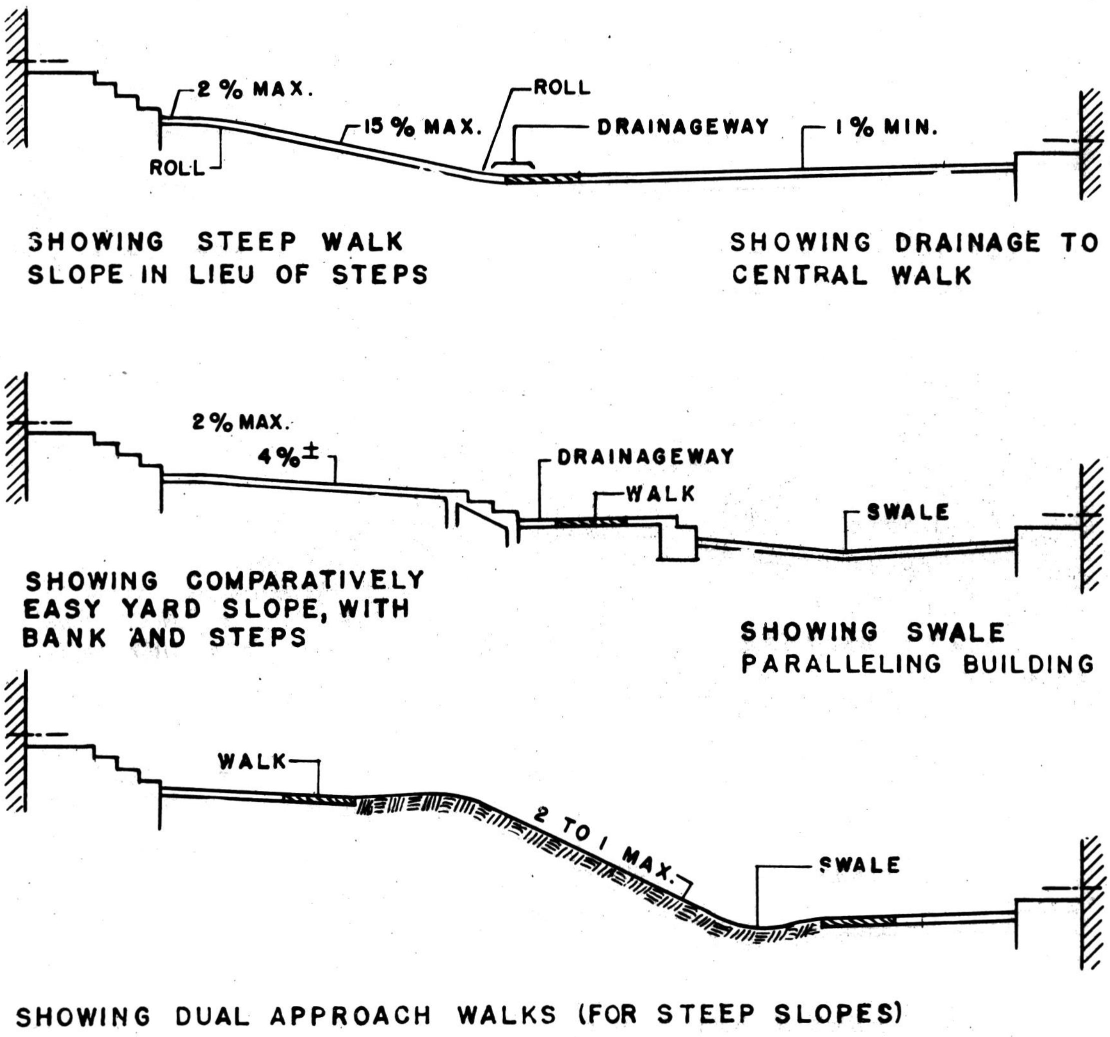


FIGURE 3 TYPICAL GRADING BETWEEN BUILDINGS ON SLOPING SITES

9. **SWALES.** The preferred drainage plan is one in which no swales are required, since at best these shallow depressions carry concentrated flows which may be seriously erosive. However, it is often impossible to develop a plan in which grassed areas everywhere present smooth, continuous slopes to paved areas.

Certain uses of swales are illustrated in Figures 2 and 3, others in Figures 4 and 5. That in Figure 5, entailing storm water flow across entrance walks, is definitely undesirable, since imperfect drainage of the walks is the almost inevitable result. However, row buildings must sometimes be located at a lower elevation than adjacent streets and drives, and an intervening swale becomes necessary. Figure 5 illustrates how to make the best of this undesirable situation. But the scheme should be adopted only after every effort has been made, through raising building levels, depressing roadway grades and/or adjusting the site plan, to provide continuous downward slopes from the building to the adjacent pavement.

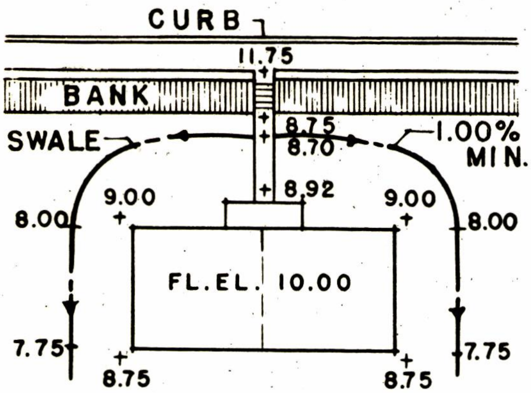


FIGURE 4 SWALE AROUND TWIN HOUSE

Other uses of swales include serving as sodded drainage channels from downspouts, and intercepting side-hill or off-site drainage and carrying it around the built-up part of the project. In the latter use, the swale may attain the proportions of a grassed ditch. In rare cases, too, a sodded swale must be used to carry off drainage from a small surfaced area. This is another undesirable drainage, but occasionally employed when no storm sewer is available. Such swales must be given sufficient slope to prevent silting.

When possible, the bottom of swales should be at least 10 feet distant from adjacent building walls and one foot lower than finished grade at the walls. The swale section should permit grass cutting with power equipment.

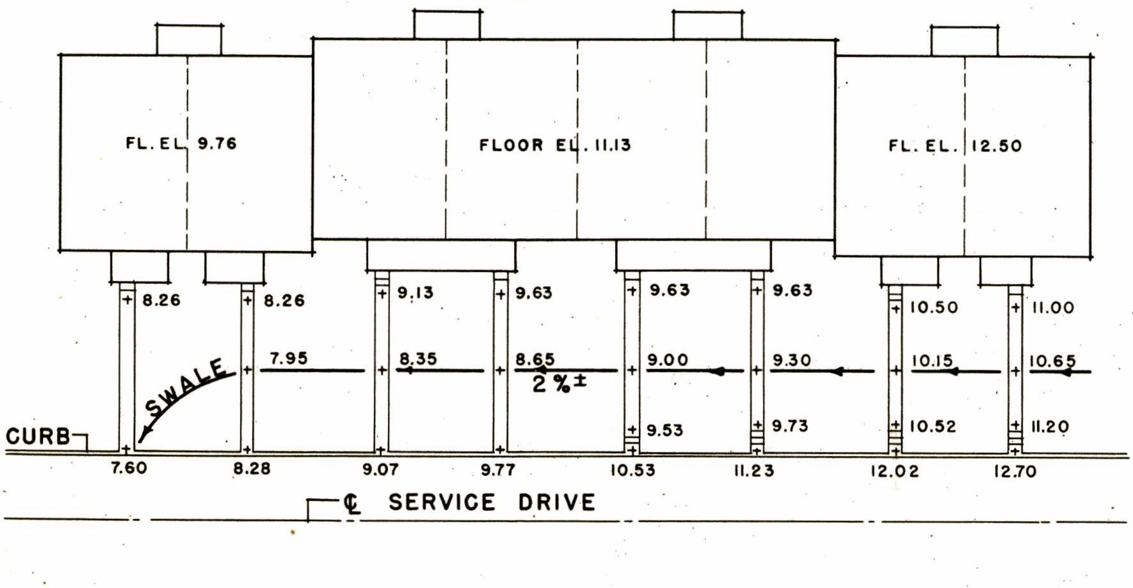


FIGURE 5 SWALE THROUGH REAR YARD

The following table shows suggested maximum slopes for seeded swales and for sodded swales, respectively, in relation to drainage areas:

Drainage Area*	Maximum Slopes for Seeded Swales	Maximum Slopes for Sodded Swales
1,000 sq. ft.	5%	--
2,000 " "	3%	--
5,000 " "	1-1/2%	25%
10,000 " "	1%	15%
20,000 " "	--	8%
50,000 " "	--	4%
100,000 " "	--	2%
200,000 " "	--	1%

* Include roofs and pavements at double their actual area (horizontal projection)

The preceding figures are intended to serve as a rough guide in determining when flow channels should have sod protection and when they should be paved, or underground drains provided. With seeded swales the objective obviously is to get a stand of grass before appreciable erosion occurs; in this, much will depend on the season as well as on soil characteristics. Swales may require protection in the form of mulch or tree boughs until more permanent protection can be provided.

10. EARTH BANKS. Experience has proved conclusively that earth banks are a source of endless trouble in low-rent housing projects. Erosion and wear from children's play make them costly to maintain and they often remain unsightly in spite of maintenance efforts and expense. Moreover, banks necessitate walkway steps, which are a hazard, as well as a nuisance to tenants.

To minimize the need for steep earth banks and walkway steps:

a. Use sloping grade lines along buildings, instead of striving for more or less level "benches". (Smoothly flowing surfaces throughout the site may be more pleasing than a series of terraces; and the sloping grade lines will not necessarily entail stepped footings for buildings.)

b. Give building entrance walks moderately steep slopes with an ogee profile, in preference to light grades which would necessitate steps down to main walks.

c. Use stepped ramps, where practicable, in lieu of steps. (These will give slopes, from 4 to 1 to 6 to 1, over which a power mower can be operated.)

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d. Substitute retaining walls for earth banks in favorable locations and when cost limitations permit. (Dry masonry walls, where suitable stone is available, are less costly than concrete and more pleasing in appearance. The first cost of retaining walls may be offset to a considerable extent by the additional ground area made usable. When steep banks extend down from buildings to street sidewalks, low walls along the walks have been found particularly advantageous.)

Every effort should be made to eliminate all low banks. They have often been used where the difference in elevation could have been taken up easily by giving a little more slope to walks and grassed areas.

Where a steep earth bank (2 to 1, maximum) must be used, it should be given a well-rounded section, and surface water should be diverted back from its top, unless the drainage area above it is extremely small. Diversion may be accomplished by a very shallow swale, continued down or around the bank in a sodded channel.

11. **DRAINAGE FROM DOWNSPOUTS.** In high-density projects sewer connections to roof leaders are indispensable; in practically all low-rent projects they are most desirable. They were not provided, however, in numerous existing projects -- in some instances because of lack of outlet for storm sewers, in others for reasons of economy. The results frequently have been continued erosion in grassed areas and dampness in basements and crawl spaces; a considerable amount of corrective work has been necessary.

Nevertheless, for very low-density projects with downspouts on both sides of buildings, the cost of sewer connections may be extremely high. Therefore, where conditions are favorable (where slopes are light and the soil porous), the omission of downspout connections may be warranted.

In some instances connections may be necessary to only a few downspouts, such as those discharging near the top of a slope. And, where no storm sewers are available, downspout drainage, in some cases, may be piped to discharge through a street or driveway curb. Further, sodded swales may serve in certain locations to conduct roof water to safe points of discharge. The important thing is to give the problem careful study.

12. **POCKETS.** The grounds areas in many projects contain low areas from which storm water must escape through underground drains. As a rule these depressions are shallow and if a drain becomes stopped, the water will simply overflow to a roadway or another drain without causing serious damage. Occasionally, however, there is a deeper pocket, such as a decided sag in a street, or a court partially enclosed by a building, where the clogging of a drain would result in damage to some building or in serious erosion. Obviously, such a condition should be eliminated by a change in the site or building plans, or guarded against by precautions taken in the drainage design. Duplicate drains may be warranted in some instances.

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13. **PROCEDURE IN GRADE DESIGN; ESTABLISHING BUILDING FLOOR ELEVATIONS.** The project grade design is normally developed as a whole, adjusting and readjusting building, grounds and roadway elevations, until a thoroughly satisfactory balance of all features is achieved. The starting point, as a rule, consists of the established grades of boundary streets.

Except projects comprised of multi-story buildings, the grade design normally includes the fixing of building first-floor elevations. In this phase of design, architectural considerations - more specifically, the correlation of building levels - may be important, but no viewpoint should prevail to the exclusion of others. Very often, raising the floor elevation of a building only a few inches will improve drainage conditions immeasurably.

Building levels may be governed simply by the necessary rise in walkways to building entrances. More often, floor levels throughout the project are established tentatively, or roadway grades are assumed; then through trial all grade elevations are adjusted until the result is satisfactory.

When a walk closely parallels a row building, the walk slope will generally necessitate variation in the number of steps, and sometimes in riser heights, at entrances. These determinations may be included in the grade design.

14. **WALKWAY GRADES.** Walkway grades constitute a major part of the grade design work and its proper execution is essential to effective site drainage and to the satisfactory appearance of open areas.

The minimum grade recommended for project walks is 0.50%, although two exceptions merit mention: first, walks adjoining roadways or parking area curbs are sometimes laid practically without longitudinal slope; and second, building entrance or other short walks can best be planned for a 1.00% slope to absorb minor inaccuracies in construction. As previously noted, all walks should be cross-sloped or crowned.

The maximum grade recommended for main walks is 10%, for entrance walks 15%, but with consideration given to grades common in the locality, and restricting the slope to 6% where snow and ice may prevail for a long winter season. Generally speaking, steep grades are far preferable to steps and the earth banks that go with them. Adjoining the top and bottom of steps, walk slopes should not exceed 2 per cent.

Sharp breaks in grade -- in long walks, at walkway intersections, or in building entrance walks -- are conspicuous and unsightly. Grading plans should show the characteristics of vertical curves required.

Another unsightly grade condition is a long walkway with a wavy or "roller-coaster" profile. This is seen occasionally on flat sites, where walks dip toward catch basins located at intervals; and along sloping malls, the grades of parallel walks are sometimes objectionably irregular.

15. GRADES AT EXISTING TREES TO BE PRESERVED. Finished grades should, if possible, be made to conform very closely to existing ground levels at tree locations. Trees should never be left on small mounds, and filling around them is permissible only if special protective measures are taken. Moreover, tree locations may be shown inaccurately on the survey map and so carried over on the project drawings; or the spread of branches may not be fully taken into account. Locations and base elevations of trees should be checked as soon as buildings are staked out in the field. An ill-advised and unsuccessful attempt to save a tree is likely to result in an unsightly grade condition after the tree has been removed.

16. MAXIMUM AND MINIMUM SLOPES. Limiting slopes for grassed and surfaced areas depend to some extent on local conditions: porosity and erosibility of the soil, frequency of icy conditions, and the steepness of slopes to which the people in the locality are accustomed.

Costs also are a consideration. When a site is extremely flat or extremely steep, some risk must be assumed in employing grades that will not result in exorbitant grading costs. However, slopes lighter than the recommended minima should be used with caution, especially if the soil is nonporous. Grades used must be sufficient to "take up" minor inaccuracies in construction, including some slight settlement of fill and backfill.

The following tabulation shows maximum and minimum slopes considered desirable for what may be termed "average" conditions:

	Maximum Slope	Minimum Slope
Streets and drives - crowned section with curbs	8.00%	0.50%
Streets and drives - crowned section with combination curb and gutter	8.00%	0.40%
Service drives - inverted crown section	8.00%	0.60%
Collector and approach walks	10.00% 1/	0.50%
Entrance walks:		
Adjoining building platforms	2.00%	1.00%
Elsewhere	15.00% 1/	1.00%
Paved recreation areas, including sitting areas	2.00%	0.50%
Surfaced laundry yards	5.00%	0.50%
Tenant yards:		
Up to 4 feet from buildings	4.00%	2.00%
Elsewhere (except banks)	15.00%	1.00%
Management-maintenance areas:		
Up to 4 feet from buildings	4.00%	2.00%
Elsewhere (except banks)	25.00%	1.00%
Grassed playgrounds	2.00%	0.75%
Paved gutters	--	0.50%
Swales:		
With flow crossing over walk	(See Table on page 8)	2.00%
Other	(See Table on page 8)	1.00%
Earth banks	2 to 1	--

1/ 6% where icy conditions may prevail in winter season.

17. GRADING DRAWINGS. The manner of showing finished grades on the drawings is most important both for accurate execution of the design and for use of the plans on the job. Following are brief suggestions on the nature and scope of grade design information:

a. Show proposed roadway elevations on the grading block plans for proper correlation and checking with finished grades for interior areas. Give stationing, rates of grade, and PC's and PT's of vertical curves. (Roadway profiles are usually not essential in the construction contract drawings, but may be needed in the design study.) Show roadway curb elevations at all connecting walks; show curb elevations also at the ends of all roundings, and gutter elevations where special sections are required.

b. Show walkway grades at all building entrances, walk intersections, walk and roadway intersections, breaks in grade, etc. Where necessary, indicate requisite warping of walk surfaces.

c. Show finished grades for surfaced areas (other than roadways and walks) along their sides and at interior points as necessary to indicate shaping.

d. For lawns and planted areas, show finished grades at corners of buildings, breaks in grade, top and bottom of banks, etc. Show cross sections of banks and swales, indicating roundings.

e. Show building first floor elevations and, as necessary, the number of entrance steps and riser heights. (Architectural drawings should show a section through each type of entrance.

f. Show finished grades of surfaced areas solely by spot elevations, and finished grades of lawns and planted areas generally by this method; use finished grade contours only when they are necessary to indicate how the surface is to be shaped.

18. GRADING SUPERVISION. While site slopes must be sufficient to absorb minor inaccuracies in construction, the grade design cannot provide insurance against careless work, such as insufficient compaction of fill and backfill, irregular finished grading, and inaccuracies in setting walkway forms.

Such defects have been experienced, not infrequently and with costly results, in existing projects. The remedy obviously lies in thorough, competent inspection. Occasional checks should be made of the contractor's grades, and the inspectors and the engineer (to the extent of his supervisory services) should follow grading operations closely.

APPENDIX I

PROJECT GRADE DESIGN

CHECK LIST FOR GRADE DESIGN

1. FOR EFFECTIVE DRAINAGE:

a. Give continuous adequate slopes to all parts of the site not occupied by buildings; provide positive slopes away from buildings; provide good longitudinal, as well as transverse, slope in walkways, unless they adjoin paved gutters.

b. Avoid draining surfaced areas onto grassed areas.

c. Do not hesitate to use one side of a walk as a drainageway where that is definitely the simplest and most economical method of drainage and where the storm water flow will not be excessive, but provide swales paralleling walks where practicable.

d. So far as possible, avoid swales crossing walkways -- either under them (in culverts) or over them.

e. Avoid pockets from which the stoppage of a drain would cause damage to buildings or serious wash across grassed areas. If such pockets are unavoidable, provide duplicate drains or take other adequate design precautions.

f. Provide storm sewers and sewer inlets, so far as feasible, to intercept concentration of storm water flow.

(1) In grounds areas, locate inlets adjacent to, but not within, walkways; provide a paved border between the gratings and lawns or planting; set gratings about 3 inches below adjacent finished grade in small depressions that will collect the storm water.

(2) In roadways, relate the spacing of inlets to their capacity to receive the flow.

g. Divert from the site (or that portion of it to be developed) any drainage from off-site or unbuildable areas.

h. Avoid increasing the storm water runoff onto adjoining properties.

2. FOR EROSION CONTROL:

a. Utilize <u>underground</u> drains to the greatest feasible extent.

(1) Connect downspouts to storm sewers if sewers are available and the cost is not prohibitive; or, where feasible, provide downspout connections to discharge through roadway or parking area curbs.

(2) Work out grades to minimize damage if storm sewers are surcharged.

b. Keep water diffused over grassed areas so far as possible.

c. Provide sod or pavement, if and as necessary, in open drainage channels.

d. Minimize the use of steep earth banks by:

(1) Using sloping grade line along buildings, instead of striving for series of more or less level benches.

(2) Giving building entrance walks comparatively steep slopes, in preference to light grades which would necessitate steps down to main walks.

(3) Using perrons, where practicable, in lieu of steps.

(4) Substituting retaining walls for earth banks when cost limitations permit and conditions are favorable.

e. Round the top and bottom of banks.

f. Divert drainage away from the top of earth banks and steep slopes, except when the drainage area is very small.

g. Preserve existing ground cover on large open areas where practicable.

3. FOR SAFETY AND LIVABILITY:

a. Where icy conditions occur frequently during winter months, try to keep walk and roadway grades well within recommended maximums.

b. Where an entrance walk is steep, round off the top to give a grade not exceeding 2% where the walk joins the building steps.

c. Avoid steps in yard walks; never use a single step.

d. Carry service drives across street sidewalks at sidewalk grade, rather than depressing the roadways and using curbs; but provide storm sewer inlets, where feasible, to prevent excessive storm water flow across the walks.

e. Avoid sharp breaks in grade and wavy profiles in walks and roadways.

f. Work out grades to insure preservation of trees which are to remain in place.

g. Provide positive drainage for crawl spaces.

h. Avoid hillside cuts with slopes that are not certain to be stable.

4. FOR ECONOMY IN FIRST COST:

a. Drain project areas directly into adjacent public streets so far as possible.

b. Strive for a reasonable balance of cut and fill.

c. At building sites avoid deep fills which would add materially to the cost of foundations. (This is mainly a site-planning consideration; where deep fills are necessary, the areas can best be used for playgrounds or parking areas.)

d. Keep grades as high as practicable where rock or water-bearing soil will increase materially the cost of utility installation. (Filling, made to this end, may result in simplified grade design and less need for storm sewers.)

e. In low density projects, preserve topsoil in place where practicable, avoiding cuts of but a few inches.

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SITE ENGINEERING

PART II - ROADWAY AND PARKING AREA PAVEMENTS

1. SCOPE OF ENGINEERING WORK

The general layout of project streets, drives and parking areas is fixed in preparing the site plan. The ensuing engineering work consists of selecting proper surfacing materials, establishing lines and grades, drafting roadway cross sections and other details, and preparing construction specifications and estimates.

This work should be done by an engineer experienced in pavement construction. Since these notes are prepared mainly for his reference, they outline the conditions bearing on pavement design which are peculiar to low-rent housing or which project maintenance experience has proved require special attention.

2. SUBGRADE

The subsurface investigation of the project site 1/, as carried out by the Local Authority, will supply information useful in pavement design. Such information will necessarily be supplemented by field investigation on the part of the engineer, who must be in possession of all facts necessary to determine the need for subdrainage, subgrade stablization, or a subbase for the surfacing. The extent of filling for roadways will be ascertained as project grading plans are developed, and precautions can be taken toward insuring stability of the pavement. Even though project roadways are of limited extent, the experienced engineer will not neglect subgrade examination.

3. ROADWAY CROSS SECTION

The crowned roadway section with curbs is most commonly used for project streets and main driveways and, with the exception later noted, is the most desirable. Curbs have been omitted in some earlier projects, but with consequent extra expense for maintaining shoulders, side ditches and pavement edges.

The dished or inverted-crown section has been employed extensively for service drives. It is economical as regards storm drainage and is adapted to carrying drives across sidewalks at the sidewalk grade -- a desirable arrangement. However, the dished section has met with some disfavor, chiefly because of the difficulty of accurately grading the central gutter. If the dished section is given a fairly good longitudinal slope, there need be little hesitancy in using it. The section is not recommended for other than service drives, or for paving material other than concrete.

The side-slope section, with drainage to one side, has been employed advantageously in a few projects to obtain a better adjustment of driveways to topography and to reduce storm sewer costs.

1/ See Bulletin No. LR-2, "Subsurface Soil Investigation."

Recommended roadway crowns per foot of roadway width are as follows:

Section	Average Crown	Form of Crown
Crowned - service drives	1/4 inch per foot	Parabolic
Crowned - streets	3/16 " " "	Parabolic
Dished	3/8 " " " (Max.)	Plane
Side-slope	3/8 " " " (Max.)	Plane or parabolic

4. CURBS AND GUTTERS

Roadway curbs have three functions, each important from a project maintenance standpoint: to control drainage, to keep wheeled traffic on the pavement, and to protect pavement edges.

With reference to drainage, curbs have been omitted advantageously under one unusual combination of conditions, namely, a flat site, porous soil, and mild climate. Under these conditions, with the roadways draining onto grassed shoulders, much of the surface water seeps into the ground and a minimum of storm sewer is required. Ordinarily, however, curbs are desirable to form paved drainage channels and to prevent roadside erosion.

Curbs are obviously not required to control drainage along dished pavement or the upper edge of the side-slope section of road. However, experience has demonstrated the need of curbs to keep cars off lawns and to protect planting, fences, clothes-line posts, etc., located close to project drives. "Rolled" curbs are not effective for this purpose. A curb height of 5 or 6 inches is recommended.

For concrete pavement, an integral curb serves the purpose of a "thickened edge," and its cost is, therefore, more or less offset by greater pavement strength. For bituminous pavement, curbing provides permanent protection of the pavement edge. Combination curb and gutter is preferred to plain curb, not only because concrete is a better material for the gutter, but there is less tendency for the curb and gutter to draw away from the pavement and permit water to reach the subgrade.

5. ROADWAY GRADES 1/

The site plan, in its relation to topography, obviously fixes within rather close limits the grades to which roadways must be built. As a rule, the engineer (grade designer) must simply obtain the most satisfactory slopes, maximum and minimum, that the plan permits. The grade design is normally developed as a whole, adjusting and readjusting building, grounds and roadway elevations until the best possible balance of all considerations is obtained.

1/ See Part I, "Project Grade Design", of this Bulletin.

Eight per cent may be cited as generally the steepest desirable grade for roadways, although the maximum will depend considerably on street gradients commonly used in the locality. A 0.50% grade is considered the minimum desirable for straight or integral curbs, while with combined curb and gutter, permitting more accurate finishing, a slope of 0.40% is admissible. A grade of at least 0.60% is desirable for pavement of the dished cross section.

Vertical curves should be used where the algebraic difference between the gradients of intersecting grade lines exceeds 0.50%.

6. CURVES AND CURB RADII

Horizontal curves in roadways are fixed roughly by the site plan, and the engineer works out the precise measurements, including the curve data required for field location and street dedication plats.

Minimum curb return radii recommended for street and driveway intersections are:

Widths of Intersecting Roadways	Minimum Curb Radius
10 feet and 10 feet	25 feet
10 feet and 16 feet	20 feet
10 feet and 20 feet	15 feet
16 feet and greater widths	10 feet (preferably 15 ft.)

7. CHOICE OF PAVEMENT TYPE

Two groups of surfacings are <u>un</u>suitable for use in low-rent projects -- one because of high first cost, the other because of excessive maintenance. The former group includes pavements such as sheet asphalt or brick, which normally are laid on a concrete base; the latter comprises surfacings like calcium chloride-treated gravel or water-bound macadam, without a bituminous wearing course.

The choice of pavement type, therefore, will lie between bituminous surfacing and portland cement concrete, and if the former is decided on the engineer must select the class which from the standpoints of cost and durability is best adapted to the project. The principal considerations are the following:

a. <u>Character of Project; Wheel Loads</u>. High-density projects usually warrant or require a higher type pavement than those of low density.

b. <u>Pavement on Filled Ground</u>. A flexible pavement (bituminous) is considered safer than a rigid pavement for laying over new fills of any depth.

c. Local Materials and Local Construction Practice. With particular reference to bituminous pavement, the best product for the money will be obtained by selecting a type that permits fullest use of locally available aggregates, and that local contracting organizations are equipped to lay and are experienced in laying.

d. Pavement Cross Section. As previously noted, concrete should be used for pavements of dished cross section.

e. Durability; Low Maintenance. Housing management seldom has the personnel or equipment which city street departments have to carry out regular pavement inspection and repairs. Consequently, the need for project surfacing repairs may be overlooked until disintegration has become serious. It is most desirable to lay a durable pavement.

f. First Cost. The consideration just mentioned must of course be related to reliable construction cost estimates of the surfacing types considered.

g. City Requirements. Streets paved under a project construction contract are frequently dedicated to the city, thus relieving the project of their maintenance. When this is to be the case, the street improvements must obviously be constructed to meet city requirements.

8. BITUMINOUS PAVEMENT

Bituminous pavement for housing projects has the advantages of pleasing appearance, flexibility, ease of repair, and sometimes low first cost. The last is not attainable if the pavement must be comparatively heavy -- consisting, for example, of a 2-inch plant-mix wearing surface on a two-course crushed rock base. Such a roadway, with curb and gutter, is likely to cost about as much as portland cement concrete. But in some localities surface-treatment or penetration methods, successfully adapted to inexpensive locally available aggregates, produce comparatively low-cost and wear-resistant surfacing which the Local Authority can hardly afford not to use.

To prepare proper specifications for bituminous paving, the engineer must not only be thoroughly familiar with site conditions, but should have first-hand knowledge of local practice and all related conditions.

The main disadvantage experienced with bituminous pavement in low-rent projects has been its frequently high maintenance cost. In most instances this has been attributable to the use of too light a surfacing, either as to base or wearing course or both. In some cases the fault has been poor workmanship (lack of competent inspection). Since bituminous pavement construction is a specialized line of work, the Local Authority should arrange for the full-time services of a qualified inspector. (The limited supervision furnished by the engineer under the terms of the Architect's Contract is not enough.)

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9. PORTLAND CEMENT CONCRETE PAVEMENT

The recognized merits of concrete pavement for project roadways are durability, low maintenance expense, and in many cases a first cost in keeping with low-rent housing.

The engineer should be able to use local standards as a generally safe guide in concrete roadway design. Practice varies widely, however, and the following summary shows, for convenient reference, certain widely accepted design standards:

a. Slab Thickness (based on 350 p.s.i. tensile strength in concrete; modulus of subgrade reaction of 100 lbs. per sq. in. per in. of yield; and "protected corners").

Class of Street	Uniform Thickness
Residential (6,000 lbs. ordinary maximum wheel load)	6"
Feeder (7,000 lbs. ordinary maximum wheel load)	7"

b. Longitudinal Joints.

Spacing: $12\frac{1}{2}$ feet maximum.
Type: Dummy-groove marking lanes for 2- and 3-lane roadways; same for 4-lane roadway, but center joint to be free, keyed; all joints to be sealed; dummy-groove (about 0.3 depth of slab) to have non-extruding filler.
Tie bars: $\frac{1}{2}$" x 30" @ 2'6", deformed, for dummy-groove joints

c. Transverse Contraction Joints.

Spacing: 15 feet for gravel aggregate, 20 feet for crushed rock.
Type: Dummy-groove, with non-extruding filler, and seal.
Dowels: None required for joints 50 feet or more from expansion joints; closer to expansion joints, same dowels as required for expansion joints.

d. Transverse Expansion Joints.

Spacing: At each side of pavement intersections; 300 to 600 feet between intersections (this spacing only when contraction joints provided as above).
Type: 3/4 inch wide with non-extruding filler, and seal.
Dowels: Slip type; 3/4" x 18" @ 18" smooth, for 6,000-lb. wheel load; 3/4" x 18" @ 15" for 7,000-lb. wheel load.

e. Transverse Construction Joints.

Type: Plane, sealed.
Dowels: Same as for expansion joints.

It is generally desirable to specify the local standard for concrete mix; however, air-entraining concrete should be considered in all cases.

10. PARKING AREAS

The preceding discussion of roadway pavement design is generally applicable to parking area surfacing. Wheel loading on the latter is lighter, however, and pavement thickness may be slightly less.

Concrete pavement for parking areas should be confined, as a rule, to small bays adjoining concrete roadways. Elsewhere, bituminous surfacing is preferable because of its generally lower cost and more satisfactory appearance. For resisting disintegration due to oil drippings, a tar mixture is preferable to asphalt.

Maintenance experience has shown the need for curbing around parking areas. Wood bumpers of one kind or another have been used in some cases, but they are not as satisfactory as concrete curbs.

11. DRAWINGS AND SPECIFICATIONS

The "architectural block plans" usually show construction contract information regarding the location, surface dimensions and grade elevations of roadways, parking spaces and other surfaced areas. However, a special site plan showing roadway location data may be needed when streets and drives have very irregular alignment.

Roadway profiles should form a part of the design studies, except when slopes are very light, and preferably should be included in the contract drawings. In the event they are not so issued, vertical curve data as well as other road grades should be shown in full detail on the block plans.

Details for concrete pavements should include complete layouts of joints -- expansion, longitudinal, and transverse contraction -- for parking bays and roadway intersections.

Specifications for pavements and surfacings may be shortened greatly by stipulating construction in accordance with certain city or state highway department specifications. Some such standard or standards will usually fit the project needs, and lower costs are likely to result from directly specifying pavement types with which local contractors are familiar. However, the city or state specifications should be examined carefully, and exception taken to any requirements that would be impracticable or unnecessary for the project work.

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12. INSPECTION OF CONSTRUCTION

The need for competent inspection was mentioned previously in connection with bituminous pavement, but poor workmanship in project roadway paving has not been confined to surfacing of this kind. From the preparation of subgrade to completion of surface course, close inspection should be provided for all pavement laid. Furthermore, even though project roadways are of limited extent, laboratory testing of materials should not be ignored. At a reasonable cost, it provides an important form of insurance against poor workmanship.

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SITE ENGINEERING

PART III - RECREATION AREA SURFACING

1. INTRODUCTION

The importance of proper surfacing for recreation areas was recognized at the inception of the public housing program, but considerable time has been required to gain basic experience. For early projects, the principal design guide lay in public playground practice, although the surfacing problem there is not altogether the same as in housing.

Much valuable information on recreation area design has now been obtained. Although there remains some difference of opinion as to the best surfaces for specific play uses, the divergent views are based on experience under differing conditions, especially as to climate. Majority opinion, as reflected in this bulletin, appears fairly clear.

Satisfactory surfacing for recreation areas can be had only by: (1) a proper choice of surfacing type, (2) competently drafted specifications, and (3) first class workmanship. A deficiency in any of these factors may result in seriously impaired usefulness of the surfacing or the need for costly reconstruction.

The locations, dimensions and proposed uses of recreation areas are fixed in preparing the site plan. This bulletin deals with the surfacing for such areas.

2. SURFACING USES

From a use standpoint as related to surfacing, recreation areas in low-rent housing projects may be classified as follows;

a. Sports fields for softball, football, etc.

b. Game courts:

(1) Those requiring a hard surface -- for basketball, shuffleboard, hopscotch, etc.

(2) Those requiring a soft surface -- for croquet, marbles, horseshoe pitching, etc.

(3) Those for which a hard or soft surface is optional -- for paddle tennis, badminton, volleyball, etc.

c. Areas for roller skating and other intensive use by school-age children and adults.

d. Water play areas.

e. Play areas for small children:

(1) Yards for supervised play (mainly in turf).

(2) Areas close to dwellings, for play under parental supervision (surfacing optional).

f. Local play areas:

(1) Paved courts between apartment buildings.

(2) Other areas, surfaced or unsurfaced, for recreational uses.

g. Areas under fixed playground equipment.

h. Sitting areas:

(1) At apartment building entrances.

(2) Elsewhere, for common use.

(3) At individual dwelling entrances.

A given area may, of course, serve different recreational purposes, but its principal use or uses must be known before selecting the surfacing type.

Not listed above are certain areas which should be hard-surfaced merely because it would be impossible to maintain grass on them. Examples are strips between sidewalk and curbs, and miscellaneous small plots which would suffer from pedestrian short-cutting. While such areas are not planned primarily for recreational use, the surfacing problem is much the same. The esthetic value of grassed strips between sidewalks and curbs is fully appreciated. However, management experience indicates that only under the most favorable conditions, including low project density, is it practicable to maintain grass on such areas.

3. DESIRABLE QUALITIES IN SURFACING

There is no perfect surfacing material. The problem in each case is to select the material possessing the best combination of qualities for the particular use in the locality. The following desirable qualities apply to surfacings for all uses:

a. Year-round utility.

b. Freedom from dust and material that will stain or track.

c. Non-abrasiveness, minimizing cuts and bruises from falls.

d. Pleasing appearance.

e. Durability.

f. Availability at reasonable cost.

For "hard" surfacing, the following additional qualities are important:

a. Requisite smoothness for the intended use -- for wheel toys, games with bouncing balls, roller skating, etc.

b. Firmness of footing (dry or wet).

c. A degree of resilience.

d. Sufficient hardness to prevent scuffing or permanent indentation under use.

4. CLASSES AND TYPES OF SURFACINGS

Following are the principal surfacings which have been laid on recreation areas in low-rent housing projects:

Class	Type
Earth	Turf Loam Sand-clay Clay-gravel
Aggregate	Gravel Stone screenings Granulated slag Shell
Bituminous	Penetration macadam Bituminous concrete Sheet asphalt Cork-asphalt (bituminous concrete and surface treatment)
Concrete and Masonry	Monolithic concrete Precast concrete slabs Flagstones Brick Granite blocks

Marked differences in specifications have added greatly to the kinds of surfacing laid. Bituminous surfacing has been of both asphalt and tar; and the asphalt has been of various kinds and grades.

Table I, a summary of recommendations on recreation area surfacings, relates the above-listed materials to the uses enumerated on pages 1 and 2. The recommendations are subject to considerable adjustment for local conditions, as explained in the following brief discussion of the various surfacing types.

TABLE I

Recommended Surfacings for Recreation Areas, Related to Project Density and Type of Dwellings [1/]

Kind of Area	Low- and Moderate-Density Projects (Twins, Row-Houses, and Flats)	High-Density Projects (Apartments)
Sports fields	Turf; loam	-
Game courts	Sheet asphalt; bituminous concrete; portland cement concrete; sand-clay; turf (according to intended use)	Sheet asphalt; bituminous concrete; portland cement concrete; sand-clay (according to intended use)
Areas for roller skating	Sheet asphalt; bituminous concrete; portland cement concrete	Sheet asphalt; bituminous concrete; portland cement concrete
Water play areas:		
Spray surface	Portland cement concrete	Portland cement concrete
Border	Bituminous concrete	Bituminous concrete; brick laid over concrete base
Play areas for small children (supervised play)	Mainly turf, but with some portland cement concrete	Mainly turf, but with some portland cement concrete
Paved courts between apartment buildings	-	Sheet asphalt; bituminous concrete; portland cement concrete
Areas under fixed playground equipment	Light loam; sand; tanbark; sawdust; shavings	Light loam; sand; tanbark; sawdust; shavings
Sitting areas	Portland cement concrete; brick or flagstones on sand cushion	Portland cement concrete; brick; flagstones

1/ Surfacings are listed roughly in the order of their desirability under "average" conditions. The recommendations are subject to some adjustment for soil and climatic conditions, materials available locally, etc.

5. SUBGRADE

A thoroughly drained subgrade is important for every kind of recreation area surface. With turf and other soft surfaces (loam, sand-clay, etc.), effective subdrainage will increase the number of hours the areas can be used and decrease maintenance costs. With hard surfacings, subdrainage will minimize damage from freezing and thawing.

Generally speaking, money is better spent in improving the subgrade than in combating an unfavorable soil condition by constructing a heavy base. On plastic clay soils that are unstable when wet, a subbase of material such as pit-run gravel or stone screenings, will provide subdrainage and serve as a cushion against soil movement. Tile drains should be provided in conjunction with such a subbase.

6. TURF

Turf is generally recognized to be the nearest-to-ideal surface for large playgrounds. Its principal disadvantages lie in its unsuitability for use when wet or when the ground is frozen or thawing, and the difficulty of maintaining a stand of grass on areas that receive intensive use. Consequently, with the exception noted below, turf should be employed as a play surface only on relatively large areas in low- and moderate-density projects.

Since playground turf will be subjected to more severe wear than will lawns generally, special care must be taken in soil preparation. Otherwise, maintenance cost will be increased and the value of the playground permanently impaired. If by any means practicable, the establishing of turf should be undertaken soon after building construction starts; if possible, a cover crop should be grown and plowed under. In any case, the specifications for soil preparation, seeding, etc., should be ralated to the project construction program and the area should not be opened to play use until a good stand of grass is obtained. It generally takes 6 or 8 months from the time of seeding to establish turf vigorous enough to withstand playground use.

(Pertinent to the preceding is the fact that considerable investigation has been made of economical means of establishing turf for hard wear, "gravelled turf" being a development in that direction. As a result, some authorities now lean, under certain conditions, to using the right kind of grass and commercial fertilizer on hard or poor soil, in lieu of the customary top-soiling process.)

Play areas for small children should be mainly in turf, although up to 1/3 of the area may be hard-surfaced if the unpaved portion will provide 400 sq. ft. for free play and sufficient use space for apparatus. Since these areas are quite small, they may often be sodded, rather than seeded.

7. LOAM

Loam and natural soil have seldom been employed as playfield surfaces in low-rent projects. Their advantages and disadvantages are too obvious to require mention, although it should be noted that dust nuisance can be abated effectively by calcium chloride applications.

8. SAND-CLAY, CLAY-GRAVEL

Clay mixtures have found their principal use in southern states where bituminous surfaces become quite hot in the summer. Such mixtures have been laid in the North also, but with rather less satisfactory results, partly because the break-up from freezing adds to maintenance and makes the surfacing unsuitable for use during a greater proportion of the year.

Sand-clay is most likely to be advantageous in localities where a suitable natural mixture is available and is in common use for playground surfacing, since laboratory control and mechanical mixing add greatly to cost. However, if mechanical mixing is required, the specifications should provide for the advance preparation of sample plots with different proportions of materials, to determine the best combination. It is suggested that the test mixtures contain 30%, upward and downward, of sand.

Sand-clay should be laid on a subbase of cinders, gravel, stone or slag to permit using the surface more quickly after rains. It is sometimes so laid with a compacted thickness of only 2 inches.

9. GRAVEL

Gravel surfacing is low in cost and pleasing in appearance, but the loose material must be swept off pavements and raked out of lawns; children throw it around; and weeds must be cleared out frequently. Gravel is considered unsuitable generally for any use as surfacing in low-rent projects.

10. SCREENINGS

Limestone screenings, granulated slag, cinders, shell, and similar materials have some of the disadvantages of gravel; moreover, they are abrasive and detract generally from appearances. These materials also are considered unsuitable for recreation area surfacing in housing projects.

11. BITUMINOUS SURFACING

For intensively used recreation areas, bituminous surfacing properly laid has important advantages: year-round usefulness, smoothness, firmness of footing, a degree of resilience, and a surface that can be marked for court games. Moreover, it is easy to repair and generally reasonable in first cost. In housing project experience, however, bituminous surfacing has frequently proved far from satisfactory. The reasons for this are noted in the following discussion, which covers the principal points meriting consideration in the use of this class of surfacing:

a. Limitations on Use. Bituminous surfacing has met objection in some localities because of its becoming soft, sticky, and too hot for bare feet in the summer. With the proper grade of asphalt cement specified, bituminous concrete should not become sticky or objectionably soft in midsummer. However, it is heat-absorbent and should not be used in the southern states unless careful consideration indicates that no superior material is available.

Bituminous surfacing should not be laid on small or irregularly shaped areas, all parts of which cannot be reached easily with a power roller. Compaction by tamping is likely to result in poor workmanship -- in a rough surface and one that indents easily. Further, in the case of small areas, the necessary permanent edging increases materially the per-square-foot cost.

b. Base Course. The base course for bituminous surfacing consists commonly of well-compacted crushed rock with fines swept and rolled into the surface voids. The thickness necessary to provide a firm foundation for the surface course obviously depends on soil and climatic conditions (see the previous discussion of "Subgrade"). Four inches is the recommended minimum depth.

c. Surface Course. The most common defect in bituminous surfacing as laid on recreation areas has been roughness and abrasiveness -- a defect due in part to inappropriate surfacing types and in part to poor workmanship (lack of competent inspection). As to surfacing type, the principal fault has lain in using too coarse-graded aggregate.

The bituminous wearing surface should be smooth, dense, impervious and fine-grained -- in other words, of a texture similar to sheet asphalt or hot-laid bituminous concrete. This is not to infer that, properly specified and laid, a satisfactory surface cannot be produced by using dense-graded, cold-laid mixtures, but the hot-laid types are more certain to prove satisfactory. Moreover, one or both of them are standard in most states and large cities. Sheet asphalt and bituminous concrete are preferably laid in two courses, having a total thickness of about 2 inches.

Specifications for bituminous surfacing should be prepared with a full knowledge of the kinds of such surfacing laid locally in streets and roads, that is, of the kinds which local contractors are equipped to lay and for which aggregates are readily available. The specifications may often be shortened greatly by stipulating construction in accordance with city or state highway department specifications. However, such specifications should be examined carefully and any requirements eliminated that are not entirely practicable in their application to the project work.

d. Permanent Side Supports. Unless bituminous surfacing is laid against buildings, walks or other solid construction, permanent side supports of concrete, brick, or steel curbing should be provided. Otherwise, ravelling is quite certain to occur, even though the base course is extended slightly beyond the edge of the top course. Wood side forms may be heaved by frost and at best are impermanent; they have generally proved unsatisfactory.

e. Workmanship in Laying. The usefulness of bituminous-surfaced recreation areas in low-rent project has often been impaired by inferior workmanship.

Specifying a suitable mix is in itself no guarantee of a satisfactory job. Apart from the general supervision normally supplied by the civil engineer, bituminous surfacing should be laid under the constant supervision of an inspector thoroughly experienced in that line of work.

12. CORK-ASPHALT

Cork-asphalt surfacing of both the hot-mix and surface-treatment types has been laid in a number of low-rent projects; and specimen areas of the two types and of different mixtures were laid on a large play area in a Washington, D. C. project. The hot-mix specimens show no sign of disintegration after ten years of use. Based on these tests, the tentatively recommended formula for hot-mix cork-asphalt is:

	Percentage by Weight
Ground cork, 8- to 24-mesh	$5\frac{1}{2}$
Sand, graded as for sheet asphalt	71
Limestone dust	$7\frac{1}{2}$
Asphalt, 70 to 85 penetration	16
	100

Cork-asphalt is slightly more resilient (or soft) than standard bituminous pavements, and slightly superior to sheet asphalt as regards abrasiveness. However, it is considerably more costly and rather more difficult to lay than hot-mix asphaltic concrete or sheet asphalt. Consequently, there is greater risk of inferior workmanship; cork-asphalt surfacing inspected on certain public playgrounds was not standing up satisfactorily in all cases. The material is recommended for use in low-rent projects only when it has been laid in the locality and its use has proved generally successful.

13. PORTLAND CEMENT CONCRETE

The advantages and disadvantages of concrete surfacing are too obvious to require emphasis. The advantages include year-round utility, minimum maintenance expense, and a smooth surface for roller skating, wheel toys and various court games. Among the disadvantages are hardness on the feet (lack of resiliency), glare (which may be lessened by dark coloring), and the necessity for contraction joints in other than small areas. For comparatively large, intensively used play areas, bituminous surfacing has been laid in far more projects than has portland cement concrete. For small sitting areas, concrete is, as a rule, decidedly preferable to bituminous surfacing.

14. PRECAST CONCRETE SLABS

To lend variety, precast concrete slabs (about 16 inches square and 2 inches thick) have sometimes been used for sitting-area surfacing. Laid with open joints, such surfaces have proved unsightly, dangerous, and difficult to maintain. If used at all, the slabs should be laid with tight joints and on a sand cushion. However, their initial cost is little less than that of a monolithic concrete slab and maintenance costs are higher.

15. FLAGSTONES

Flagging laid on a sand bed should be in large slabs that can not be removed by childred, and joints should be tight. As a rule, there is little justification for using this type of surfacing except on special areas in high-density projects. In such instances, the flags should be laid on a sand cushion over a concrete base.

16. BRICK

Brick on sand cushion does not provide a surface smooth enough for wheel toys, court games, etc. However, brick surfacing is satisfactory for sitting areas and it furnishes needed color in grounds areas. It has been laid in numerous existing projects -- sometimes successfully, sometimes not. Tight laying is important; otherwise children remove the brick. Edges of brick areas should be protected by solid curbing of concrete, steel, or brick set on end in concrete. Brick laid on a mastic bed over a concrete base makes an excellent surfacing for sitting areas, but, as in the case of flagstones similarly laid, is rather too costly to be provided in other than exceptional cases in high-density projects.

17. GRANITE BLOCKS

Granite blocks salvaged from old pavements have been utilized in low-rent projects in several eastern cities. They have been employed mainly for walkway edging, for surfacing the space between sidewalk and curb, and for covering other areas subject to severe wear. The blocks are altogether too rough for most play uses and are not very satisfactory for sitting areas. Reports indicate that, if used, they should be laid on a sand bed and with tight joints, rather than with open joints filled with topsoil.

18. FINAL CHOICE OF SURFACING

The recommendations contained in Table I, (page 4) are, as noted, subject to adjustment for local conditions, and these should be investigated carefully. Bituminous surfaces should be specified with caution, for laying in the southern states.

Local practice in surfacing school yards and park playgrounds is often worth investigating. Some locally employed type not referred to in this bulletin may be found suitable for housing project use; or check may be had on experience reported in this discussion. Local practice is necessarily based on locally prevailing conditions of every sort -- climate, availability of materials, skill in laying certain kinds of surfacing, etc. -- and useful information may be obtained.

Care in the selection of surfacing types is important. Decisions should not be perfunctory and should not be made without field examination, or first-hand knowledge, of the kinds of surfacing proposed for use.

SITE ENGINEERING

PART IV - WALKWAYS

1. SCOPE

The general layout and widths of project walkways are fixed in the development of the site plan, the details of which are discussed in other PHA bulletins. Thereafter, in project grade design, walk grades are established and walkway steps located and dimensioned. This disposes of a major part of the design work in connection with project walks. This particular bulletin, therefore, covers the field of walkway materials and construction details, in light of actual project construction and maintenance experience.

Portland cement concrete has proved generally to be by far the best material for walkways in low-rent projects. Concrete walks are satisfactory in almost every respect from a "use" point of view, and they require a minimum of maintenance. Other walk materials are discussed in this bulletin, but mainly to explain why their use is <u>not</u> recommended.

The following text refers to walks <u>within</u> the project site. Sidewalks in existing streets, or in streets to be dedicated, must be built to comply with local municipal standards.

2. CONCRETE WALK CONSTRUCTION

Concrete walks are built to a variety of specifications, but the trend in recent years has been toward (1) one-course construction (a 4-inch slab thickness is commonly used in housing projects), (2) omission of any subbase unless soil conditions are unfavorable (see Par. 8 following), and (3) expansion joints at intervals generally not exceeding 50 feet. Such construction has proved satisfactory and should generally be followed.

There is no prevailing practice, however, as regards contraction joints. In some places they are omitted entirely; in others, metal separation plates are used to form full-depth joints, often spaced as closely as 4 or 5 feet; elsewhere, grooves (dummy joints) one or two inches deep are similarly spaced. This latter practice, which has become quite common, corresponds to that widely used in highway construction; when the slab parts at the weakened plane, an irregular break prevents displacement.

From a construction-cost standpoint, it is desirable to specify construction methods that local contractors are accustomed to and equipped to follow. However, fairly closely spaced contraction joints are recommended for controlling the location of cracks.

Air-entraining cement should be specified in severe climates where salt or calcium chloride may be used frequently for ice removal. The use of coloring compound in project walks is rarely justifiable.

3. BITUMINOUS WALKS

Bituminous walks present a pleasing appearance -- when they are kept in good repair -- and they can sometimes be laid at a cost comparing favorably with that of concrete. But experience with them in low-rent projects has been unsatisfactory. Roller operation has been difficult, if not impossible, over narrow walkways having frequent sharp intersections; permanent side supports to prevent ravelling have generally been omitted; and lack of expert inspection has been reflected in faulty workmanship.

If and when laid, bituminous walks should be of a mix that will produce a smooth, dense surface. However, such walks should not be laid without permanent side supports (steel or concrete) or unless local experience in walk construction, preferably in nearby housing projects, proves that the difficulties cited above can be overcome.

4. PRECAST CONCRETE SLABS; FLAGSTONES

Stepping-stones, about 12 x 18 inches, have been laid to form house-entrance and other minor walks in various existing projects. These are usually laid 26" to 28" on centers. They are sightly, when well laid and maintained, but the stones are hard to keep at grade; children dig them up; it is difficult to wheel baby-carriages over them, etc. Minimum-width concrete walks can be built at little more cost and are far more satisfactory.

Closely-laid concrete slabs or flagstones cost at least as much as concrete walks and, excepting possibly the matter of appearances, are less satisfactory than monolithic concrete.

5. GRAVEL WALKS

Experience with gravel walks in low-rent projects has been wholly unsatisfactory. Children scatter the pebbles around and the binder tracks into houses. No such walkways should be specified.

6. ROUNDINGS

Experience has shown that roundings (or splayings) are needed for lawn protection at all walk intersections, with the possible exception of those at house entrance walks. Radius of the rounding may be approximately half the greater walk width. As a rule, an expansion joint should be located at the end of each such rounding; thus, at a right-angled intersection of two 6-foot walkways, there should be four expansion joints, each 6 feet from the intersection of the walkway centerlines.

7. VERGES

In certain high-density projects walkway verges (or borders) have been required to prevent destructive wear on adjoining grassed areas. Old stone paving blocks have been used for the purpose; since they are uncomfortable to walk on, they keep pedestrians on the concrete surface. A low curb serves the same purpose, although not so effectively.

8. SUBBASE, SUBGRADE

A subbase of gravel, cinders or similar material, under concrete walks, is unnecessary unless drainage conditions are unfavorable or the soil is soft or unstable. If provided, it is important that the subbase have adequate tile drain outlets. Subdrainage is important for walks, as well as for roadways, where the ground-water level is very close to the surface.

9. WALKWAY SLOPES

The minimum grade recommended for project walks is 0.50% -- 1.00% for building entrance walks. A 1.00% minimum is preferred, however, for all walks. The recommended maximum is 10% for main walks and 15% for entrance walks -- 6% in each case, where snow and ice may prevail during a long winter season; and due consideration should always be given to the nature of the terrain and to the slopes commonly used in the locality. 1/

Sharp breaks in grade should always be avoided, and the drawings should show typical details of vertical curves in walks. In main walks, such curves may be fairly long -- 25 feet or more -- with forms set in short straight chords. In steep entrance walks, the curves will necessarily be quite short -- 6 feet, more or less, with top of forms curved to fit. Providing vertical curves in walks requires additional care in design and in staking the work in the field, but it adds only slightly to construction costs, and appearances are improved materially.

As a safety provision, walks within about 2 feet from the top and bottom of steps should have very little slope -- say, only 1/4 inch per foot. This may be accomplished, where a steep entrance walk joins a building platform, by a level tangent extending from the base of the steps to a point of intersection of vertical curve, about 3 feet distant.

Walks should be cross-sloped (or crowned) not less than 1/4 inch per foot. The direction of cross slope, to fit the drainage scheme, should be shown on the grade drawings by arrow points.

10. WALKWAY STEPS.

While walkway steps, and the earth banks that go with them, are extremely undesirable, they are frequently unavoidable. When required, their location, rise and run are fixed in the project grade design. The rise obviously should be based on a uniform step throughout the project. A 6-inch riser and 12-inch tread, corresponding to a 2 to 1 slope, are commonly used

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1/ See also Part I, "Project Grade Design", of this Bulletin.

although, where ground space permits, 3 to 1 banks with 5-inch by 15-inch steps may be considered preferable. (These observations do not apply to steps at building platforms. Where approach walks are laid quite close to row houses, steps at all such building platforms can seldom be kept of the same dimension.) Steps should be pitched slightly for drainage. An intermediate landing is desirable when a flight of steps rises more than 6 feet. Short sections of walkway should be provided between ends of steps and adjacent cross walks or drives.

Cheek walls along the sides of steps serve as beams and aid in keeping the adjoining bank in good condition. When not provided, erosion often leaves the step corners protruding in an unsightly and unsafe way.

Where there will be much storm water flow to the top of a flight of steps, it is recommended that a concrete gutter be cast integrally with the cheek wall on the down-hill side of the steps, that is, on the side toward which the connecting walk from above is cross-sloped. At its top, the gutter should be spread to intercept the storm water flow. Controlling erosion at the side of steps has always been a difficult problem, not only due to surface drainage but because children play and run their wheeled vehicles up and down slopes in these places.

Handrails are generally considered advisable for flights of yard steps containing 5 or more risers -- 3 or 4, where snow and ice are common during the winter months. A double rail is desirable so that one pipe will be low enough for small children.

Foundation walls (or posts) at top and bottom of steps should be carried down to undisturbed soil.

11. PERRONS

Stepped ramps, or perrons, are adapted to slopes up to about 4 to 1, over which a power mower can be operated. They are better for passage of bicycles and perambulators than are ordinary steps, but are recommended for use only where a walkway, without them, would definitely be too steep. The longitudinal slope of perron treads should not exceed 1/2 inch per foot, preferably 1/4 inch.

12. INSPECTION

Although walks comprise a simple phase of project construction, poor workmanship has caused trouble in various existing projects. Probably the most serious defects have resulted from inaccurate grading of forms, particularly where grades have been light. To this and other details of walk construction the engineer and inspectors should give close attention.

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SITE ENGINEERING

PART V - SPRAY POOL DESIGN

1. INTRODUCTION

Water play facilities, consisting of spray pools, wading pools or makeshift apparatus, are in use in a large majority of existing low-rent projects. Makeshift sprays, such as attachments to fire hydrants, have been resorted to mainly because the need for pools was not foreseen; and wading pools are no longer recommended since they are a definite health hazard. Children lie down and paddle in them and it is impossible to provide necessary health precautions. Wading pools are prohibited in many cities.

The spray pool is, therefore, the recommended type of water play facility, and is dealt with in these notes which are concerned primarily with the construction details of the pools. Water play facilities in their relation to site planning are covered in Part III of Bulletin No. LR-3, Local recreation officials and nearby Housing Authorities should be consulted in each case, in deciding whether a spray pool should be included in the project.

The recommendations which follow are mostly tentative and are based in part on an investigation conducted in 1945. The views expressed by management personnel in connection with that study differed in some respects, but majority opinion on various points was clear and in large part is reflected herein.

2. SPRAY HEADS AND SETTINGS

Table I lists types of spray heads and settings, which have been used more or less satisfactorily in existing projects. The spray arrangements are listed roughly in their order of preference, as indicated by field reports, and notes are given concerning observed results.

Observations indicate that for a good spray the heads or nozzles should deliver from 2 1/2 to 5 GPM per 100 sq. ft. of area sprayed, this being roughly equivalent to a rainfall of from 2 1/2 to 5 inches per hour. Dome heads (as used in some projects) deliver water at about this rate (one tested at 10 p.s.i. discharged 31 GPM) and small nozzles, although varying greatly in characteristics, can be obtained and arranged to give any desired spray intensity.

The spray should preferably consist of drops, rather than jets or mist. That from orifices not exceeding 1/16 inch in diameter and from various makes of small nozzles is satisfactory.

TABLE I
SPRAY APPARATUS

Type	Height above Floor	Direction of Discharge	Observations
Dome	6-7 ft.	Lateral-horizontal or at upward angle	Water pressure at spray head must be reduced to 5 to 10 psi.
Dome	6-7 ft.	Vertically upward	This position of head gives a lower intensity of spray than does the lateral setting. Pressure must be reduced as above.
8-inch bath	6-7 ft.	Vertically upward	Intense spray; comparatively small coverage.
Dome	0-3 ft.	Upward at 45°	Children block spray, when operated at requisite reduced pressure for an ordinary-sized pool. Satisfactory results reported when installed at edge of large paved playground where a higher pressure was used.
Small nozzles	0-1 ft.	Upward vertically or at 45°	While consensus favors large spray heads set high above floor, small low-set nozzles have given fairly satisfactory results in many projects.

The preferred spray arrangement, as indicated in Table I appears to be the large high-set dome, discharging laterally. A setting with the spray axis horizontal is recommended, although by means of an elbow (22-1/2° or 45°), the angle may later be adjusted, if necessary, to give a more satisfactory coverage for the pool dimensions. Spray heads are sometimes made with orifices especially arranged to give a predetermined spread and intensity. (A 1/16-inch orifice discharges about 0.20 GPM at the low pressure at which the spray must be operated.)

If the spray heads are to be nozzles located at floor level, they should be of ample size to give the proper discharge at low pressure, and so avoid misting. The nozzles should be set for overlapping sprays.

The preceding remarks regarding spray intensity, etc., apply to facilities for school-age children, who like the spray heavy enough to be exciting. For tots, the spray preferably should be fine and light, and low sprays are better, since very small children do not like spray falling on their heads. Space and cost considerations permitting, the pool area may, therefore, contain facilities suitable for both age-groups. Those needed for small children would be quite limited in extent.

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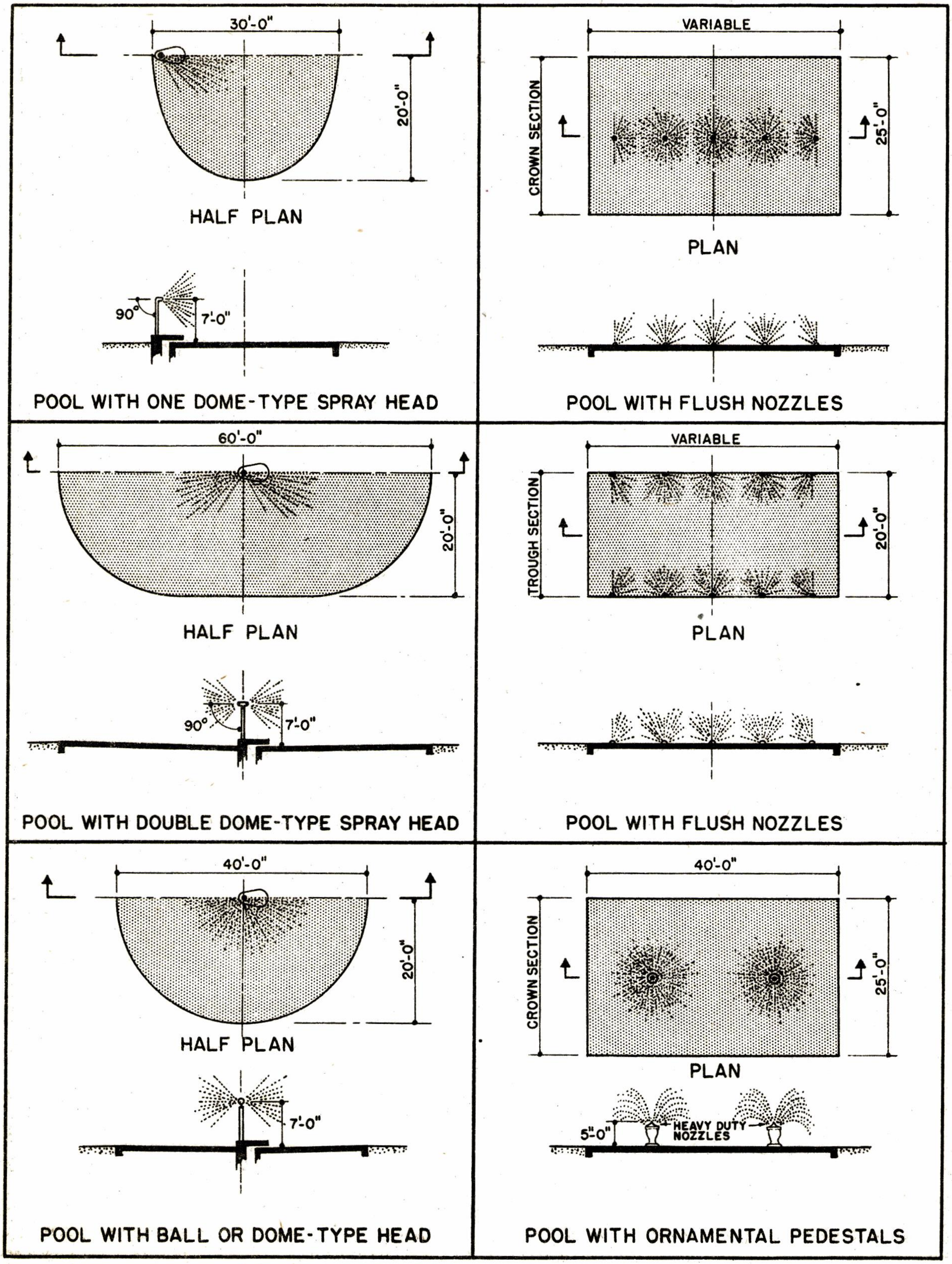

NOTE: DIMENSIONS INDICATED DO NOT INCLUDED POOL BORDERS

FIGURE I SUGGESTED FORMS FOR SPRAY POOLS

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3. SPRAY POOL AREA AND SHAPE

Where the space available for recreation areas does not exceed that required by the PHA Physical Standards, the spray pool area will be limited approximately as follows: 400 sq. ft. for 100 DU's plus 100 sq. ft. for each additional 100 DU's, with 1000 sq. ft. as a maximum. Where more recreational space is available, a larger area may be allotted to the pool, and this may be desirable, particularly in the south where pools receive much more use than in northern states; further, allowance should be made for the "drift" of the spray. However, 1500 sq. ft. may be regarded generally as the maximum area needed (not including the paved border) for any pool. In large projects, two or more pools may be provided. It is worth noting that the major cost item in spray pool construction is usually the piping installation, not the concrete slab.

Figure No. 1 shows typical forms and suggested dimensions for spray pools. For a large spray head on an elevated standard, an area of about 700 sq. ft. is required, while small nozzles can be arranged to spray practically any size or form of pool, from positions within the area or along its border. Should more than one large spray head be installed for a pool, the heads should be located to avoid overlapping sprays, as children need a little space "to come up for air."

4. POOL PAVEMENT AND BORDER

Float-finished concrete is recommended for the spray area. Expansion joints in the slab are undesirable and unnecessary and, by use of heavy mesh reinforcement, the number of contraction joints may be minimized. The latter may be formed as tongue-and-groove "construction joints", with minimum-radius rounding so as to detract as little as possible from the suitability of the area for roller skating and other kinds of play. Minimum slope to the drain should be 1/8 inch per foot.

Field opinion is unanimous as to the need for a paved border at least 8 feet wide around the spray area. This border may be of bituminous material, concrete, or brick, and preferably should pitch away from the pool. In no case should grassed or planted areas drain onto the spray pool pavement.

5. CONTROL VALVES

The water supply control valves must be secure from tampering by children, reasonably accessible, and within sight of the spray area. They may be located in a masonry pit with indestructible cover and lock, or in the basement of a nearby community building.

In addition to the cut-off in the supply line, there should be a globe valve, or a pressure-reducing valve, which can be adjusted to the proper flow (see Figure 2). When more than one large spray head is used, an individual control should be provided for each, as well as a valve on the main supply. The water supply piping must slope to a small drain valve

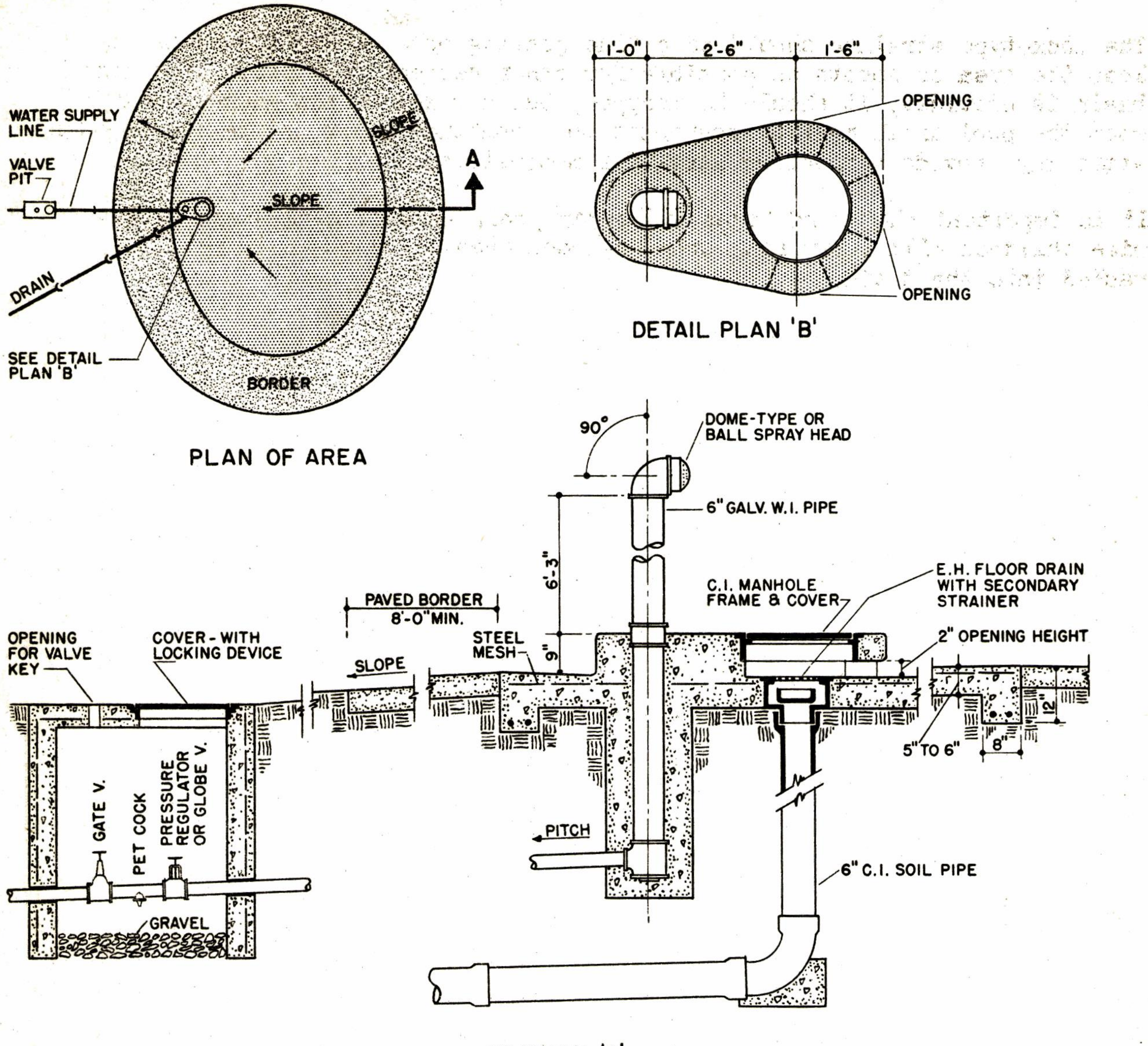

FIGURE 2 SPRAY POOL DETAILS

which will permit draining the water from the piping after the water play season is over.

6. DRAIN

The spray pool drain should be of an anti-freezing type, and adequate in capacity to take the spray-head discharge without impounding more than an inch or so of water. Moreover, it should be secure against tampering by children, and stoppage by sticks and stones. It may consist of a heavy, lock-type strainer with a secondary strainer, or a lock-type strainer set over a small catch basin; or it may be of some special design as illustrated in Figure 2. Long gratings, such as are used to intercept drainage from driveways onto sidewalks, may also be used.

The lock-type strainer should be a fine grating or a perforated plate, to keep the area as smooth as possible for other recreational use. If a catch basin is provided, it should be trapped, but a basin is recommended only when the pool drain must be connected to a combined sewer, since the standing water may provide a breeding place for mosquitoes.

It is important that sand boxes and spray pools be well separated; otherwise children will carry sand onto the pool area, from which it will be washed into the drain.

SITE ENGINEERING

PART VI - MISCELLANEOUS SITE IMPROVEMENTS

1. RETAINING WALLS

a. Where Needed. Housing projects on steep sites are usually planned in a series of terraces, with the transition from one to another made in part by the project buildings and in part by earth banks or retaining walls. The banks, because of their far lower first cost, must generally be used.

In high-density projects, however, where land costs are high, retaining walls may conserve valuable space needed for recreational use, laundry drying yards, etc., space that otherwise would be occupied by banks. Moreover, retaining walls are sometimes essential in fitting a site plan to rugged terrain; and such walls, to the extent they are used in any project, eliminate the costly maintenance of earth banks. This latter consideration, however, is rarely important enough in itself to justify wall construction.

Determination of the need for retaining walls is a combined site-planning and grade-design problem. In visualizing project grades as the plan is developed, the site planner can, to a large extent, determine if and where walls will be necessary. Then, as finished grades are established, the site engineer can make the final determinations and, in the detailed design, fix top, base and footing elevations.

b. Special Considerations. Since civil engineers generally are familiar with retaining wall design, no discussion of wall stability, expansion joints, contraction joints, drainage, etc., is included in this bulletin. Noted below, however, are several considerations, based on planning and maintenance experience, concerning the provision of such walls in low-rent projects:

(1) Retaining walls with footings carried below frost line are comparatively costly structures. They have been used in some locations where they could have been avoided satisfactorily by finished grade adjustments.

(2) Reinforced concrete is generally the most economical material for retaining walls.

(3) Dry stone masonry, however, where suitable stone is available, is an economical and suitable material for walls of up to moderate height. As a rule, dry walls need not extend much below finished grade, although they should rest on undisturbed soil.

(4) Where a slope must extend down sharply from a building to an adjacent walk or roadway, a low wall may be advantageous at the base of the slope, to give needed berm along the building and/or decrease the length of slope. For such purpose, a dry wall, or a concrete wall in the form of a high curb, may be adequate.

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(5) Elsewhere, at the base of a long steep slope, a low wall with a swale behind it, is useful in intercepting storm water and containing eroded material.

(6) Fences should be provided along the tops of retaining walls, except in the case of low walls such as referred to in subparagraph (4) above.

(7) Again excepting low walls, also those of dry stone masonry, surface water should not be permitted to flow down the wall face.

(8) Fitting the ends of walls to finished grade usually requires wings extending back into the bank.

(9) Existing retaining walls, if any, to be left in place should be investigated for stability.

e. Retaining Wall Plans. In addition to showing wall sections, joint details, provisions for drainage, etc., the drawings should include an elevation (or profile) showing original ground line and finished grades along each retaining wall. This facilitates taking off quantities and checking wall dimensions.

2. CLOTHESLINE SUPPORTS

a. Planning Considerations. The layout of outdoor clothes-drying facilities is properly a feature of the site plan, and the design of the clothesline supports certainly presents no "engineering problem". However, site engineers on low-rent projects should be familiar with recommended minimal requirements for these facilities and with certain data useful in their design.

(1) In tenant yards, clotheslines are often strung more or less perpendicular to the buildings, from hooks set in the building walls to posts (with short cross arms or hooks) located as far back as practicable from the buildings but not too close to service drives or walks. However, where rear yards are very shallow, multiple lines are strung parallel to the buildings and are supported on posts with cross arms. Under the latter arrangement, the posts can be made to serve as yard division markers and in some cases as yard fence posts. Recommended line lengths, height, etc., are as follows:

Line length: 60 feet for one-bedroom units, 75 to 100 feet for larger units.

Line height: 6'-2", measured above finished grade at posts or wall.

Spacing between parallel lines: Alternately 12" and 18".

(2) In community drying yards, post-supported rails are located on two sides of the area and wires strung between. Intermediate supports are

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provided if the line length exceeds about 35 feet. Recommended details are as follows:

Line length: At least 20 feet per DU served.

Line Height: (As above).

Spacing between parallel lines: Alternately, two spaces of 18 inches and one of 30 inches.

Space between posts and adjacent drying-yard fence: 36 inches.

b. Post Dimensions. Clothesline supports, in project design, have generally been sized largely by guess but on the whole fairly satisfactorily. Instances of flimsy section, requiring subsequent reinforcement by means of concrete piers, have been experienced, however, and Tables I and II have been prepared to show suggested post sizes, also more detailed data for the engineer who desires to check his sizing, particularly of supports in community drying yards.

TABLE I
Estimated Clothesline Pulls and
Requisite Diameters for Standard Steel Pipe Posts

Number of Lines	Average Length of Line 25 feet	30 feet	35 feet
1	120 lbs. (2")	160 lbs. (2")	210 lbs. (2½")
2	150 lbs. (2")	200 lbs. (2")	270 lbs. (2½")
3	180 lbs. (2")	250 lbs. (2½")	330 lbs. (2½")
4	210 lbs. (2½")	300 lbs. (2½")	390 lbs. (3")
5	240 lbs. (2½")	350 lbs. (2½")	450 lbs. (3")

TABLE II
Flexural Strength of Steel Pipe

Inside Diameter	Section Modulus Standard Pipe	Extra Strong Pipe
1"	0.13	0.16
1¼"	0.23	0.29
1½"	0.33	0.41
2"	0.56	0.73
2½"	1.06	1.33
3"	1.72	2.22

In Table II section moduli are given for both standard and extra strong pipe. While the latter is not as efficient structurally as standard pipe, it may be expected to have a considerably longer life.

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Rolled H and I sections, as used by fence manufacturers, have been utilized as clothesline posts in numerous projects. Weighing slightly over 4 pounds per foot, their section modulus (around their major axis) is approximately 0.80. These sections have the advantage of practically indefinite life if they are kept painted, particularly at the ground line. Steel angles and tees are not efficient sections for posts.

Steel posts should be either painted after erection or galvanized after fabrication, although the latter is not necessary if galvanized materials are used and the members are not welded in fabricating. (Wood posts were used extensively in war housing but, owing to their shorter life, their use in low-rent projects is not recommended.)

3. FENCES

The location of project fences is fixed in the development of the site plan. While these notes deal mainly with design details, the subject can not be separated from certain planning considerations. The latter include fencing costs, project appearances, and the need for fencing as related to project maintenance and to the customs of the people to be housed.

a. Fencing Uses. Table IV gives suggested fence types and heights for various uses. For uses 1 through 6 as listed, fences are as a rule considered extremely desirable, if not necessary. Permanent protective fencing (use 7) is generally needed around lawn and planted areas in multi-story-building projects, also often in special locations in row-house projects, such as diagonally between building corners and main walkway intersections, to prevent corner-cutting. Ultimate economy is best served by forseeing where fencing will be needed, rather than by constructing it later, after lawns and planting have been damaged. However, decisions in the matter must often be influenced by construction cost limitations.

b. Tenant Yard Enclosures. There is considerable difference of opinion due to local conditions, as to whether tenants' rear yards should be fenced, or the plots marked off in some other manner, such as by shrubs, trees, clothes line supports, or markers in walks and building walls. Yards in the rear of a building are sometimes enclosed as a group, with no divisions within the group. Whenever tenant yard fencing is considered, management experience on operating projects (if any) in the locality should by all means be investigated. The most important consideration, however, will be that of cost limitations. As a rule, chain link fencing of individual yards must be regarded as an extravagant item and one which can be considered only (1) when local experience proves it is extremely desirable, and (2) when site improvement and other project development costs will be unusually low.

c. Temporary protective fencing may be provided by the lawns and planting contractor or by the Local Authority, depending on whether the contract calls for maintenance. In either case, such fencing may be required for a somewhat extended period and it is desirable that a uniform, sightly and adequate type of fence be erected.

TABLE IV
Fencing Types and Heights

Fencing Uses	Appropriate Types	Suggested Heights
1. On retaining walls	Chain link	4 feet
2. Boundary barricades along railroads, private property, etc.	Chain link	6 feet
3. Clothes drying yard enclosures	Chain link	4 to 5 feet
4. Principal recreation area enclosures 1/	Chain link	6 feet (more for special uses)
5. Pre-school children's play area enclosures 1/	Chain link or wood	3½ feet
6. Temporary protection of lawns and planting	Wire strand, one to three wires	2 to 3½ feet
7. Permanent protection of lawns and planting	Wire strand, as described on page 6, or chain link	2½ to 3½ feet for wire strand; 3 to 4 feet for chain link
8. Garbage collection platform enclosures	Chain link	4 feet
9. Tenant rear yard enclosures	Wire strand, as described in page 6, or chain link	2½ to 3½ feet for wire strand; 3 to 4 feet for chain link

d. Chain-link fencing, although too costly to be employed for any and all purposes, is by far the most useful type in low-rent projects. Its advantages are a fairly long life and a tight barricade where such is required. Its disadvantages lie in reported high maintenance cost in some projects (with particular reference to yard gates) and appearance when used for tenant yard enclosures. Gates are generally considered unnecessary in openings in chain link fencing around laundry-drying yards, general play areas, and garbage collection stations. However, despite maintenance considerations, gates are usually regarded as an important feature of tenant-yard fencing, if and when built. Recommended construction details for chain link fencing are given in Division 23, Site Improvements (Roads, Walks, Etc.), Guide Specifications, Bulletin No. LR-13.

1/ Refer to Bulletin No. LR-3, Part III

e. Wire-strand fencing, although sometimes extremely difficult to maintain, has been used successfully in many projects. It is often advantageous from the standpoint of appearance as well as cost, and has proved satisfactory built as follows:

Posts: 1-1/2 to 2-1/2 inch I.D. galvanized steel pipe with screw cap, or 2.7-lb. galvanized steel H or I section; posts 6 to 8 feet apart, with 2-1/2 to 3-1/2 feet exposed and 2-1/2 feet in concrete setting.

Strands: Two 1/4 to 3/8 inch, 7-wire twisted strands, at least 12 inches apart, top strand 2'3" to 3'3" above finished grade; strands strung through holes drilled in posts or, preferably, securely clamped to posts.

f. Wood fencing, employed extensively in defense and war housing, is not as sound an investment as steel fence, but may be preferred for appearance. When used (construction cost considerations not precluding its use), main connections should be bolted and the lumber should receive preservative treatment by a method that will not interfere with its being painted. Posts may be made replaceable in concrete settings.

4. REFUSE COLLECTION STATIONS

a. Scope. The following notes consist of brief recommendations on the design of refuse collection stations when and where they are to be built — without reference to site-planning considerations and without discussion of the advantages and disadvantages of these stations in low-rent projects.

b. Design Features. The principal elements of a well designed refuse collection station are:

(1) A concrete-paved platform, preferably with ridges or wood cleats on which the cans will stand, sloped to a central drain.

(2) Concrete foundation walls at least 18 inches deep and extended below frost line, with an outward projection of approximately 12 inches, as a barrier against rats' burrowing under the platform.

(3) Enclosure walls of brick or concrete, at least 3-1/2 feet high, with entrance through one end, or chain link fence and screen planting. (A wall is preferred — and one which harmonizes with building exteriors. At best, refuse collection stations detract in some degree from project appearances.)

(4) Water and sewer connections for cleaning and drainage.

Furthermore, some means should be provided, such as chain attachments to the walls, to prevent the loss of can lids.

c. Quantity of Refuse. Data on the quantities of garbage and rubbish, the main components of refuse, from low-rent projects are not as complete as might be desired. The amounts vary in different sections of the country, and every effort should be made to obtain reliable information locally, especially from any existing projects. The following are believed to be fairly representative estimates of peak quantities, suitable for checking purposes:

Garbage (bulk, unwrapped): 2-1/2 gallons, or approximately 5 pounds, per family per day.

Rubbish: 3-1/2 gallons, or approximately 1-1/4 pounds, per family per day. (Ashes not included).

Combined Garbage and Rubbish: 5 gallons, or approximately 6-1/4 pounds, per family per day.

d. Collection Station Capacity. Garbage is collected semi-weekly, if not more often, in most cities, although rubbish collection may be weekly. Having ascertained local requirements as to the separation of garbage and rubbish, knowing the collection intervals, and having made the best possible estimate on quantities (including ashes, if any), can capacity, and requisite station dimensions for varying numbers of dwellings can be computed.

Twenty-five gallon cans (18" diameter x 26" high) are suggested as the maximum size for garbage, and 33-gallon cans (20-1/2" diameter x 33" high) as suitable for rubbish, or combined garbage and rubbish. The municipal department having jurisdiction should be consulted on can sizes, however.

The collection station platform should be of ample size. A little extra floor area and a few additional feet of wall will increase cost but little, while inadequate capacity will quite certainly result in unsightly and insanitary conditions. Moreover, refuse containers last longer and involve less maintenance and clean-up of spillage, if sized for at least 25% more than peak quantities.

e. Conclusion. Refuse collection station design should be undertaken only after obtaining all pertinent information available locally concerning refuse quantities and other conditions affecting the design. Collection stations, concededly far from an ideal means of getting rid of project refuse, have caused operating difficulties on many projects, and every precaution should be taken to minimize such difficulties when this method of disposal is to be employed.

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SITE ENGINEERING

PART VII - WATER DISTRIBUTION

1. SCOPE

An ample supply of potable water is indispensable to "decent, safe and sanitary housing" built under the United States Housing Act. Water must be available at adequate pressure, as well as in sufficient quantity, for domestic consumption, fire fighting, lawn sprinkling, and incidental uses.

Urban low-rent projects are always supplied from operating water works systems and it is expected that nearly all rural nonfarm projects will be so served. Should a project be proposed in a place where there is no operating utility, decision as to source of water supply must obviously be made at the time of site selection. The responsibility of operating a water supply plant is one which the Local Authority should avoid, if possible.

Since water supply works, if any, in low-rent housing will be exceptional, these notes deal with water distribution only, and this generally is a simple engineering problem. Nevertheless, competence and attention to detail are essential in developing an efficient layout and specifying proper materials. The engineer's work often includes a check on the adequacy of the public water supply at the site.

2. EXISTING MAINS; WORKING PRESSURES

The site utility map furnishes certain information on existing water mains and working pressures needed for distribution system design. However, it ordinarily shows only the mains within or immediately adjacent to the site and, unless these lines are of ample size and are connected to nearby feeders, they may not provide an adequate supply for the project, particularly for fire protection.

In any event, the engineer must be accurately informed regarding working pressures and capacities of existing mains, and the most reliable information can be obtained by fire-flow tests made at hydrants near the site. Upon request by the Architect, the Local Authority may have such tests made by the local water works or fire department.

3. METHOD OF WATER SERVICE; METERING 1/

Local regulations, unusual rate structures, or other conditions sometimes necessitate installing a meter on the service to each dwelling unit, or to each building. Usually, however, water can be purchased at considerably less cost through a master meter by the Local Authority, than through individual meters by tenants; so the former is the method commonly employed and, for

1/ See Bulletin No. LR-11, "Selection of Utilities".

the most part, that referred to in this discussion. Generally speaking, check meters on tenants' services, when water is purchased wholesale, are not economical.

Water may be supplied (1) through a single master meter, (2) through two or more meters off different mains, with the lines interconnected for security against interruption of service, or (3) through "group meters" -- a separate meter for each group of buildings or dwellings. Under the last two methods arrangements should be made, if possible, to consolidate the meter readings and thus obtain a lower rate. In principle, the problem in each case is to determine the method of water service which, within the rate structure and any concessions negotiated, will result in minimum annual costs, water rentals, operating costs, and debt service considered. The distribution system design obviously cannot be undertaken until agreement is reached with the water department (company) as to the method of water service, and the point(s) of delivery and metering.

4. DOMESTIC WATER SUPPLY

a. Water Consumption. The average daily water consumption in public, low-rent projects varies widely with climatic conditions, type of dwelling, and habits of occupants, ranging from about 100 to 300 gallons per dwelling. For a specific project, the figure can best be based on records from existing projects (if any) in the locality, although 200 gallons is a fairly safe allowance except in more or less arid regions.

Water consumption, however, is usually not an important figure in project distribution system design. It is employed in studying the methods of water service described above, and in rare instances in considering special water storage facilities.

b. Peak Domestic Demand. Domestic water supply lines are sized to furnish the "maximum momentary demand" which may be expected to occur occasionally, due to the simultaneous opening of a number of faucets. The peak varies with local conditions such as climate, type of project, operating pressure in the mains, tenants' customs and occupations, etc., and cannot be estimated with any accuracy. Nevertheless, from data derived from various sources, Figure 1 has been prepared to show roughly, for design purposes, the maximum flows for varying numbers of dwelling units. The indicated flows are doubtless somewhat liberal for high-density projects and probably light for low-density projects in semi-arid regions, where the lawn-sprinkling demand is quite heavy. For cold-water distribution only (hot water distributed from central or group heating plants), about 25% may be deducted from the demands shown.

c. Residual Pressure.1/ For sizing domestic water supply lines, the requisite minimum pressure at the building wall must be determined for each

1/ See Bulletin No. LR-7, Part XI, "Water Supply Systems in Buildings"

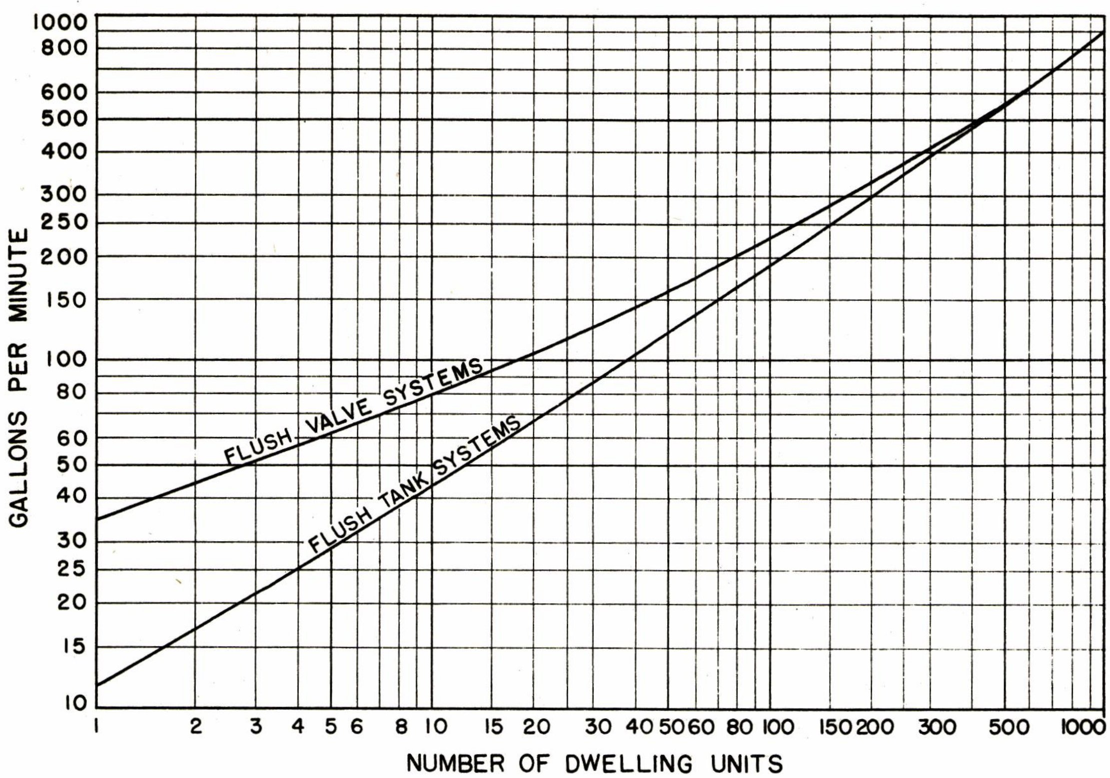

FIGURE 1 ESTIMATED PEAK DEMANDS FOR DOMESTIC WATER SUPPLY

type of building proposed. This involves decision (or agreement between the distribution system designer and the building piping designer) as to how the available pressure drop will be split up, that is, how much will be expended in the distribution system and how much within the building. It will generally be found desirable, when practicable, to supply the peak domestic demand at building walls, at not less than the following pressures:

Service to one or two dwelling units only: 25 p.s.i. for one-story buildings; 30 p.s.i. for 2-story; add 5 to 10 p.s.i. in each case for flush valves.

Single service to a 2- or 3-story building: 30 p.s.i. for 2-story; 35 p.s.i. for 3-story; add 5 to 10 p.s.i. in each case for flush valves.

Service to multi-story building: A pressure as high as feasible, that is, with negligible pressure drop in service line.

5. WATER SUPPLY FOR FIRE PROTECTION

a. Fire Flows. The flow of water required for fire protection depends on the characteristics of the project - its size, type and spacing of buildings, nature of construction, etc. - also on fire risks from adjoining properties and on the capacity of available pumpers. Subject to adjustment for these conditions, and to modification in the light of advice received from the local water department or from engineers of the fire insurance bureau in the state, the following flows may be regarded as average requirements:

Type of Project	Fire Flow (Single Fire)
Three-story apartments or combinations	750 GPM from any one hydrant 1500 GPM from any two adjacent hydrants
Two-story row houses or flats	(Same as preceding)
Single-story row houses or two-story closely spaced semi-detached houses	750 GPM from any one hydrant 1/ 1000 GPM from any two adjacent hydrants
Detached or semi-detached houses, generally	750 GPM from any one hydrant 1/

Multistory building projects are usually in metropolitan areas where requirements regarding fire flows are well established. Rural nonfarm projects may be in places having limited water supply and distribution facilities; in such cases the designer should (1) provide a degree of fire protection consistent with that generally available in the community, and (2) recognize the fire risk in spacing buildings and choosing building materials.

b. Total Fire Demand. The preceding discussion referred to the flow at any specific location. For a large project, especially one on an outlying site, the total demand for water for fire protection should be related to the size of the project. This demand can be approximated from the following table: 2/

1/ Adequate protection may be afforded by 500 GPM, especially if housing is of fire-resistant construction. However, most fire department pumpers are of 750 GPM capacity, and the supply at each hydrant should be such that a pumper cannot cause negative pressure in the mains.

2/ Based on "Table of Required Fire Flow," the National Board of Fire Underwriters' "Standard Schedule for Grading Cities and Towns."

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Approximate Number of Dwelling Units	GPM Required
250	1,000
500	1,500
1,000	2,000
1,500	2,500
2,500	3,000

c. Residual Pressure. At fire hydrants, the residual pressure at times of maximum fire flow can hardly be figured safely at less than 15 p.s.i. for engine streams. It should not be so low as to cause negative pressure at any plumbing fixtures in the project. When hydrant streams are direct, the residual pressure at hydrants should, if possible, be not less than 50 p.s.i.

d. Fire Hydrants and Hydrant Spacing. Fire hydrants in housing projects are commonly spaced 300 to 400 feet apart and, when practicable, are so arranged that every building can be reached from two hydrants with a maximum hose length of 300 feet from each. A good check on hydrant spacing may be made by noting the area served by each hydrant: it should not exceed 120,000 sq.ft. for low-density and 100,000 sq.ft. for high-density projects. (The preceding statements apply to fire protection by engine streams. For direct hydrant streams, a special determination, based on the available residual pressure, is necessary.)

To permit pumper connection by a single length of suction hose, hydrants should be located not farther than 7 feet from a surfaced roadway. However, when the roadway does not have curbing, it will be to the interest of safety to set hydrants back about 6 feet from the edge of the surfacing. Hydrants should never be located within 25 feet of the building protected; fifty feet is the preferred distance.

It is important that the local fire department be consulted regarding the type of fire hydrant and the hose-coupling thread to be specified, also the proposed locations of hydrants. Hydrants installed in housing projects usually have a 5-inch valve opening, two hose nozzles, one pumper nozzle, and 6-inch connection to the main.

6. GENERAL LAYOUT OF WATER LINES

a. Fire mains, as a rule, can best be located along streets and main drives, since that is where the hydrants are set. To facilitate repairs, they should be in the grassed area at one side of the pavement and at a generally uniform distance from the curb. An irregular layout, with mains angling here and there across yard areas, should be avoided. Preferably fire mains should be looped, in order to eliminate dead ends. Consultation with the local fire or water department regarding water main location and sizes is generally advisable.

b. Domestic supply lines should, in general, be laid out in whatever way will minimize pipe quantities, but their location must be carefully coordinated with that of other utilities -- sanitary sewers, storm sewers, and gas. For row-house projects, comparative layouts and estimates are

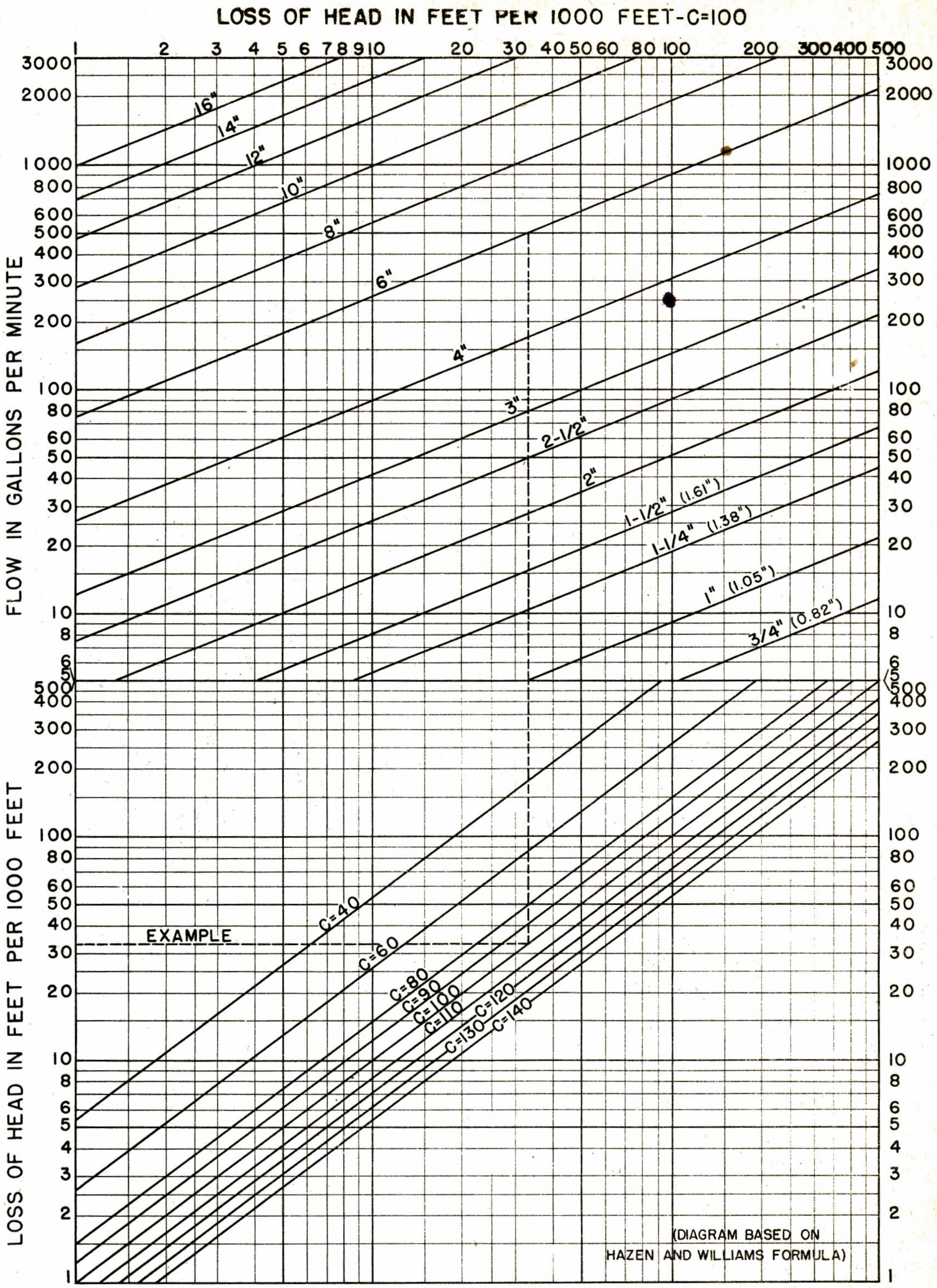

FIGURE 2. FLOW OF WATER IN PIPES

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needed to determine the arrangement of utilities that will be most economical, with building spacing and grade conditions taken into account. The various utilities should be spaced sufficiently to permit laying each in a separate trench.

7. HYDRAULIC CALCULATIONS

a. Flow Diagram. For convenient reference, a comprehensive flow diagram, Figure 2, "Flow of Water in Pipes," based on the Hazen and Williams formula, is included in these notes.

The value of the coefficient "c" to be assumed in using the diagram must take into account the probable reduction in carrying capacity of the pipe during a period of at least 40 years. While this is quite difficult to estimate, the determination must obviously be made jointly with the selection of pipe materials 1/ and it should be based on information as to how city distribution lines have sustained their carrying capacity over long periods. Such experience cannot supply conclusive evidence concerning pipe that has come into use during comparatively recent years. For the latter, the chemical analysis of the water, its aggressiveness as measured by its action on other kinds of piping, and any short-term experience will serve as guides. In any event, conservative assumptions are warranted, since water lines lose capacity from sedimentation, mineral deposits, and vegetable and animal growths, as well as from corrosion. Moreover, the coefficient must cover loss of head due to valves and fittings; and cement lining, when used, reduces appreciably the sectional area of flow. It is suggested that only where there is good evidence to the contrary, the coefficient assumed for tar-coated cast iron pipe be not higher than 80, and that for no other material be higher than 110.

b. Available Loss of Head. Pipe sizing is of course based on the available pipe-friction loss between the point of supply and that of delivery within the project. The loss is fixed by (1) the initial pressure, that is, the minimum pressure which ordinarily may be expected at the point of supply during hours of high water consumption, (2) the pressure loss through the master meter, (3) the requisite residual pressures at building walls and at fire hydrants, and (4) the pressure gain or loss due to difference in ground elevation.

c. Pressure Loss Through Meters. Figure 3, "Pressure Loss through Water Meters," shows approximate pressure losses through disc, compound and fire-service meters at different rates of flow. Compound meters are most often installed as master meters in housing projects. Meters may frequently be one size smaller than the line in which they are installed.

d. Line Sizing. It may be assumed safely that the domestic water supply demand will be comparatively light in case of a serious fire in the

1/ See paragraph 8, "Pipe Materials".

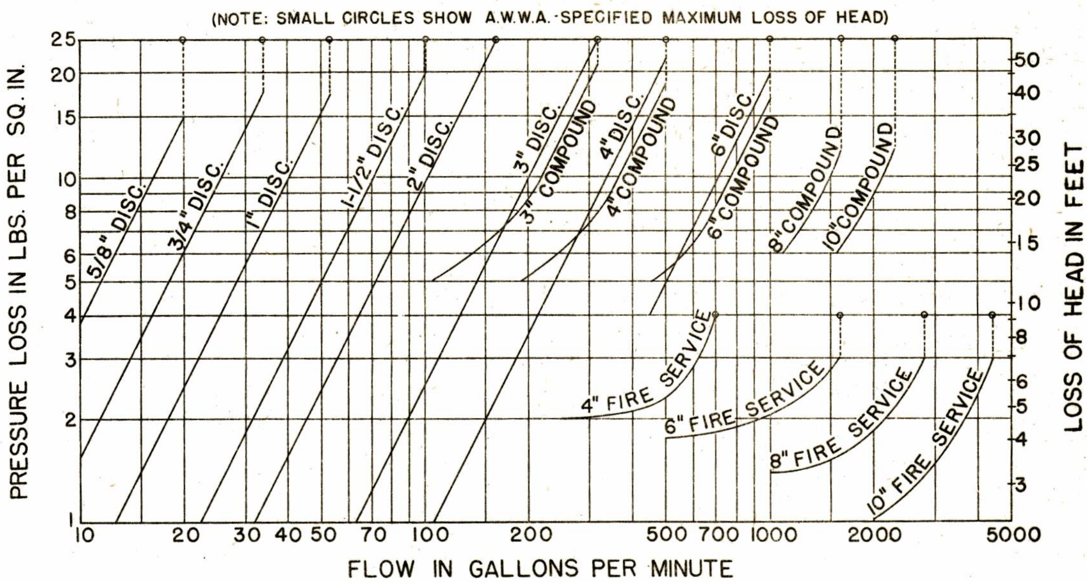

FIGURE 3. PRESSURE LOSS THROUGH WATER METERS

project; and that, for other than large projects, the average domestic demand is negligible in comparison with the maximum fire demand. Generally, therefore, mains on which fire hydrants are located may be sized for the peak fire demand; then, with the sizes of these mains known, the remaining lines may be sized for the maximum domestic demand, with no allowance for fire flow. The following is a suggested procedure for determining domestic supply pipe sizes:

(1) Select first the longest run of piping from the point of supply to a building or dwelling unit.

(2) Note the number of dwelling units served at critical points along this line and from Figure 1 find the maximum momentary demand at each such point, thus determining the maximum flows in various sections of the line.

(3) Assume pipe sizes and determine corresponding pressure drops, repeating the process until the total drop approximates the available pipe-friction loss in the line.

(4) Follow the same procedure for shorter runs in the system, but maintain reasonable uniformity in sizing.

8. PIPE MATERIALS

Obviously, underground water pipe should, if practicable, be of materials which will not require replacement for a period of at least 40 years. In

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principle, the selection of materials should be based on comparative estimates of annual costs - interest, replacement and maintenance. Practically, the most economical pipe materials are generally those which quite certainly give the longest service. Trenching and pipe laying comprise a considerable part of the total cost of the pipe installed, and a definitely superior material may add but a small percentage to total cost. It is most important to avoid a perfunctory choice of pipe materials, without thorough consideration of all available information.

Any discussion of the theory of corrosion or the various conditions (of soil and water) influencing its rate, is beyond the scope of these notes, which are confined to a brief summary of special considerations and suggestions as to practice.

a. Internal Corrosion and Incrustation. Generally speaking, soft water (1 to 60 p.p.m. of hardness), such as found in New England and along the south Atlantic coast, are quite corrosive, while harder waters are less so, the alkaline salts being precipitated to form a protective coating on the pipe wall.

(1) For water mains, cast iron pipe has been used generally in projects. The pipe has been cement-lined in some cases, but more often has had coal tar pitch coating. Tar-coated pipe is known to tuberculate rapidly with very aggressive waters. Unless local experience indicates that with such pipe the coefficient "c" will not drop below about 80 during a 40-year period, cast iron pipe with cement (or enamel) lining, or cement-asbestos pipe, may best be used. It should be practicable, economically, to specify a material for mains that will render satisfactory service for the life of the project.

(2) For services and other small-sized lines (3/4-inch up to 2-1/2-inch), the problem may be more difficult, as to both perforation and chokage. Small piping used in existing projects has, in large part, been Type K copper tubing. However, lead, brass, galvanized wrought iron, and cast iron have been laid in many cases. (The use of galvanized steel pipe for underground lines was confined mainly to war housing.)

(3) The possible effect of pipe material on the quality of the water, due to the dissolving of minute amounts of the metal (iron, lead, or copper) requires consideration in some cases. Protection against iron discoloration ("red water"), where such protection is necessary, can be had by cement lining. Lead pipe should be specified only when local experience or experiment has proven that it can be used safely, since lead may be picked up by very soft waters high in carbon dioxide and its salts are very poisonous. (U.S. Public Health Service Drinking Water Standards state that lead present should not exceed 0.1 p.p.m.). Copper also may be attacked by soft, acid waters. The amount of metal dissolved is unlikely to approach the 3.0 p.p.m. permitted under U.S.P.H.S. standards, but a much smaller quantity may be objectionable in staining fixtures and laundry, also in causing perforation of the tubing.

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b. External Corrosion. This topic refers mainly to soil or galvanic corrosion, as electrolysis is seldom a problem in piping laid within project sites.

(1) Resistance to Corrosion. Extensive tests have shown that: (1) the commonly used ferrous pipe materials do not differ greatly in their resistance to soil corrosion; (2) the rate of pitting, however, decreases with time -- hence additional thickness of metal adds, in greater than direct ratio, to the life of the pipe; (3) in most soils, copper and red brass (85% copper, 15% zinc) corrode much more slowly than do iron and steel, and the corrosion is more uniform; (4) wet, organic soil in which sulphites are present is especially corrosive to copper; and (5) lead generally corrodes more rapidly than copper but more slowly than ferrous metals.

Soil corrosion, like internal corrosion, should seldom be a serious problem with water mains, since the wall thickness of the pipe (if cast iron) is sufficient under ordinary conditions to withstand pitting for a long period. With services and other small domestic supply piping, wall thicknesses are less and the possibility of complete penetration is much greater.

(2) Conditions accelerating soil corrosion include variation in moisture content and in soil characteristics, and dissimilarity of materials (electrically connected). An example of the latter is copper tubing connected, without insulating coupling, to cast iron pipe. Corrosion of the iron will be accelerated. However, when the copper (cathodic) area is very small in comparison with the iron (anodic) area, e.g., a brass valve in a ferrous service line, the corrosive effect may be slight.

(3) Cathodic Protection. 1/ When the soil at the project site is known to be corrosive, the Local Authority may well retain a corrosion engineer to (1) advise regarding gas and water distribution system materials, (2) determine whether cathodic protection is necessary and, if so, (3) decide whether for the gas system only or for both gas and water, and (4) design and supervise the installation of the cathodic protective system.

Cathodic protection of water lines will become far more important, should emergency regulations prohibit the use of copper pipe. Although the cathodic protection may not be installed until some time after general construction is completed, the possible need for it must be foreseen when the distribution system is installed, so that jumper wires can be provided around cast iron pipe joints, and the project piping can be insulated from the public water works system.

c. Local Experience. The corrosion of underground water lines, internally and externally, is caused by numerous interrelated factors, and it is impossible to predict with accuracy the effect of a given water or soil on

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1/ See Bulletin No. LR-7, Part V, "Safety Considerations in the Installation of Gas Piping."

different pipe materials. However, the city water works system is in effect a laboratory in which various kinds of piping have been tested, often over long periods, and the results of such tests should comprise the most reliable guide in the selection of pipe materials. This is not to imply that local practice should be followed perfunctorily, that all pipe materials will have been tried out adequately, or that recommendations received may not be influenced by personal preferences. Expert interpretation of results may be needed, with attention to special soil conditions at the site, and to possible future changes in local water purification methods.

A few Local Authorities have initiated corrosion detection and control programs and may have formed sound opinion as to the kinds of water piping that should be installed for additional projects.

9. DISTRIBUTION SYSTEM APPURTENANCES 1/

a. Meter Installation. Master meters are provided sometimes by the water department, sometimes by the Local Authority; in either case, the installations must meet water department requirements. Master meters should have by-passes and, if service is through two or more meters at different points in the project and with interconnecting lines, a check valve should be provided at each meter. Meters are occasionally located in building basements, but more often in concrete vaults. Vaults should be drained by a pipe leading to the ground surface nearby or to a storm sewer (if there is no possibility of backwater); or a dry well may be provided.

b. Valves. Valves (including stops) are recommended (1) at intervals of not more than 800 feet in all mains, (2) in branch lines near their points of take-off from larger lines, and (3) in all services. As a rule, valves in hydrant branches may be provided or omitted, according to local practice, but they should be installed wherever hydrants are connected to important feeders or are so located as to be particularly subject to accidental damage by traffic. A uniform position of valves throughout the project --for example, in line with curbs, street sidewalks, or buildings-- should be maintained.

10. PROTECTION OF WATER SUPPLY

Since water for low-rent housing projects is obtained almost always from public water works, it may be assumed to meet local health department standards and to be safe and potable. While the possibility of its becoming contaminated within the project distribution system may seem negligible, water mains are not necessarily always under pressure and they cannot be kept absolutely watertight, especially at joints. The following precautionary measures are, therefore, recommended:

1/ See "Fire Hydrants and Hydrant Spacing," paragraph 5d.

a. Design Measures. These consist of requirements to be incorporated in the drawings and specifications.

(1) Lay water lines and sewers generally in separate trenches and keep the trenches well separated.

(2) In the event sewer and water lines must be laid in the same trench, bench the water piping on undisturbed earth well above the sewer and make the sewer water-tight.

(3) Lay water lines, so far as practicable, at a higher elevation than sewers; provide adequate support where one line spans the trench of another.

(4) Avoid using stop-and-waste cocks; in any event, do not install them below ground water level or at less than adjudged safe distance, soil conditions considered, from a sanitary sewer.

(5) Avoid any direct connection between the water distribution system and the sanitary sewer system. (This refers to water connections to flush tanks, sewage pumps, etc., and sewer connections to meter vaults, fire hydrant drains, etc.)

(6) Size fire mains large enough to deliver, under positive pressure, the maximum draft that will be imposed on them by fire department pumpers -- this to obviate the possibility of polluted ground water being drawn into the mains through minute leaks.

(7) Use sterile yarning material; if braided hemp, sterilize it on the job. Do not use jute.

(8) Provide for thorough flushing and effective sterilization of the distribution system after completion.

b. Precautionary Measures in Distribution System Installation. These are covered in Division 24, "Utilities (Sewers, Water and Gas)", of the Guide Specifications, Bulletin No. LR-13. They include all customary precautions to keep pipe and appurtenances reasonably free from dirt and trench water while they are being installed.

c. Health Board Regulations. The drawings and specifications for the water distribution system should, of course, comply with state or other health board requirements and any requisite approval be obtained.

SITE ENGINEERING

PART VIII - GAS DISTRIBUTION

1. APPROACH TO DESIGN

Gas main extensions in urban areas can seldom be sized with precision since population growth and future uses of gas are extremely difficult to foresee. It is considered better practice to install pipe a little larger than necessary than risk its proving too small. In public low-rent housing, however, the situation is somewhat different: the exact number of families to be housed is known and the uses of gas are predetermed. From this basic knowledge a reasonable approximation of the peak demand is possible and a closer determination of pipe size is warranted. Gas lines must be sized amply as a safeguard to life and property, but wasteful overdesign avoided.

The method herein recommended for sizing gas distribution system piping is described in some detail, since engineering reference books contain little directly usable material on the subject. The gas-flow diagrams supplied are like hydraulic tables and diagrams, in that they obviate the need for detailed computations.

The sizing of mains, however, is but one feature of the preparation of drawings and specifications for gas distribution systems. The task should not be performed perfunctorily, as careful study and investigation are required in many details. The principal points to be considered, together with recommended practice, are outlined in these notes which refer to piping for natural and manufactured gas distribution. (A forthcoming bulletin will deal with liquefied petroleum gas installations.)

2. EXPLANATION OF TERMS

a. Gas distribution pressures are classified as follows:

Low -- up to about 15 inches of water colums, generally 3 to 9 inches (one inch of water column equals 0.578 oz. per sq. in.)

Intermediate -- from 1 lb. to approximately 15 lbs. per sq. in.

(High pressure mains, which generally carry pressures of 50 lbs. per sq. in. or more, are not used in public housing projects.)

b. The specific gravity of gas is the ratio of its weight to that of air, with air at 1.00. Manufactured gas generally has a Sp. Gr. of from 0.40 to 0.70; natural gas from about 0.55 to 0.65 for "dry" gas, and 0.65 to 0.85 for "casinghead" gas. The capacities of meters and regulators, and the flow of gas through piping, vary inversely with the square root of the

Sp. Gr. of the gas. Thus, with equipment capacity ratings based on 0.60 Sp. Gr., factors such as follow should be applied to the ratings:

For Sp. Gr. of 0.45, a factor of 1.15
For Sp. Gr. of 0.85, a factor of 0.84

c. The heating value of gas is expressed in Btu per cubic foot at 60° F, and 30 inches of mercury. The heating value of manufactured gas in the United States ranges roughly from 400 to 600 Btu and that of natural gas from 900 to 1200 Btu per cubic foot.

d. One therm equals 100,000 Btu.

3. METHOD OF GAS SERVICE 1/

a. Wholesale Purchase. The gas supply for public housing projects is usually obtained by wholesale purchase, the utility company delivering the gas at a metering station or stations located near the border of the site. These notes apply mainly to that method of service.

b. Number of Connections. Gas may be supplied through a single connection, with its master meter or meters, or through several independent connections - one for each block or group of buildings. Where there are existing gas mains in various abutting streets, the "group-metering" method may result in considerable saving in initial cost. However, unless meter readings can be consolidated, the resultant higher gas cost may far outweigh the possible saving in first cost. A centrally located point of delivery will minimize project distribution system costs, but no one existing main may be of sufficient capacity to deliver the entire supply at a single point.

c. Service Contract. The service contract with the utility company will stipulate (1) the point or points at which gas will be delivered, (2) the maximum and minimum pressures that will be maintained on the project side of the meters at the delivery point, and (3) the minimum Btu content of the gas. This information is prerequisite to distribution system design.

4. LOW-PRESSURE vs. INTERMEDIATE-PRESSURE DISTRIBUTION

Intermediate-pressure distribution (Generally available with natural gas only) permits using much smaller piping than for low-pressure, whereas with the latter no pressure regulators are required and there is less possibility of gas leakage. In general, intermediate pressure (where it is available at the site) gives a much more economical installation in low-density projects, while low-pressure distribution may be preferable for high-density projects. Further, the smaller mains which can be used with intermediate pressure cost less to protect cathodically against corrosion.

1/ See also Bulletin No. LR-11, "Selection of Utilities"

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5. LAYOUT OF MAINS AND SERVICES

a. The radial system of distribution provides for the flow of gas by one route only. It results in the most direct runs of piping from the point of supply to the buildings served and, therefore, in lowest costs.

b. The loop system permits gas flow by two or more routes. Secondary distributors are sometimes connected at each end to a main distributor. Looping tends to provide slightly greater security of service by absorbing high unbalanced demand and by maintaining a supply of gas by one route, should that from the other be cut off. However, a main distributor virtually encircling a project, and sized to supply practically the entire peak demand through either leg, is wasteful and unnecessary, especially in low-pressure distribution.

c. Coordination with Other Utilities. The location of gas lines must be coordinated carefully with that of other utilities -- water, sanitary sewers and storm sewers. For row-house projects, comparative layouts and estimates are needed to determine the arrangement that will be most economical, building spacing and other conditions taken into account.

d. Separate Trenches for Gas Lines. Gas piping should not be laid in the same trench with any other utility. Leaking gas, if any, may enter sewers and sewer manholes, endangering the life of maintenance men and causing fire or explosions. Further, gas may seep through backfilled earth in trenches for considerable distances; when the gas lines are laid in separate trenches, adequate precautions can be taken to prevent such seepage from entering basements or crawl spaces. 1/

6. PEAK-HOUR GAS DEMAND FOR COOKING, WATER HEATING, AND REFRIGERATION

a. The peak demand for gas varies with climate, customs, occupations, etc., and is not susceptible of accurate estimate. Some gas companies have done considerable research on demand rates, and their practice should be a reliable guide in project design in their localities. For use elsewhere and for checking purposes in any case, Figure 1, based on information obtained from numerous sources, shows approximate peak loads for varying numbers of dwelling units and different uses of gas (except space heating). Although the loading is expressed in peak-hour rates, the maximum rate of demand may occur for only a few mintues.

b. Appliance ratings, on which the peak demands shown in Figure 1 are based, are noted on the diagram. They are approximate averages for appliances of different makes. Variations from them will ordinarily not affect pipe sizing.

1/ See Bulletin LR-7, Part V, "Safety Consideration in the Installation of Gas Piping."

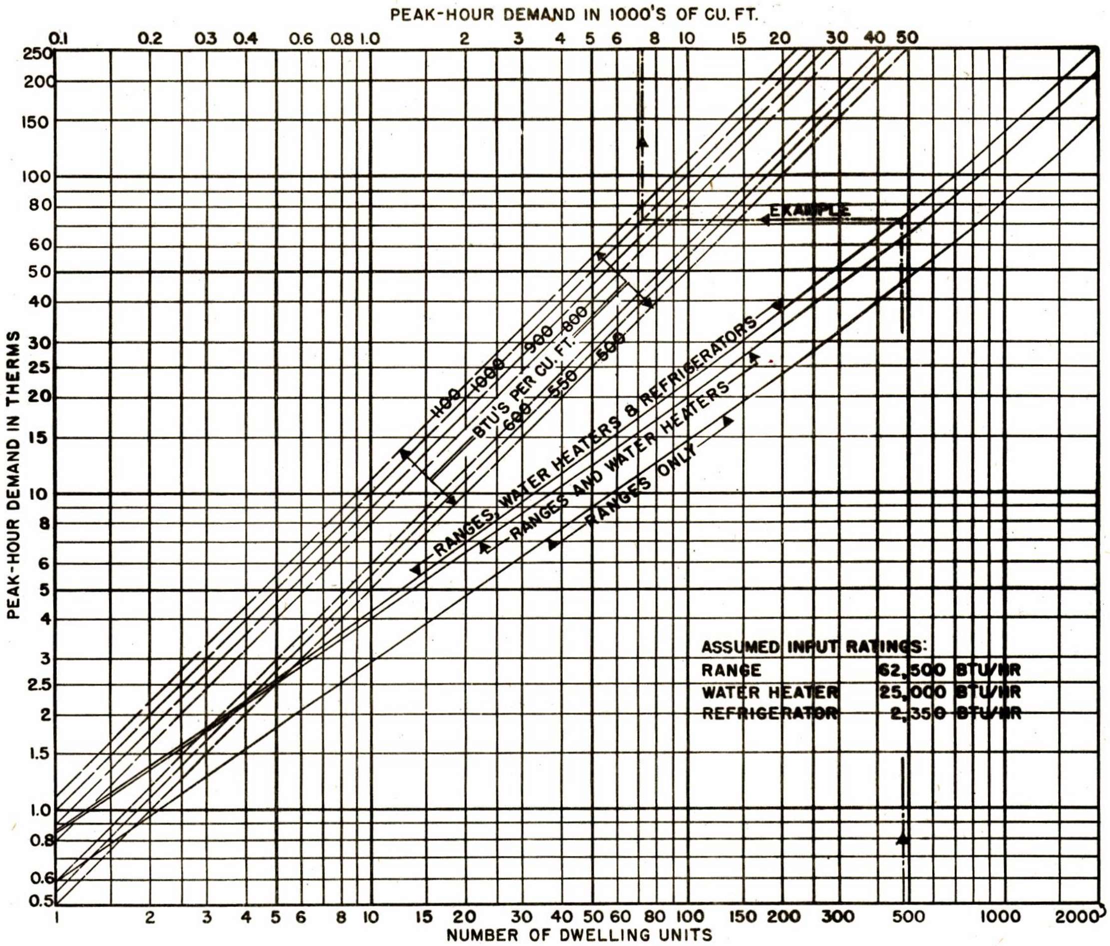

FIGURE I PEAK-HOUR GAS DEMAND FOR COOKING, WATER HEATING AND REFRIGERATION

c. Range Ovens for Space Heating. The demands derived from Figure 1 can be considered to include but little allowance for the incidental use of ovens for space heating. If dwellings will be "tenant-heated" and gas for cooking "management-supplied," some allowance should be made for this possible extra demand.

7. PEAK-HOUR DEMAND FOR SPACE HEATING

It must be assumed that in extremely cold weather practically all space heating appliances will be operated simultaneously during early morning hours. However, it is extremely improbable that the peak heating load will occur simultaneously with the peak cooking load, except possibly in very small groups of units. It is recommended, therefore, that the combined peak-hour demand be determined (1) by applying the percentages noted below to the

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total of the input ratings of connected heating appliances, and (2) by adding to the peak-hour load for heating, so determined, that for other uses of gas as derived from Figure 1 (or as otherwise estimated):

Number of DU's	Percentage of Total Input Ratings of Heating Appliances
1	100%
10	90%
100	85%
1000	80%

Obviously the designer must be informed as to the input ratings of all space heating appliances to be installed, including those in community facility buildings. The input ratings of gas-fired space heaters in low-rent projects vary from about 30,000 to 45,000 Btu, those of gas-fired furnaces from 60,000 to 80,000 Btu, per dwelling unit.

8. AVAILABLE PRESSURE DROP

a. Residual Pressure. The available pressure drop to be used in pipe sizing is, of course, the guaranteed delivery pressure on the project side of the master meter less the requisite residual pressure at the building wall (or house regulator). For intermediate-pressure distribution, a minimum pressure of 2 lbs. per sq. in. at the house regulator is recommended. For low pressure distribution, the minimum desirable pressure at the building wall may be determined as follows:

	Inches of Water Column	
	Manufactured gas	Natural gas
Minimum pressure at appliances	2.3*	4.6*
Pressure drop in building piping	0.3	0.3
Pressure drop through check meter	0.5	0.5
	3.1	5.4
or approximately	3	5 1/2

* These figures should be checked against local practice in adjusting appliances.

b. Differences in Ground Elevation. Gas pressure increases roughly 0.1 inch of water column for each 15 foot rise in elevation. Obviously this has a measurable effect solely in low-pressure distribution; and only in multi-story buildings, or in the unusual case of buildings being materially lower than the point of gas supply, need the factor be taken into account.

9. GAS-FLOW FORMULAS

With the exceptions noted below, the gas-flow diagrams, Figures 2 and 3, are based on the Spitzglass formulas for "end-to-end" flow of gas in pipes:

(1) for low pressures (not exceeding 1 lb. gage):

$$Q = 3550\ K \left(\frac{h}{SL}\right)^{\frac{1}{2}}$$

(2) for intermediate and high pressures (exceeding 1 lb. gage):

$$Q = 4830\ K \left(\frac{Pa}{SL}\right)^{\frac{1}{2}}$$

in which:

Q is the quantity of gas in cu. ft. per hour, at 30 inches mercury and 60 degrees F.

K is a constant based on the pipe diameter (see below)

h is the pressure drop in inches of water column

P is the pressure drop in lbs. per sq. in.

a is the average pressure (absolute) in the pipe line, in lbs. per sq. in. (absolute pressure in gage plus atmospheric; latter is 14.7 p.s.i. at sea level

S is the specific gravity of the gas

L is the length of pipe in feet

K is equal to $\left(\frac{D^5}{1 + \frac{3.6}{D} + 0.03D}\right)^{\frac{1}{2}}$

D is the actual internal diameter of the pipe in inches.

For low pressures, however, the "Pole" formula was used for pipe sizes larger than 4-inch, since in those sizes it gives more conservative results than the Spitzglass formula. The Pole formula (symbols as above) is:

$$Q = 2338 \left(\frac{D^5 h}{SL}\right)^{\frac{1}{2}}$$

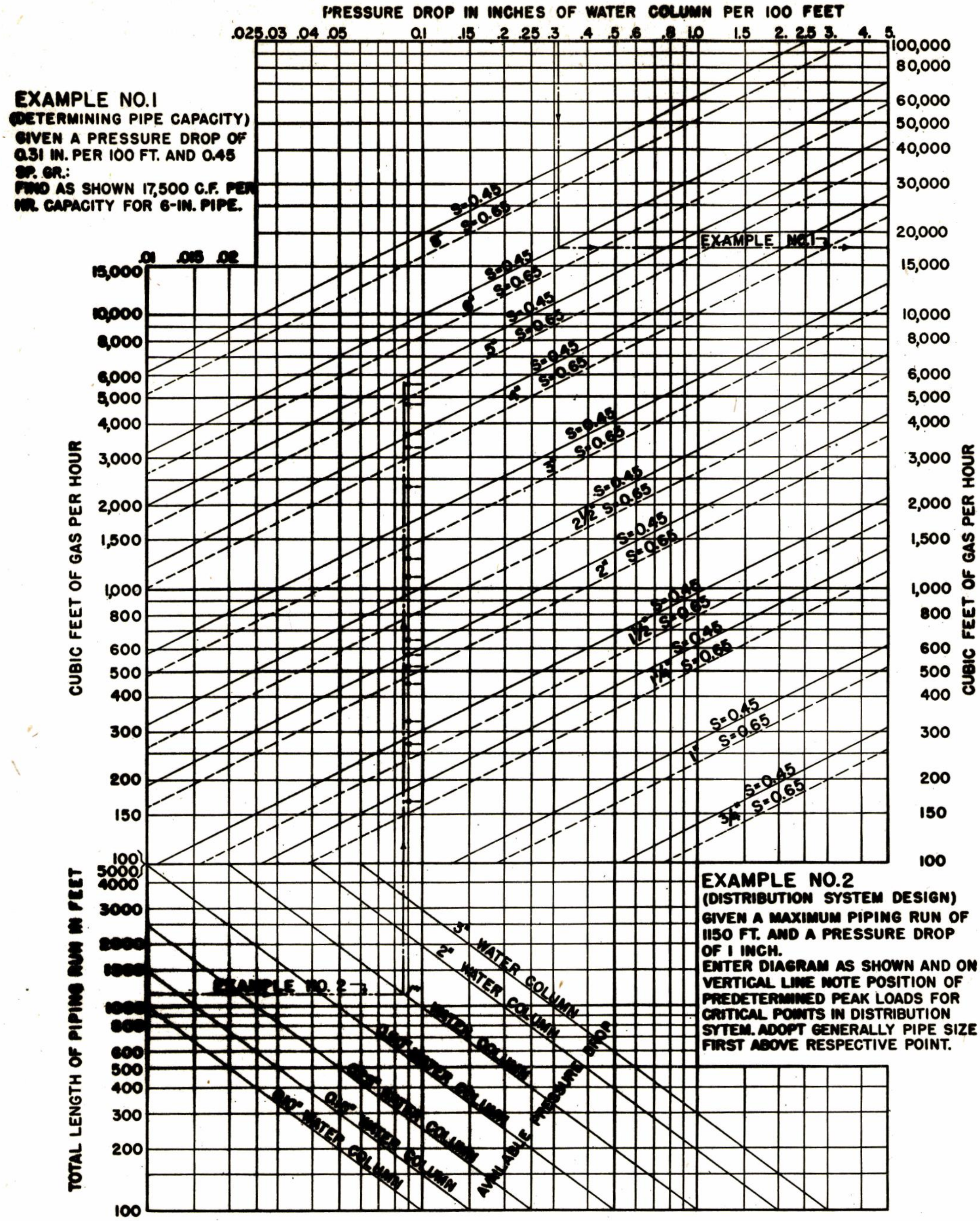

FIGURE 2 GAS LINE SIZING DIAGRAM-LOW PRESSURE

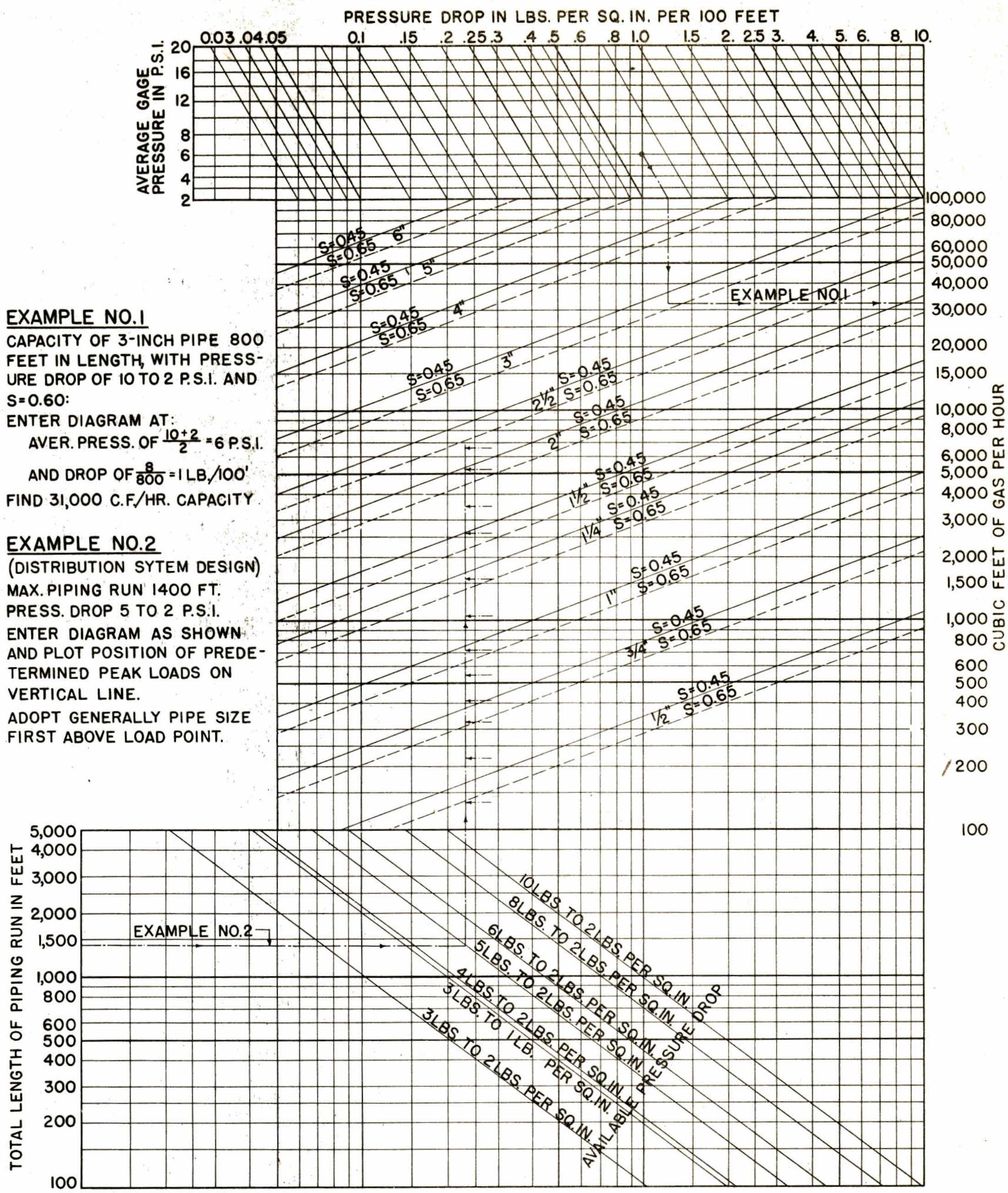

FIGURE 3 GAS LINE SIZING DIAGRAM - INTERMEDIATE PRESSURE

10. PIPE SIZING

a. Gas-Flow Diagrams. Figure 2 is for low-pressure distribution, Figure 3 for intermediate. Example No. 1 in each diagram shows the solution of a simple gas-flow problem, and Example No. 2 illustrates the practical use of the diagram in distribution system design.

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b. Procedure. Following is a recommended rational procedure for distribution system pipe sizing:

(1) Determine as described above, the available pressure drop in the system.

(2) From Figure 1, and with adjustment for space-heating appliances if any, determine the peak gas demands above all "critical points" (principal junctions of lines, etc.) in the system, thus determining the flow for which each line should be sized.

(3) Select first the principal (and preferably the longest) run of piping in the system and, proceeding as illustrated in Example 2 in each diagram, read off pipe sizes for every section of the line.

(4) (Optional) Increase slightly the diameters thus determined for piping near the point of supply and decrease those toward the upper end of the line. Compute pressure drop section-by-section, readjust sizes if necessary, and recompute, until the total drop approximates that available. (This step tends to give more uniformity in the computed sizes of branch lines. The procedure corresponds to that usually employed in sizing water lines.)

(5) Note the "remaining pressure drop" at each of the above-mentioned "critical points," thus fixing the available pressure drop for each branch.

(6) Size the branch lines in the same general way as the principal line.

c. Sizing Looped Lines. It was previously noted that loops may serve to absorb unbalanced demand and maintain a supply of gas from one end of the loop, should that from the other be cut off. To insure fulfilment of the latter function, the following procedure in pipe sizing is suggested:

(1) Find by inspection the approximate location of the "point of no velocity" in the loop.

(2) Size each leg as though it were an independent line.

(3) Increase the size of the intermediate part of the loop so that, with a load approximating 50% of the peak, service can be maintained through either leg.

11. PIPE MATERIALS; CORROSION CONTROL

It is obviously desirable that the project distribution system be installed so as to serve without extensive replacements for a period of at least 40 years.

In most projects this can be accomplished, practicably and economically. Gas leakage with its attendant hazards can be minimized and general relaying of lines (with resultant damage to site improvements and inconvenience to tenants) can be avoided.

The principal problem is that of controlling soil corrosion, and the solution lies in proper pipe coating and, in many instances, in cathodic protection.

This bulletin contains no discussion of the theory of soil corrosion, the characteristics of corrosive and non-corrosive soils, or the design of cathodid protection systems. 1/ It outlines, rather, certain steps to be taken, in connection with gas distribution system design, to gain effective corrosion control.

a. Determination of Soil Corrosivity. It is essential, first, to ascertain the degree of corrosiveness of the soil at the project site. From the local gas company the engineer should be able to obtain valuable information concerning the lasting qualities of different pipe and coating materials in local soils, although the possibility of exceptional conditions at the site, particularly as regards the ground water level, old fills, etc., should be considered. Further, unless such investigation indicates strongly that soil at the project site is not corrosive (or only mildly so) electrical resistibility tests should, if practicable, be made at intervals over the area. Information so obtained serves the following purposes.

(1) Aids in determining the kind of pipe coating to be applied.

(2) Indicates whether cathodic protection is necessary. (Generally needed if electrical resistivity is less than 3000 ohm-cms.; may be needed for higher values.)

(3) Indicates, in case cathodic protection is necessary, whether a sacrificial anode system will be satisfactory or a rectifier system should be installed. (Latter advisable for electrical resistivity of more than 4000 ohm-cms.)

(4) Shows, if a rectifier system is needed, the area or areas of lowest resistivity, where the ground beds can best be installed. (It is desirable that these be at least 150 feet from the piping to be protected.)

(b) Corrosion Engineering Services. When the distribution system will be laid in corrosive soil, the Local Authority should, as a general rule, obtain competent corrosion engineering advice at an early stage of the project planning. The services (not a part of those rendered under the Architect's Contract), which a corrosion engineer can perform, include (1) making the above-mentioned resistivity tests, (2) supplying expert advice on the need

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1/ See Bulletin No. LR-16, "Corrosion of Underground Piping (General Treatise)."

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for cathodic protection, (3) determining the type of protective system (galvanic anodes or rectifier), if any, to be provided, (4) checking on available and suitable locations for anodes, and (5) advising regarding pipe materials and coatings. (These services may cover both the gas and water systems.) Further, if a cathodic protection system is found advisable, the corrosion engineer can design it (after project construction) and supervise its installation. Moreover, he can train management personnel in its inspection, testing and maintenance.

In the case of very small projects, the employment of a corrosion engineer during the project-design stage may not be considered entirely necessary, even though the soil on the site is known to be corrosive. In such instances, the utility company may be able to make preliminary soil tests and furnish a report; otherwise, the tests can be deferred until the completion of project construction. In the latter event, specifications for the underground piping and coating will necessarily be based on general local experience, and the piping installation should be adapted to cathodic protection. The protective system, if and when later determined necessary, can be designed and installed at such time.

c. Pipe Material. This discussion is predicated on the use of steel pipe, since that is the material generally specified for underground gas lines in public housing projects. Steel costs less than cast iron and copper, and is safer against fracture than cast iron. Moreover, in most projects, the major part of the piping is small-size, not obtainable in cast iron; further, the development of cathodic protection has worked to the advantage of steel pipe. Nevertheless, the fact that the Guide Specifications 1/ cover steel only is not to be construed as a recommendation against the other materials, which generally have a longer life than steel without cathodic protection. Cast iron pipe, however, should not be laid in unstable ground, nor copper in cinders or wet organic soil.

d. Pipe Coating. The amount and kind of pipe coating required on steel pipe depend on soil corrosivity and mechanical soil action (soil stresses). For extraordinarily severe conditions the covering may be such as follows: 1/16" enamel, glass wrap, 1/32" enamel, tar-impregnated felt, 1/32" enamel, and kraft paper, respectively. On the other hand, in alkaline soils of very high electrical resistivity, bare steel pipe may last indefinitely. Most engineers, however, prefer some sort of coating under practically all circumstances. Ample protective covering is particularly desirable for service lines, since these have less wall thickness than mains and they are generally laid close to the surface, where they are more liable to attack due to surface water (from lawns and roofs) percolating through the soil.

The Guide Specifications cover but two types of coatings: (1) factory-applied bituminous enamel with tar-impreganted felt and kraft paper (the latter to protect the coating and to show up damage in handling), and

1/ Bulletin No. LR-13.

(2) a field-applied, coal-tar-base coating. However, there are various other more or less widely used protective coverings on the market, and specifications may be drawn in the light of local experience, with special regard to possible coating damage from soil movement. It is preferable to avoid reference to proprietary products. Field-applied coating is likely to be more practical than factory wrapping for very small projects, requiring limited quantities of pipe.

There is no unanimity of opinion as to the coating that should be used in connection with cathodic protection. Some engineers consider bituminous enamel with one layer of asbestos felt, or glass wrap, sufficient. A good degree of insulation is desirable to minimize the electrical energy required for the protection and increase the life of sacrificial anodes.

e. Protection of Pipe Coating. The Guide Specifications include the customary requirements for uniform bearing for pipe, refilling with sand the trench bottoms cut in rock, care in pipe handling, careful backfilling around pipe, etc., all directed toward preventing damage to the pipe coating and obtaining an even distribution of earth pressure against the coated surface. The enforcement of all such requirements is most important.

f. Adapting the System to Cathodic Protection. Unless local experience or resistivity tests prove, beyond doubt, that the gas distribution system will be laid in non-corrosive soil, the system should be installed to facilitate cathodic protection. The requisite measures (covered in the Guide Specifications) include: (1) insulation of the system from the gas company supply main, (2) provision of jumper wires around mechanical couplings or other joints that do not provide electrical contact, and (3) installing insulating couplings in service lines at buildings (unless both gas and water systems will be cathodically protected). The cost of this work is negligible in comparison with the expense of doing it at a later time.

12. DISTRIBUTION SYSTEM APPURTENANCES

a. Master Meter and Regulator Station. The master gas meters and the pressure regulators (if any) on the main supply are usually provided by the gas company. Housing for the equipment is sometimes provided by the company, sometimes by the Local Authority. The housing, whether it consists of a separate building or of a utility room or rooms in the project, should be of fire-resistant construction with special provision for ventilation. Meters and regulators should be of ample capacity.

b. Valves and Cut-Offs. Valves are little used in low-pressure mains because the flow of gas can be stopped effectively and easily by means of bags or stoppers. They may be provided, however, in small secondary distributors near their point of connection to mains. In intermediate-pressure lines, valves are recommended (1) at convenient intervals in loops, and (2) in secondary distributors at their points of connection to the mains. A stop should be provided in each service, whether low-pressure or intermediate pressure, at a point where it will be accessible in case of fire.

c. Service Regulators. Service (or house) regulators, as needed in intermediate-pressure systems, may generally be placed to serve two, four or more dwelling units. However, careful check should be made of the manufacturers' recommended working capacities of the regulators against the maximum rate or gas demand. It is important that the specifications state accurately the requisite capacities and pressure reduction for the regulators required.

d. Drip Pots. To prevent accumulation of condensate which will obstruct the flow of gas, distribution lines for manufactured or mixed gas should be sloped to drip pots at low points. Gas services also should be sloped, if possible, so that condensate will flow back to the mains. Otherwise, a drip pipe, outside the building or in the basement (if any), should be provided.1/ In natural gas systems, drips should be provided at a sufficient number of low points to permit blowing out all lines.

13. LOCAL PRACTICE

While the responsibility for the efficient planning of the gas distribution system lies with the engineer, the advice of local gas company officials on various matters should be obtained. The company's experience under actual conditions of soil, climate and gas characteristics will be most valuable, and its practice concerning various details can often be followed to advantage. Following is a summary, in part covering points mentioned in the preceding pages, of the information which it is generally desirable to obtain from the local company.

(1) Description, including rated working capacities, of the master meters and regulators which the company proposes to install for serving the project.

(2) Specific gravity of the gas.

(3) Peak-hour gas demand data, if any available; extent to which range ovens are commonly used in the locality for incidental space heating.

(4) Corrosivity of local soils; experience with different pipe coverings.

(5) Type of joints currently used in steel pipe of different sizes.

(6) Minimum pipe size used for house services.

(7) Depth to which mains and services are laid.

1/ Failure to observe this design precaution was a contributory cause of an explosion wrecking a multi-family building in a low-rent project.

(8) Pressure for which appliances are customarily adjusted.

(9) Practice as to provision of drip pots in intermediate-pressure mains; design of drip pots.

(10) Makes of service regulators employed (if any are to be used in the project); minimum pressure maintained at service regulators.

The preceding is in addition to the information to be set forth in the contract for gas service, namely, (1) the point or points at which gas will be delivered, (2) the maximum and minimum pressure of supply to the project, and (3) the minimum Btu content of the gas.

SITE ENGINEERING

PART IX - SANITARY SEWER DESIGN

1. GENERAL

A water-carriage system of sewerage is recognized as necessary for "decent, safe and sanitary dwellings" constructed under the United States Housing Act. The need has been met generally, in completed projects, through connection to public sewerage systems, although in occasional instances other means of sewage disposal have been employed. Experience has shown that if public sewers are not available, the sewage disposal problem should be solved at the time of site selection: a feasible method of disposal, acceptable to local health authorities, must be found and adopted if the site is to be utilized.

This discussion comprises, first, some observations regarding alternative methods of project sewage disposal, noting points to be investigated during site selection and project planning; and, second, an outline of recommended bases of sanitary sewer design, together with suggestions derived from project maintenance experience.

2. PROJECT SEWAGE TREATMENT PLANT

Rarely have permanent public housing projects been built on sites where "project" sewage treatment plants were required, although this method of sewage disposal was of necessity widely used in the war housing program. It may be necessary to employ it for some rural nonfarm, if not urban, projects under the current program. However, the method involves relatively high initial cost and operating expense and, generally speaking, can be justified only for a site which, lacking public sewerage facilities, otherwise possesses remarkable advantages. If and when such a site is considered for acquisition, an experienced sanitary engineer should be retained and information obtained as to the type and cost of a sewage treatment plant which will meet the approval of local health authorities. Design of the plant should also, if the site is selected, be entrusted to a competent sanitary engineer.

3. SUBSURFACE SEWAGE DISPOSAL

Sewage from a few projects has been disposed of by means of small septic tanks and tile beds, each installation serving a single dwelling or, more often, a group of three or four units. The results have been generally unsatisfactory, notwithstanding successful use of the method for private houses in the same localities. In varying degrees, the fault apparently has lain in inadequate soil investigation, inadequate space for tile beds, and tenants' carelessness.

Nevertheless, consideration may occasionally be given to sites, especially for rural nonfarm projects, that have outstanding merit, but no public sewerage facilities. In any such instance, it is strongly recommended that: (1) subsurface sewage disposal be considered only for a very small project - so small that a project treatment plant would be too costly to build and operate; and (2) the method be adopted only after competent engineering investigation, and when soil percolation tests, topographic conditions, and ground water levels, indicate strongly that the method will prove satisfactory and there will be no possibility of contaminating any water supply, public or private. Prior approval of the method should be obtained from local health authorities.

4. CONNECTION TO PUBLIC SEWERAGE SYSTEM

Sanitary sewers available at public housing sites are usually adequate to serve the projects. (A few exceptions, not discovered or fully recognized before project completion, have caused serious difficulty in the past.) Reliable answers to the following questions should be obtained at the time of site selection and verified during project design:

a. Are existing sanitary (or combined) sewers of sufficient capacity and in satisfactory condition to receive project sewage?

b. Are existing sewers deep enough to serve the entire site by gravity flow? If not, from what portion of the site must sewage be pumped or buildings excluded?

c. If existing sewers require extensions or other improvements in public streets, what part (if any) of the cost must be borne by the project?

d. If public sewers are available only at some distance from the site, will it be economically feasible to provide the necessary connections to them?

Project sewage should be discharged into a public sewerage system unless the cost is prohibitive. Only under extraordinary circumstances should the local authority assume the responsibility and expense of sewage disposal by any other means.

5. TYPE OF SEWERAGE SYSTEM

When storm water drains are required, the type of system, "separate" or "combined", to be constructed in the project will generally be that in use locally. However, if the municipality is working toward separation of sewage from storm water, public interest may be better served by paying the necessarily higher cost of separate sewers, even though public sewers at the site are of the combined type. This is a matter for special determination. A separate system of sewers within a project may afford better protection against sewage backing up into basements.

6. MAXIMUM RATE OF SEWAGE FLOW

While water supply systems must be capable of meeting the maximum momentary demand, sanitary sewerage systems have an impounding capacity which levels off all minor peaks. (The cubic contents of the sanitary sewers in a project may equal the average sewage flow for a period of 3 hours or more.) Thus, the maximum rate of sewage flow is much less than the maximum momentary demand for water, except in the case of very large groups of dwellings.

The sewage flow consists not only of domestic sewage, but of infiltration and surface water entering the sewers around manhole lids or elsewhere. While, in general, there should be no storm water connection to sanitary sewers, it is preferable, if municipal regulations permit, that garbage collection platform drains connect to sanitary sewers rather than to storm sewers.

Recommended design rates of flow in sanitary sewers serving public low-rent housing projects are as follows:

from 400 gallons per capita per day, or approximately 0.25 cu.ft. per second per 100 DU's, for 100 DU's or less.

to 300 gallons per capita per day, or approximately 0.19 cu.ft. per second per 100 DU's, for 1000 DU's or more.

OBSOLETE

The above flows are for sewers flowing full and should be sufficient to cover a moderate amount of infiltration. When sewers are to be laid below the ground water level or in areas subject to flooding, the maximum allowable leakage should be stipulated in the specifications. A maximum infiltration of 8,000 to 12,000 gallons per day per mile of sewer, depending on soil conditions, is suggested. (The figure may be fixed by local regulation.)

The diagram on page 3 shows sanitary sewer sizes for varying numbers of dwelling units and different pipe slopes. It is based on the above-recommended design rates of flow and on n = 0.015 in the Kutter formula.

7. MINIMUM GRADES FOR SANITARY SEWERS

Standard practice calls for slopes which will produce a velocity of at least 2 feet per second in sanitary sewers flowing full or half full. For n = 0.013, following are the corresponding rates of grade:

Pipe Size	Minimum Grade
4"	1.10%
6"	0.60%
8"	0.40%
10"	0.28%
12"	0.22%
15"	0.16%
18"	0.12%

However, when little additional trenching cost will result, it is desirable to base minimum grades on n = 0.015. Such grades are approximately 50% higher than the preceding, and may be taken from the diagram.

On the other hand, grades lighter than tabulated above must be used frequently to avoid sewage pumping, since periodic sewer flushing is likely to cost much less than the maintenance and operation of a pumping station. In such cases, it is important to work out the grades consistently to use to best advantage all of the fall that is available. The velocity of flow should not be less than 1-1/2 feet per second with sewers flowing full.

8. MINIMUM DIAMETERS FOR SANITARY SEWERS

Four inches is the recommended minimum diameter for house connections, 6 inches for short laterals not located in streets, and 8 inches for other lines. Under standard practice in many cities, 6-inch pipe is used in house connections and 8-inch or larger in all laterals.

9. SANITARY SEWER LAYOUT

Design objectives which are in part peculiar to public, low-rent housing projects, include the following:

a. Locating sewer mains and laterals in street areas, preferably not under pavements, where practicable, so that the project will be relieved of the maintenance of the lines if the streets are dedicated.

b. Locating the sewers to avoid existing trees 1/, and coordinating the sewer layout and the planting design so that new trees will not be planted over or near sewer ditches.

c. Coordinating the sanitary sewer lines with the locations and grade elevations of other utilities: storm sewers, steam and hot water conduits, and gas and water lines. The various utilities should be spaced sufficiently to permit laying each in a separate trench and, where possible, sewers should be laid below water lines.

10. MANHOLES AND CLEAN-OUTS

The usual practice of providing manholes at all breaks in line or grade, and at all junctions in lateral sewers, is not followed rigidly in public housing projects. The reason is that irregularity in the arrangement of buildings, also rugged topography, would often necessitate an excessive number of manholes; moreover, manhole castings in lawn areas create some difficulty in maintenance operations. The maximum recommended manhole spacing is 300 to 400 feet, depending on the grades at which connecting sewers are laid, and the diameter of the sewer.

Cleanouts can generally be substituted for manholes at the upper end of sanitary sewers and at changes in the alignment of short laterals. They are sometimes terminated about one foot below finished grade, to save cost and avoid metal frames and covers in lawn areas. However, this practice has met some objection, and should be followed only where the ground never freezes to an appreciable depth.

11. SEWER PIPE AND PIPE LAYING

Engineers for public housing have usually specified only pipe and bituminous joint material for sanitary sewers. Detailed recommended requirements for materials and workmanship are contained in Division 24 of the Guide Specifications, Bulletin No.LR-13, for Urban Housing, and in Division 16a of the Basic Specifications, Bulletin No.LR-22 for Rural Nonfarm Housing.

Pipe in deep trenches requires special attention in both design and construction supervision. The trench load varies with the square of the trench width at the top of the pipe; hence, the trench should be as narrow as practicable at that level. Generally speaking, if the trench load will exceed about 3/4 of the "sand-bearing" crushing strength of standard-strength clay sewer pipe, extra-strength pipe should be employed or concrete cradles provided. 2/

1/ See Bulletin No. LR-9, Part II, "Preservation of Existing Trees."

2/ See "Trench Loading Tables", published by the Clay Sewer Pipe Association, Inc., Columbus, Ohio

Pipe in shallow trenches may require protection against damage by construction operations (grading and trucking), if not afterward. On flat sites, sewer house connections and the upper ends of laterals must often be laid quite close to grade. When existing ground levels or finished grades are such that sewers will have less than about 2-1/2 feet of cover at all time during construction, it is recommended that the pipe be encased in concrete or cast iron pipe substituted. (Breaks in pipes have remained undiscovered in some cases until long after project occupancy.)

Adverse soil conditions have been a source of difficulty in a number of projects. It is the engineer's responsibility to inform himself fully on site soil conditions and to design accordingly. Sewers in very unstable soil may consist of cast iron pipe supported on two-pile bents or hung from building walls, or of tile pipe with continuous concrete beam supports. When conditions are less severe (for example, when trenches are in saturated sand) a base of gravel or crushed rock on a floor of 2-inch plank may afford a satisfactory bearing.

12. SEWAGE PUMPING STATIONS

Project maintenance experience has shown that the following points merit special attention in the design of sewage pumping stations, when such are required:

a. Investigating the possibility, where the sewage lift is slight, of avoiding pumping entirely. This may sometimes be accomplished by deep trenching, additional length of sewer line, or omitting buildings from the lowest part of the site. Obviously, the point should be investigated at the time of site selection.

b. Selecting a pumping station location as far from dwelling buildings as practicable, especially if the station will have screens which require cleaning, and locating the station where it will be accessible from a surfaced roadway.

c. Preparing a complete and accurate statement of operating conditions in order to obtain equipment which will operate most efficiently.

d. Using the dry-well, rather than wet-well, type of centrifugal pumps.

e. Providing, where feasible, an overflow from the wet well, for use in emergencies.

f. Providing stand-by power, where an overflow is not feasible. (This may not be essential in all cases, but the possible need for it should be considered.)

g. Keeping the motor room floor well above possible flood level of sewage, should the pumps fail.

h. Constructing a superstructure over the station to facilitate proper care of the equipment.

Trans. 25, 2.14.66

i. Providing a positive system of ventilation of the pump room, also the motor room unless it is within the superstructure enclosure.

j. Providing a bar or basket screen in the wet well, unless pumps or ejectors are of a type not requiring screens; providing a manhole in the wet-well roof directly above the screen.

k. Extending valve stems, including those on the drainage sump valves in the pump pit, to the motor room floor or to a platform located above the highest possible sewage level.

l. Using guides, in lieu of tubes, for the floats.

m. Providing flexible pipe connections on the suction and discharge sides of the pumps; using no sewage piping smaller than 4-inch.

n. Avoiding connection of any kind between potable water lines and the pump or sewage piping.

The preceding points apply principally to centrifugal-pump installations. When only a small amount of sewage will be handled, pneumatic ejectors may be preferable.

For the usual duplicate-pump installation, it is recommended that the capacity of each pump be 25% to 50% greater than the maximum estimated sewage flow. However, when sewers will be laid generally above ground water level, it should be safe to base pump capacity on a rate of flow about 20% lower than that recommended for pipe sizing. Between high and low sewage levels, the wet well should provide at least 10 minutes' storage at the average rate of flow, but the width of the wet well should be not less than 5 feet. Dimensions of the dry well should provide adequate working space around the pumps.

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SITE ENGINEERING

PART X - STORM SEWER DESIGN

1. GENERAL

Drainage conditions have frequently received too little attention in site selection, and have occasionally not been understood fully during project design. Moreover, although storm sewers are not essential on all projects, efforts to economize by their omission have sometimes been ill-advised.

For these reasons, in part, numerous projects have been damaged by flooding or erosion, and costly corrective work has been necessary; tenants have been inconvenienced; and, in a few instances, sewage from combined sewers has backed up into basements or flooded yard areas, creating insanitary conditions.

This bulletin consists mainly of: (a) a brief discussion of basic information on drainage conditions, needed in site selection and project design, (b) an outline of the "rational method" of calculating storm water runoff, in its application to housing projects, and (c) recommendations on other features of storm sewer design, all based largely on project maintenance experience.

2. DISPOSAL OF STORM WATER

Storm water from projects is disposed of by one, or a combination, of the following means:

a. By discharging it through project storm sewers into existing storm or combined sewers. This method is almost always employed to some extent where existing sewers are available. It is essential for large, high-density projects.

b. By discharging it through project storm sewers into a nearby open water course. This method is employed occasionally, when a well defined water course is available. The observation, often made, that a site has "good natural drainage" is no indication that there is a water course into which project storm sewers can be discharged.

c. By merely grading the site to permit surface drainage into abutting public streets. This method is employed to a greater or less extent on all sites. It can be used as the sole method of disposal only for comparatively small sites where topographic conditions are entirely favorable.

d. By drainage wells. Deep drainage wells have been used in only one locality, where certain rarely found conditions exist. Generally speaking, shallow "dry wells" are altogether ineffective for surface drainage, including that from roofs.

3. EXISTING DRAINAGE FACILITIES

The following is a brief check list covering points on which general but reliable information is required in site selection, and detailed accurate information is indispensable for project design:

a. If existing storm or combined sewers are to be utilized for project drainage, are they structurally and otherwise in good operating condition?

b. About how often and to what extent are such sewers surcharged? (Neighborhood inquiry may be necessary to obtain a reliable answer to this question, particularly as to whether back-flow into basements ever occurs during heavy rains.)

c. Just how will the surcharge of existing sewers affect the planning and operation of the project? More specifically, will any part of the site be subject to flooding and, if so, can the project be so planned that the storm water will cause no appreciable property damage or serious inconvenience to tenants?

d. If existing sewers are of the combined type, would their overloading cause insanitary conditions in the project?

e. If existing sewers are inadequate to serve the project, to what extent, if any, will their enlargement be provided without cost to the project?

f. If a natural water course or open ditch is the obvious and only outlet for project storm sewers, is it at a low enough elevation to serve that purpose? Can project drainage, if and as increased by the site development, be discharged into such water course or ditch without causing damage to the site or adjoining property?

4. EXTENT OF PROJECT STORM SEWERS

The need for storm sewers is, of course, related to physiographic conditions - soil, topography and rainfall. However, the extent of the storm sewer system in a specific project is governed more directly by: (a) the grade design, which establishes automatically the locations of most sewer inlets, and (b) the decision as to whether sewer connections are to be extended to downspouts, and to crawl spaces, if any. The storm sewers must be laid out in the most economical way to reach the predetermined points of storm water collection.

The sewer designer should be alert to the possibility of grade changes that would simplify the storm sewer installation. (The grade study and the storm sewer design, both basically concerned with site drainage, may be regarded as largely a single design operation.) Further, some adjustment in the site plan may be found advisable to accommodate storm sewers and other utilities in the most efficient manner.

5. RATIONAL METHOD OF DESIGN

As in the case of other utility systems, storm sewers can be designed with greater accuracy for housing projects than for urban areas generally, since the physical characteristics of the site will be subject to little or no change during the life of the project. Careful sizing of storm sewers is requisite from the standpoints of safety and economy.

Under the rational method of design, the storm-water runoff in cubic feet per second is the product of: (a) the drainage area in acres, (b) the rainfall intensity in inches per hour, and (c) the runoff coefficient.

The drainage area for all or any part of the site may readily be taken from the grading drawings; the rainfall intensity is the estimated maximum in the locality for storms of an assumed frequency and of a duration equal to the "time of concentration"; the runoff coefficient is fixed by determing the proportion of the area which has an impervious surface, and then fixing the respective coefficients for pervious and impervious surfaces. The storm water flow should be calculated for every sewer inlet and junction point in the system.

The rational method of design may be considered directly applicable to either storm or combined sewers, since in housing projects the storm water flow during heavy rains, generally, so far exceeds that of domestic sewage that the latter may be disregarded.

6. TIME OF CONCENTRATION

Much of the time required for storm water on a housing site to reach a specific point is consumed in slow flow over unsurfaced areas. Only in the case of large projects is there likely to be any important difference between "inlet time" 1/ and the "time of concentration" 2/ for the entire area.

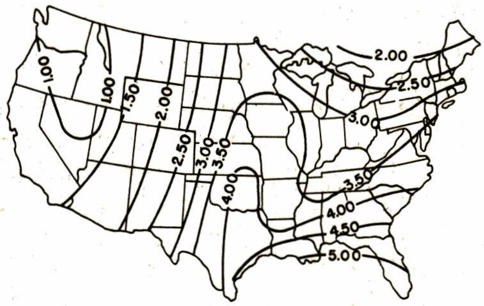
Inlet time may vary between 5 to 20 minutes, or even wider limits, depending upon surface slopes, nature of the soil, and inlet spacing. It has been found that 10 minutes is a fair estimate of this period for many projects, with 15 minutes as the time of concentration. Therefore, the rainfall-intensity diagrams (Figure 1) are for a 15-minute duration, although it may be necessary to employ a shorter duration in some instances, particularly for individual inlets located at critical points.

1/ "Inlet time" is the maximum period required for storm water to flow to an inlet from any point in the area it drains.

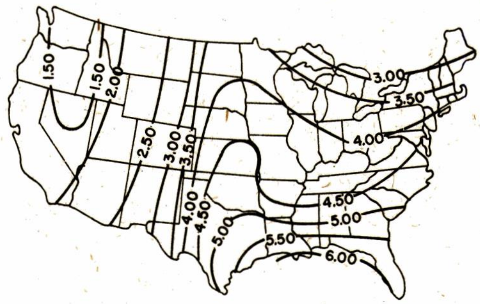
2/ "Time of concentration" is inlet time plus the period of flow in the sewers.

7. RAINFALL FREQUENCY

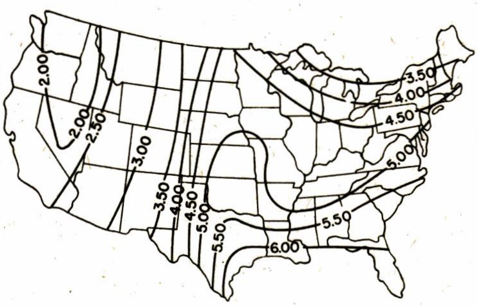
In housing projects, as in cities generally, cost considerations usually preclude building storm sewers large enough to handle the runoff during rains of maximum intensity. In principle, the rainfall frequency employed in storm sewer design should result in an approximate balance between first cost and probable future damage.



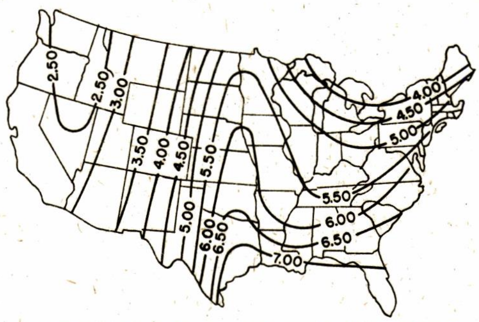
15-MIN. RAINFALL - IN.-PER-HR. RATE TO BE EXPECTED ONCE IN 2 YEARS



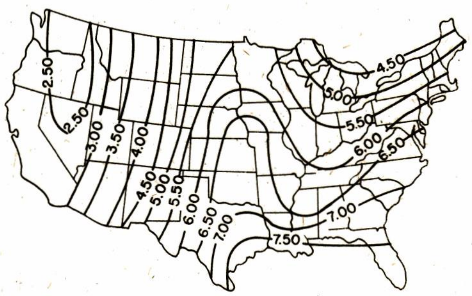
15-MIN. RAINFALL - IN.-PER-HR. RATE TO BE EXPECTED ONCE IN 5 YEARS



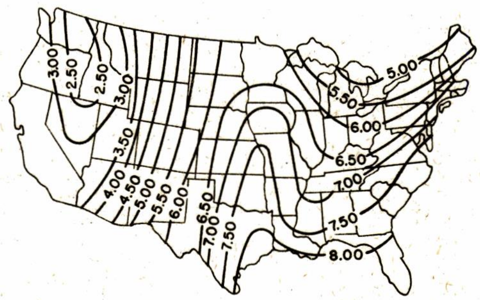
15-MIN. RAINFALL - IN.-PER-HR. RATE TO BE EXPECTED ONCE IN 10 YEARS



15-MIN. RAINFALL - IN.-PER-HR. RATE TO BE EXPECTED ONCE IN 25 YEARS



15-MIN. RAINFALL - IN.-PER-HR. RATE TO BE EXPECTED ONCE IN 50 YEARS



15-MIN. RAINFALL - IN.-PER-HR. RATE TO BE EXPECTED ONCE IN 100 YEARS

FIGURE 1 RAINFALL INTENSITIES

If the surcharge of a certain sewer would surely cause basement flooding or severe erosion, a rainfall frequency of 25 years or more may justifiedly be adopted. If, conversely, it would result in little more than ponding of storm water between street curbs, a frequency of about 2 years may be assumed. A surcharged condition is likely to be more objectionable in combined sewers than in storm sewers.

8. RAINFALL INTENSITY

Having determined the rainfall frequency and the time of concentration to be employed, the corresponding intensity of rainfall may be derived from local weather station data or taken from Figure 1. (The diagrams in Figure 1 were reproduced, in slightly altered form, from a much more complete series given in "Rainfall Intensity-Frequency Data," 1/ by David L. Yarnell.)

Figure 2 supplies a convenient means of converting 15-minute rainfall rates to rates for longer and shorter periods. (For example, if the rate for 15 minutes is 4 1/2 inches per hour, that for 30 minutes is approximately 3.1 inches.)

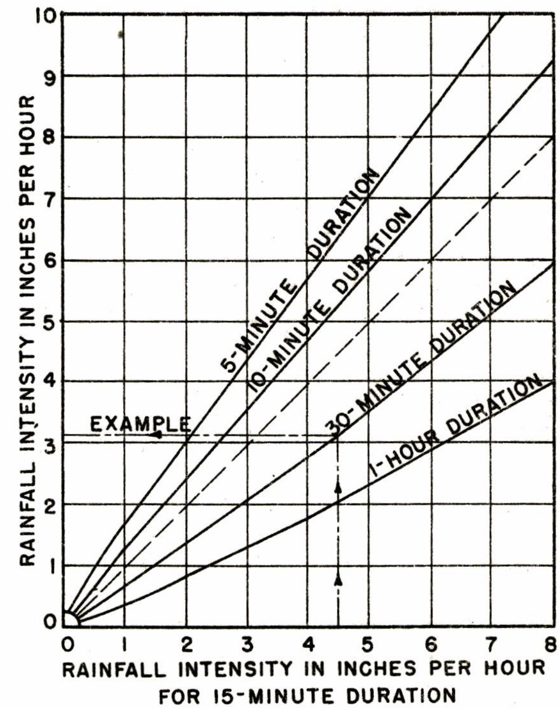


FIGURE 2 RELATION OF 15-MINUTE RAINFALL INTENSITIES TO INTENSITIES FOR OTHER DURATIONS

9. COEFFICIENT OF IMPERVIOUSNESS

The proportion of the site covered by buildings and surfacing tends to vary directly with project density. However, it varies with certain other design features. Thus, this factor - the "coefficient of imperviousness" - should be determined for each project (or each part of it separately considered) by taking off the surfaced and building-coverage areas from the approved site plan.

Following are average coefficients of imperviousness for a large number of existing projects. The figures are intended for checking purposes and preliminary estimating, and should not be employed for final design:

1/ Miscellaneous Publication No. 204, Unites States Department of Agriculture.

- -

Density 1/	Approximate Coefficient of Imperviousness
10	0.30
15	0.35
20	0.40
30	0.50
40	0.60
50 and over	0.65

10. COEFFICIENT OF RUNOFF

a. For impervious areas, recommended runoff coefficients, depending on slopes and various other conditions, are:

With downspouts connected to sewers	0.75 to 0.85
With downspouts not connected to sewers	0.60 to 0.75

b. For pervious areas, the coefficient will vary widely with surface slopes and nature of the soil. However, the following should serve as a reasonable design guide, although the upper and lower limits may not meet extreme conditions:

For very light slopes and sandy soil	0.10
For moderate slopes and clay subsoil	0.25
For steep slopes and non-porous subsoil	0.50

c. The combined coefficient of runoff is the weighted average of those for pervious and impervious areas respectively. Based on the above coefficients of imperviousness, the runoff coefficients for projects of varying density are approximately as follows:

Density	For very light slopes; sandy subsoil	For moderate slopes; clay subsoil	For Steep slopes; non-porous subsoil
10	0.30	0.45	0.60
20	0.375	0.50	0.65
30	0.45	0.55	0.70
40	0.50	0.60	0.725
50	0.55	0.65	0.75

The combined coefficient should be carefully computed for each project - preferably for each part of it considered in pipe sizing. The preceding values are suggested for checking, preliminary estimates and similar uses.

1/ DU's per acre of developed project area within property lines.

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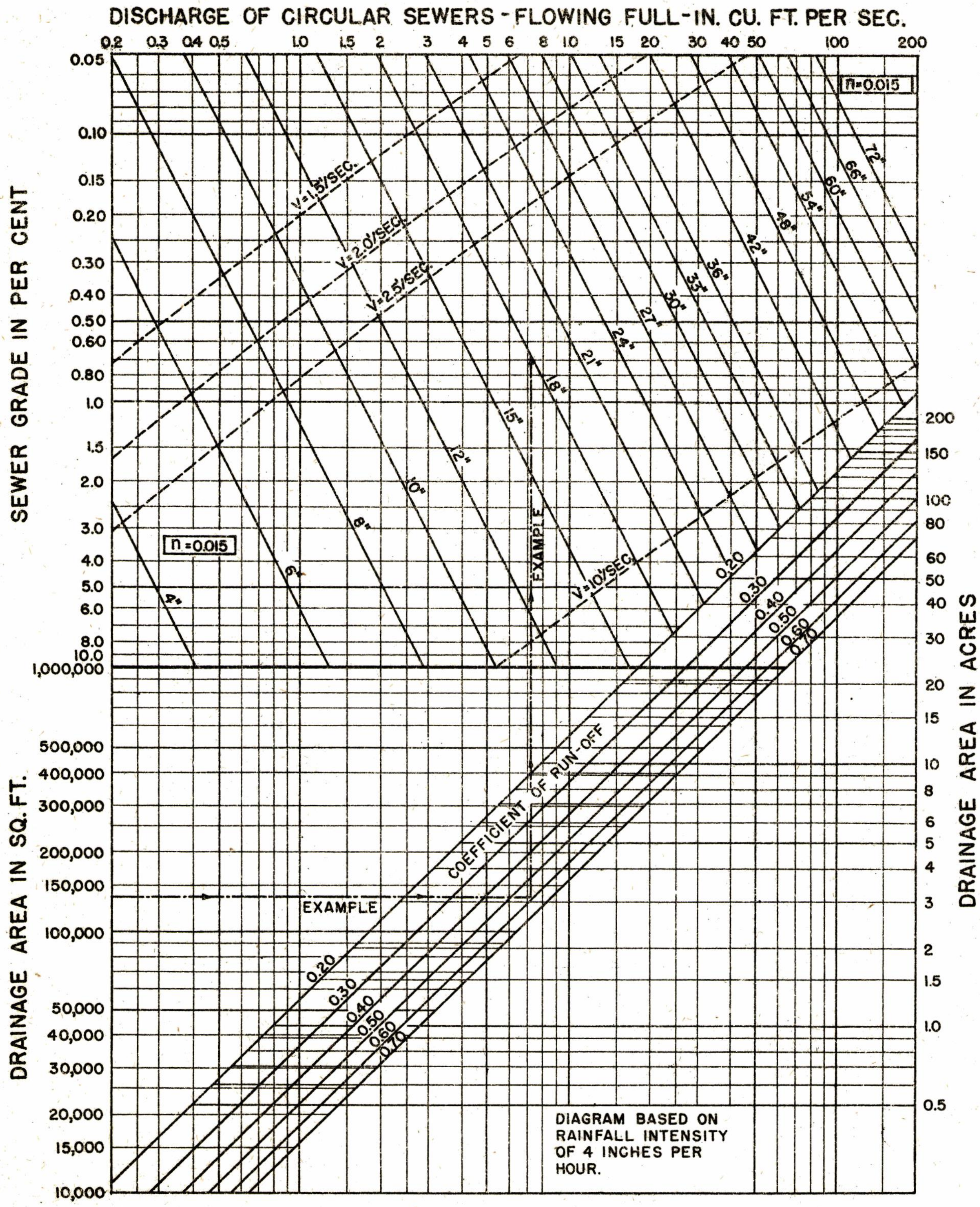

FIGURE 3 STORM-SEWER PIPE SIZING DIAGRAM

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11. STORM SEWER SIZES

Figure 3 shows requisite diameters of storm sewers in relation to drainage area, combined runoff coefficient, and hydraulic gradient. The diagram is based on a rainfall rate of 4 inches per hour and on Kutter's formula, with n = 0.015. For other rainfall rates, the diagram may be employed by increasing or decreasing the drainage areas proportionately. For n = 0.013, sewer discharges are 15% greater than those shown; the value of 0.013 may be assumed for lines larger than 24-inch, while for lines 24 inches or less in diameter a value of 0.015 is recommended.

Storm sewers should be of sufficient diameter, not only to handle estimated storm water flows, but to be reasonably secure against stoppage by grit, stones, trash or other material that can get into them through the particular type of inlet provided. Gratings, of course, afford considerable protection in this regard, at least as compared with open-throat inlets, but catch basins with trapped outlets are the most effective. Following are recommended minimum diameters for storm sewers connected to different types of inlet:

Sewers receiving drainage from catch basins with trapped outlets	8 inches
Sewers receiving drainage from plain inlets with grating type opening	10 inches
Sewers receiving drainage from plain inlets with side opening (open throat)	15 inches

In sizing sewers, the designing engineer should put his calculations - covering pervious and impervious areas, run-off coefficients, discharges, etc. - in suitable tabular form for checking uses and permanent record.

12. MINIMUM GRADES FOR STORM SEWERS

To be self-cleaning, storm and combined sewers should be laid at grades which will produce a velocity of at least 2 1/2 feet (preferably 3 feet) per second with pipes flowing full. Flow velocities in relation to grades for various pipe sizes are shown in Figure 3.

13. SEWER PIPE AND PIPE LAYING

Engineers for low-rent housing projects have usually specified clay pipe for combined sewers, and either clay or concrete pipe for storm sewers. Division 24 of the Guide Specifications, Bulletin No. LR-13, gives detailed, recommended requirements for materials and workmanship. Design problems related to trench loading and adverse soil conditions are identical with those described in Part IX, "Sanitary Sewer Design", of this bulletin.

14. SEWER INLET TYPES AND LOCATIONS

a. Types. Storm sewer inlets may be catch basins or plain inlets, and either such form of chamber may have a grating or a side-opening (or curb) inlet, or both. These types, illustrated in Figure 4, are discussed briefly below.

b. Inlet locations, as previously noted, are fixed largely in the project grade study. Nevertheless, the storm sewer design should include a check on the locations proposed, in both yard areas and streets, to ascertain whether: (1) the inlets will be necessary and effective at such points, and (2) the locations are the best possible for economy in the sewer layout. Further, inlet capacity should be checked against the calculated storm water flow at each inlet location. Inlets at street intersections are, as a rule, better located at one end of the curb return than near its center.

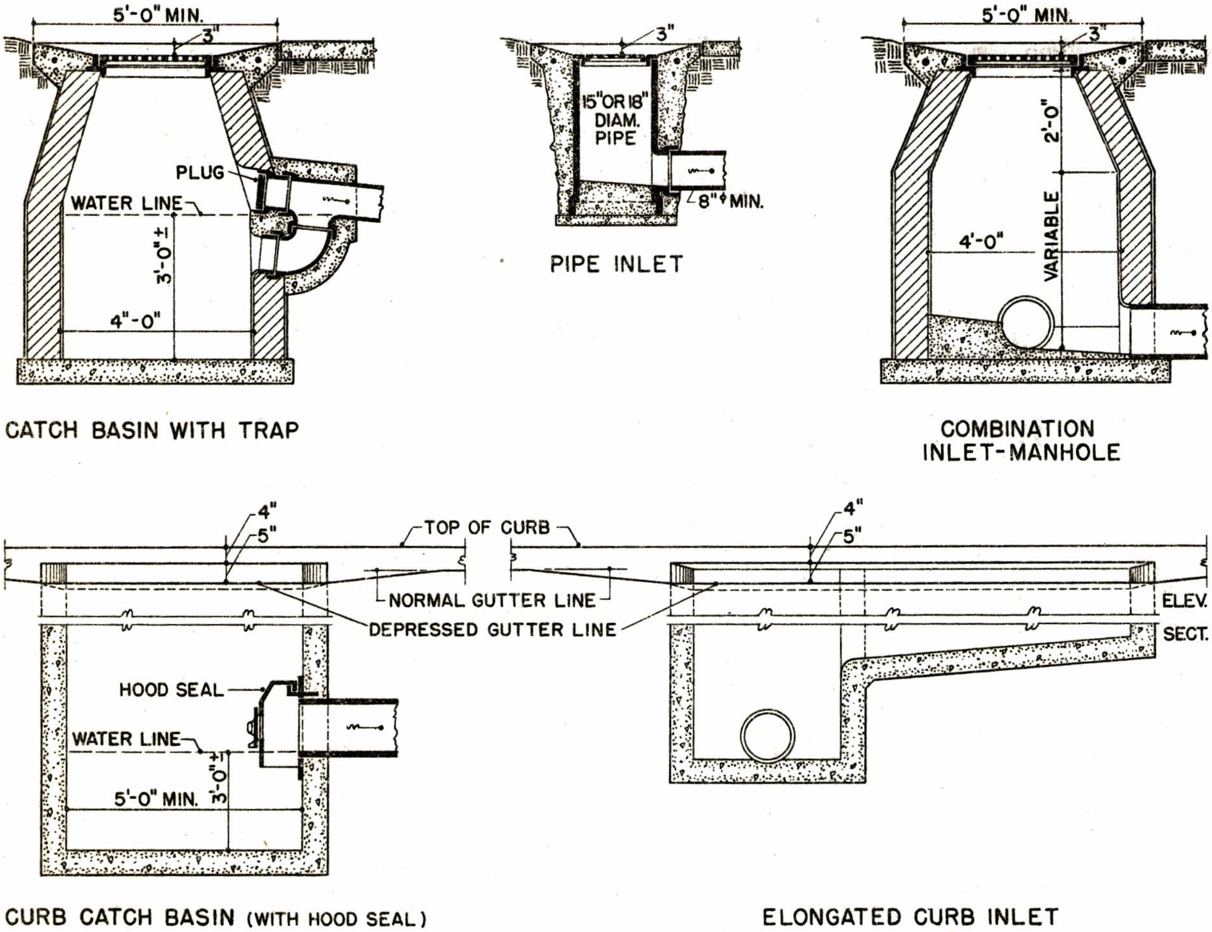


FIGURE 4 DRAINAGE STRUCTURES

15. INLET CHAMBERS: CATCH BASINS VS. PLAIN INLETS

a. Catch basins with trapped outlets are necessary on combined sewers; and catch basins, with or without trapped outlets, should be used on storm sewers having grades which may not produce a self-cleaning velocity of flow. A trapped outlet is useful in preventing the entrance into the sewers of sticks pushed through gratings by children. However, catch basins are decidedly objectionable in several respects: they require occasional cleaning; cleaning is sometimes neglected until stoppage occurs; the basins are likely to become foul and breeding places for mosquitoes; and the water seal in the trap may freeze during severe winter weather.

b. Plain inlets afford little protection against sewer stoppage, but they do not have the objectionable features of catch basins; and plain inlets may serve as manholes (which catch basins can not), with one inlet connected to another, thus effecting considerable economy. Such inlets are recommended, therefore, when:(1) sewers are not of the combined type, (2) sewer grades will produce a flow velocity of at least 2 1/2 feet per second, and (3) sewers are amply sized as protection against clogging (see paragraph 11).

c. Inlet chambers in surfaced areas should be of concrete or brick; in grassed areas they may be of such materials or of tile pipes set on end. However, it is preferable that inlets be large enough for a man to enter. Pipes with gratings resting in their bells are not satisfactory.

16. GRATING-TYPE INLETS

Grating inlets are of necessity used in grassed and plane surfaced areas, also in roadways of dished cross section, and may be used in gutters along curbs (either solely or in conjunction with curb openings). Several points regarding their design merit emphasis:

a. Except in gutters along curbs, a circular grating is preferable to a rectangular one, since the circular casting can not fall through the frame.

b. To allow for partial stoppage by leaves, paper, etc., the grating area (gross) should be not less than about three square feet per sec. ft. of storm water flow.

c. Gratings should be heavy enough not to be removable by children; otherwise, lock bolts should be provided.

d. The design should permit using standard gratings, cast in the locality. The engineer should check on the form, dimensions and weights of such products.

e. Gratings should always be set in depressions 2 to 3 inches below finished grade. This applies to gratings in lawns, roadways, and other surfaced areas. (Lack of attention to this point, in project drawings and construction, has resulted in poor drainage in many cases.)

f. Grating frames in grassed areas should have concrete collars not less than 12 inches wide. When adjoining walks, the outer edge of the collar should be about 1/4 inch below the walk edge.

g. Rectangular gratings in roadway gutters should have their bars parallel to the direction of flow. This gives maximum inflow capacity and non-clogging characteristics. Such gratings should be of ample length. Inlet castings should always be gratings - not perforated covers.

h. Occasionally, where service drives cross sidewalks at sidewalk grade, a grate-covered trough (such as used around gasoline service stations) may be extended wholly or partially across the drive. This will generally intercept the water more effectively than a standard sewer inlet, and may cost no more.

17. SIDE-OPENING INLETS

Side-opening inlets usually provide more effective openings than do gratings, and are much less subject to stoppage, but they are obviously suitable for use only in roadways or other paved areas having curbs.

The most important objective in their design is diversion of the flow from the gutter into the curb opening. This involves forming a shallow depression in front of the inlet and, especially on slopes, adjusting the length of the opening to the flow. It is essential that the storm water flow to each inlet be calculated.

Only comparatively recently has the subject of inlet capacity been receiving the attention it needs, and much research remains to be done. Following, however, are approximate figures on the intake capacity of side-opening inlets located along gutters with different longitudinal slopes: 1/

(1)	(2)	(3)	(4)	(5)
Length of Inlet	1% slope	3% slope	5% slope	10% slope
4 feet	0.75 c.f.s.	0.50 c.f.s.	0.40 c.f.s.	0.30 c.f.s.
6 feet	1.30 c.f.s.	1.00 c.f.s.	0.75 c.f.s.	0.55 c.f.s.
8 feet	1.85 c.f.s.	1.50 c.f.s.	1.15 c.f.s.	0.80 c.f.s.
10 feet	2.40 c.f.s.	2.00 c.f.s.	1.50 c.f.s.	1.10 c.f.s.

1/ Based largely on data contained in Engineering Experiment Station Bulletin No. 30, North Carolina State College.

The preceding figures should be used with caution, and only for conditions which approximate the following:

a. An inlet slot at least 5 inches high and without vertical bars or other obstruction.

b. An 18-inch gutter having a cross slope of 1 1/2 inches to the inlet slot.

c. The gutter depressed an additional 3 inches immediately in front of the inlet opening, with adjoining pavement surface warped accordingly. (With a 6-inch curb elsewhere, this gives a curb height of 9 inches - the maximum desirable - in front of the inlet.)

If the inlet is located in a pocket in the roadway, with flow to it from both directions, its capacity may be double or more than given in column (2) above.

Side inlet capacity may be increased materially by a grating set in the gutter, and this combined type of inlet is standard in many cities. It is more costly than the simple side inlet and becomes less effective with increasing slopes.

There is generally some advantage in following local standards, and it is necessary to do so in the case of streets to be dedicated; but this does not lessen the importance of checking inlet capacity against storm water flow.

Weep holes for subgrade drainage are sometimes provided in roadway inlets on the roadway side of the chamber. Located just below subgrade level, they are especially desirable in the case of inlets located at low points in the street grade.

SITE ENGINEERING

one of a series of

HOUSING DESIGN NOTES

P H A LOW-RENT HOUSING BULLETIN

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

PUBLIC HOUSING ADMINISTRATION

HOUSING AND HOME FINANCE AGENCY WASHINGTON, D.C. 20413

An up-to-date list of all Low-Rent Housing Bulletins is provided in Low-Rent Housing Manual Section 100.2, Supplement 1, Exhibit 5.

HHFA
PHA
Dec. 1965

Bulletin No. LR-4
PART 0

SITE ENGINEERING

Table of Contents

NOTE: This Part supersedes Part 0 dated August 1964.

PART	TITLE	PAGE

SITE ENGINEERING

PART I - PROJECT GRADE DESIGN

1. INTRODUCTION

The grade design for a housing project consists of the detailed fitting, in elevation, of the site plan to the topography. Basic objectives are effective drainage and erosion control. If these are attained, economy in maintenance should follow. Other considerations include economy in first cost, the convenience of tenants, and good appearances.

Unsatisfactory grade and drainage conditions have been experienced in many existing low-rent projects. Some of the difficulties have come from inaccurate construction, poor compaction of fill and backfill, and ineffective planting for erosion control; but often the grade design has been faulty. The results have been increased maintenance expense, additional capital expenditures, and permanent defects in the projects.

Grade design should be done by an experienced and competent designer of this type of work; he should realize the drainage problems created and the appearance of the completed work. Grading and drainage are inseparably tied in together. Poor grading and improper or insufficient drainage are difficult to cure later.

This Part I outlines design practice which, based on construction and maintenance experience, can be recommended as safe and satisfactory. Exhibit 1 is a check list which summarizes the means of achieving the abovementioned objectives.

2. PROJECT GRADES AND THE SITE PLAN

In planning a housing project, the grade design and the preparation of the site plan are closely interdependent design operations. If the site plan is not well adapted to the topography, the defect will be reflected in undesirable grade conditions; and if project grades are not worked out to best advantage, some merits of the site plan will be lost. Faulty design in either respect may result in unwarranted costs of site grading, drainage facilities, and building foundations.

Difficulties invariably arise when the design of building units and the organization of building shapes and building groups are determined far in advance of development study of site planning and site engineering problems involved and of the possible resultant site design conditions. Designers of buildings should seriously consider the topographic conditions and allow sufficient flexibility in the forming of buildings and building groups. Some sites may require special buildings, such as split-level with the low level in the rear, others with the low level in the front, etc. Planning of buildings and building groups, site planning, and site engineering should be truly a harmonious team effort.

Even though the site planner should visualize project grades constantly as his plan is developed, he can hardly foresee whether it will prove satisfactory as regards grades and drainage in every detail. Therefore, the plan should not be "frozen" until the grade design is completed. The grade designer may discover changes, minor ones at least, that will improve drainage, eliminate earth banks, or reduce storm sewer costs. He should be alert to these possibilities.

While a discussion of site planning is beyond the scope of this bulletin, one consideration related to drainage merits mention: it is generally perferable in low-rent projects to locate roadways in "valleys" rather than on "ridges." Yard areas should slope away from buildings towards the roads and drains. Walks should not be used for drainage-ways or as drainage swales.

3. UNDERGROUND DRAINS (Storm Sewers)

For high density projects, complete systems of storm sewers are always necessary and their per dwelling unit cost generally is quite low. But as project density decreases, this cost rises rapidly and economy in the storm sewer installation becomes increasingly important.

The grade designer must visualize project storm sewers--those that his grades will necessitate--in much the same way that the site planner visualizes project grades. In fact, the project grade study and the storm sewer design are both basically concerned with site drainage, and may be treated more or less as a single design operation.

To a certain extent, storm water may be carried away either over the surface or underground. For example, a given area may be drained by providing fill so as to shed the water to a site boundary or by installing an underground drain and inlet. But where storm water must be conducted across the site for any distance, the best place for it is underground.

The following text contains some discussion of the conditions under which storm sewers and inlets become necessary. However, site conditions, such as soil erosibility, slopes, and rainfall intensity, vary tremendously and decisions finally must be based on the designer's judgment. In some existing low-rent projects, judgment in this regard was unwisely influenced by pressure for economy in first cost rather than in maintenance.

4. PREREQUISITES TO GRADE DESIGN

Before project grade studies are undertaken, comprehensive information on site conditions (see Bulletin LR-2) must be obtained and decisions reached regarding certain design policies and details in order to take advantage of natural environment. The following data are needed:

a. An accurate boundary and complete topographic map of the site extended far enough beyond the site boundaries to provide sufficient information for the correct design of storm sewers and their final points of discharge.

b. Established grade of city streets bordering or crossing the site. If such grades are not established or changes appear desirable, the Local Authority should request appropriate action by the city.

c. Location, size, and invert elevations and information regarding the adequacy of existing sewers at the site as well as off-site sewer extensions necessary or proposed.

d. High water elevations to determine whether any part of the site is subject to flooding, either from streams, tides, or surcharged storm sewers. (Valuable information and records of flood plain data on rivers and streams and storm tides in coastal areas may be obtained from the Corps of Engineers, U.S. Army, District Offices.)

e. Subsurface soil investigation and percolation test(s) data.

f. Information on drainage conditions of adjoining properties, especially if any such properties drain onto the site or if any part of the site has natural drainage onto adjoining property. (This information should be obtained or verified by the designing engineer.)

g. Information pertaining to existing streams within, adjacent to, or near the site:

(1) Right to realign, relocate, widen, deepen, dam, and/or pipe the stream

(2) Discharge augmented storm drainage from site into stream

(3) Easements required, if any

h. The Local Authority's attorney should determine and advise of the legal responsibility involved by items in sub-paragraphs g above and j below pertaining to the existing and augmented natural drainage from the site onto adjoining property. The laws on this are not uniform in all States and may also vary within a State.

i. Storm drainage requirements for leaders, cellars, areaways, and crawl spaces, as well as quantity of storm drainage flowing onto the site from adjacent properties.

j. Can adjacent property owners legally refuse or block by curbs, walls, etc. the flow of natural drainage from the site?

k. Range of permissible heights of first floors above finished grade; heights of crawl spaces (if any) and proposed methods of grading and draining them; and requisite depths of foundations below present grade.

l. Cross sections of new streets and drives.

m. Determination as to the general extent of storm sewers to be provided.

n. Check local topographic or other available records to determine:

(1) Whether site previously had a ravine, swamp, mine, gulley or was used as a dump for sanitary disposal or a fill area.

(2) Geological history which will indicate the presence of glacial deposits and other information.

o. Obtain available information from residents of neighborhood, utility companies, and contractors as to their knowledge of surface changes and underground conditions.

p. Inspect site for evidence of damage from foundation settlement of existing buildings, dry or wet conditions of basement, and previous earth slides.

q. Local rainfall and climatological data.

5. DIRECT DRAINAGE TO STREETS

The ideal means of grounds drainage consists of continuous easy slopes, downward from buildings to adjacent streets, drives, and parking areas. This method of drainage tends to prevent any concentration of storm water flow on grassed or planted areas, and generally obviates the need for storm sewer inlets elsewhere than in pavements. The method is that commonly use for draining the yards of private houses, and it should be employed in project design to the extent that the site plan and topography permit.

6. DRAINAGE TO GRASSED AREAS

The difficulty experienced in draining onto grassed areas, as illustrated in Figure 1, has lain in the lack of effective grading. Light ground slopes, inaccuracies in topsoil grading, and expansion of the turf above original finished grade have contributed to the unsatisfactory result. In Figure 1, the storm water is expected to cross the walks and reach inlets in the center of the grassed area; therefore, extreme

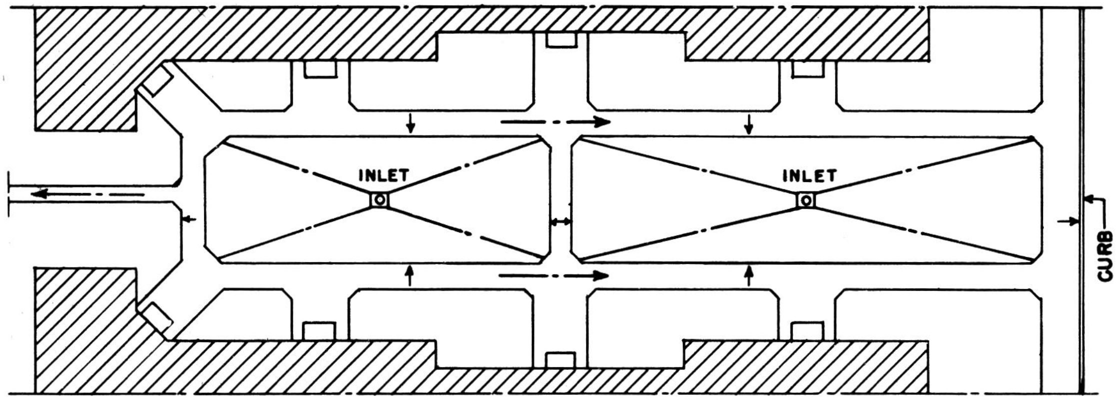


FIGURE I DRAINING COURT AREA

care is required in order to provide for positive, long-term drainage in this manner.

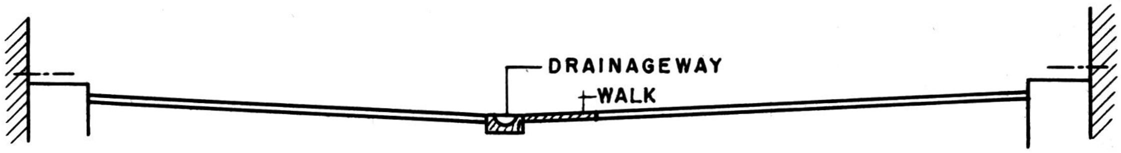
7. STORM WATER FLOW ON WALKS

As a general proposition, it is preferable not to use walks as drainage-ways. The storm water flow in some instances may be a nuisance and until turf is formed silt may be carried onto the walks, causing trouble for pedestrians and management.

It is essential that walks be cross-sloped (or crowned) properly (1/4 or 3/8 inch per foot), that they have adequate longitudinal slope, and that they be built accurately to grade. In addition, the quantity of flow along the edge of the walks should be limited. It is important, further, that storm sewer inlets be provided at points of concentrated flow. Whenever gutters and swales must pass under walks over 4 feet wide, consideration should be given to providing means for cleaning.

8. DRAINAGE BETWEEN ROW-HOUSE BUILDINGS

Figure 2 shows in section two schemes for handling storm water along a centrally located approach walk between two row-house buildings which have approximately the same elevation. Scheme A keeps the walk comparatively free from water by means of a concrete gutter; and Scheme B accomplishes the same result by means of a swale (with culverts under entrance walks) located adjacent to the central walk. In the latter instance, careful attention should be given to grades and size of opening so that the culverts will not become restricted at a later date.



(A) DRAINAGE TO PAVED GUTTER

(B) DRAINAGE TO SWALE

FIGURE 2 ALTERNATIVE METHODS OF DRAINAGE BETWEEN ROW-HOUSE BUILDINGS

9. SWALES

The preferred drainage plan is one in which no swales are required, since at best these shallow depressions carry concentrated flows which may be seriously erosive. However, it is often impossible to develop a plan in which grassed areas everywhere present smooth, continuous slopes to paved areas and storm drain inlets. Properly laid out and protected, swales can provide a means for directing storm water effectively.

Uses of swales include serving as sodded drainage channels from down-spout, splash-blocks, and intercepting side-hill or off-site drainage and carrying it around the built-up part of the project. In the latter use, the swale may attain the proportions of a grassed ditch. In rare cases, too, a sodded swale must be used to carry off drainage from a small surfaced area; however, this is an undesirable means of drainage but occasionally unavoidable when a storm sewer is not available. Such swales must be given sufficient slope to prevent silting.

The high point of a swale should be at least 0.5 feet below grade at building, with 1.0 feet preferable. When possible, the bottom of swales should be at least 10 feet distant from adjacent building walls and one foot lower than finished grade at the walls. The swale section should permit grass cutting with power equipment.

The following table shows suggested maximum slopes for seeded swales and for sodded swales, respectively, in relation to drainage areas:

	Maximum Slopes for	
Drainage Area*	Seeded Swales	Sodded Swales
1,000 sq. ft.	5%	--
2,000 " "	3%	--
5,000 " "	1-1/2%	25%
10,000 " "	1%	15%
20,000 " "	--	8%
50,000 " "	--	4%
100,000 " "	--	2%
200,000 " "	--	1%

* Include roofs at 3.75 and pavements at 3.00 times their respective actual areas in horizontal projection.

The preceding figures are intended to serve as a rough guide in determining when flow channels should have sod protection and when they should be paved, or underground drains provided. With seeded swales the objective obviously is to get a stand of grass before appreciable erosion occurs; in this, much will depend on the season as well as on soil characteristics. Swales may require protection in the form of mulch or tree boughs until more permanent protection can be provided. If the terrain is easily eroded, the swales should be paved.

10. EARTH BANKS

Experience has proved conclusively that earth banks are a source of endless trouble in low-rent housing projects. Erosion and wear from children's play make them costly to maintain and they often remain unsightly in spite of maintenance efforts and expense. Moreover, banks necessitate walkway steps, which are a hazard as well as a nuisance to tenants.

To minimize the need for steep earth banks and walkway steps:

a. Use sloping grade lines along buildings, instead of striving for more or less level "benches." Smoothly flowing surfaces throughout the site may be more pleasing than a series of terraces; and the sloping grade lines will not necessarily entail stepped footings for buildings. However, sloping grade lines along buildings should be used with caution where buildings do not have cellars (basements) or first floors are slabs on ground. The grades along the building walls should not be higher than the lowest row of weep holes of the building walls.

b. Give building entrance walks moderately steep slopes with an ogee profile, in preference to light grades which would necessitate steps down to main walks.

c. Use stepped ramps, where practicable, in lieu of steps. (These will give slopes of approximately 20% over which a power mower can be operated.)

d. Substitute retaining walls for earth banks in favorable locations and when cost limitations permit. Dry masonry walls, where suitable stone is available, are less costly than concrete and more pleasing in appearance. The first cost of retaining walls may be offset to a considerable extent by the additional ground area made usable. When steep banks extend down from buildings to street sidewalks, low walls along the walks have been found particularly advantageous. Dry masonry walls should not be used where they may be subject to damage by vandals, and the joints should be small enough that they will not be used by vermin or snakes. If small joints are not feasible because of the nature of the material, then units should be bedded in mortar.

Every effort should be made to eliminate all low banks. They have often been used where the difference in elevation could have been taken up easily by giving a little more slope to walks and grassed areas.

Where a steep earth bank (3 to 1 maximum) must be used, it should be given a well-rounded section. Surface water should be diverted back from its top, unless the drainage area above it is extremely small. Diversion may be accomplished by a very shallow swale, continued down or around the bank in a sodded channel. If flow is considerable, diversion should be in concrete paved gutters to storm drainage appurtenances. Earth banks steeper than 3 to 1 but in no case steeper than 2 to 1 may be used only after thorough investigation indicates the material to be stable for such a slope.

11. DRAINAGE FROM DOWNSPOUTS

In high-density projects sewer connections to roof leaders are indispensable; in practically all low-rent projects they are most desirable. They have not always been provided in numerous existing projects--in some instances because of lack of outlet for storm sewers, in others for reasons of economy. The results frequently have been continued erosion in grassed areas and dampness in basements and crawl spaces; a considerable amount of corrective work has been necessary.

Nevertheless, for very low-density projects with downspouts on both sides of buildings, the cost of sewer connections may be extremely high. Therefore, where conditions are favorable (where slopes are light and the soil porous), the omission of downspout connections may be warranted.

In some instances connections may be necessary to only a few downspouts, such as those discharging near the top of a slope. And, where no storm sewers are available, downspout drainage, in some cases, may be piped to discharge through a street or driveway curb. Further, sodded swales may serve in certain locations to conduct roof water to safe points of discharge. It is important to give the problem careful study. Downspouts not connected to storm drains should extend to 6 inches above grade and discharge through a boot onto heavy precast concrete splash blocks not less than 3 feet long with wide outfalls for dispersion and reduction of erosion. The lowest 6 feet of exterior downspouts, including the boots, should be of extra heavy cast iron.

12. POCKETS

The grounds in many projects contain low areas from which storm water must escape through underground drains. As a rule these depressions are shallow and if a drain becomes stopped, the water will simply overflow to a roadway or another drain without causing serious damage. Occasionally, however, there is a deeper pocket, such as a decided sag in a street, or a court partially enclosed by a building, where the clogging of a drain would result in building damage or in serious erosion. Obviously, such a condition should be eliminated by a change in the site or building plans, or guarded against by precautions taken in the drainage design. Duplicate drains may be warranted in some instances.

13. PROCEDURE IN GRADE DESIGN; ESTABLISHING BUILDING FLOOR ELEVATIONS

The project grade design is normally developed as a whole, adjusting and readjusting building, grounds, and roadway elevations, until a thoroughly satisfactory balance of all features is achieved. The starting point, as a rule, consists of the established grades of boundary streets.

The grade design should include the fixing of building first-floor elevations. In this phase of design, architectural considerations--more specifically, the correlation of building levels--may be important, but no viewpoint should prevail to the exclusion of others. Very often, raising the floor elevation of a building only a few inches will improve drainage conditions immeasurably.

In a great many projects, the establishing of well-considered and realistic first floor elevations and grades of boundary streets are the keys to good site grading design results. Avoid resting concrete floor slabs on fill over 5 feet deep. To adjust buildings to longitudinal slopes, steps in floor levels should be used. The resulting steps in grading at the buildings should be carefully designed in all details so as not to create trapped drainage areas at the buildings, maintenance problems, and unsightly conditions.

Building levels may be governed simply by the necessary rise in walkways to building entrances. More often, floor levels throughout the project are established tentatively, or roadway grades are assumed; then through trial all grade elevations are adjusted until the result is satisfactory.

When a walk closely parallels a row building, the walk slope will generally necessitate variation in the number of steps, and sometimes in riser heights, at entrances. These determinations may be included in the grade design.

14. WALKWAY GRADES

Walkway grades constitute a major part of the grade design work and proper execution is essential to effective site drainage and to the satisfactory appearance of open areas.

The minimum grade recommended for project concrete walks is 0.50%, and for bituminous walks 1.00%, although two exceptions merit mention: first, walks adjoining roadways or parking area curbs should be laid to the same grade as the top of curbs; and second, building entrance or other short walks can best be planned for a 1.00% slope to absorb minor inaccuracies in construction. As previously noted, all walks should be cross-sloped or crowned. The preferred MINIMUM grade for all walks is 1.00% as this reflects the minimum general rates.

The maximum grade recommended for main walks is 7%-8% and for entrance walks 10%, but with consideration given to grades common in the locality, and restricting the slope to 6% where snow and ice may prevail for a long winter season. Generally speaking, steep grades are far preferable to steps and the earth banks that go with them. Adjoining the top and bottom of steps, walk slopes should not exceed 2% where the approach walks exceed 5%.

Sharp breaks in grade--in long walks, at walkway intersections, or in building entrance walks--are conspicuous and unsightly. Grading plans should show the characteristics of vertical curves required. Use vertical curves where the algebraic difference between the gradients of intersecting grade lines exceeds 2%.

Another unsightly grade condition is a long walkway with a wavy or "rollercoaster" profile. This is seen occasionally on flat sites, where walks dip toward catch basins located at intervals; and along sloping malls, the grades of parallel walks are sometimes objectionably irregular.

15. GRADES AT EXISTING TREES TO BE PRESERVED

Trees that are to remain should be protected. Finished grades should, if possible, be made to conform very closely to existing ground levels at tree locations. Trees should never be left on small mounds, and filling around them is permissible only if special protective measures are taken. Tree locations should be shown accurately on the drawings. The spread of branches should be fully taken into account. Locations and base elevations of trees should be checked as soon as buildings are staked out in the field. An ill-advised and unsuccessful attempt to save a tree is likely to result in an unsightly grade condition should it be required to remove the tree at a later date.

16. MAXIMUM AND MINIMUM SLOPES

Limiting slopes for grassed and surfaced areas depends to some extent on local conditions: porosity and erosibility of the soil, frequency of icy conditions, and the steepness of slopes to which the people in the locality are accustomed. In areas where unconsolidated soils have a history of being susceptible to erosion, i.e. loess (wind-blown glacial deposits), sand, and silts, the U.S. Soil Conservation Service should be consulted on the treatment and heights of slopes. Avoid the unbalancing of slopes by overexcavating along the toe.

Where moderately steep to steep slopes are needed, the use of a jute mesh spread on the surface, or appropriate mulch, will prevent erosion until grass has rooted and formed a protection surfacing.

Costs also are a consideration. When a site is extremely flat or extremely steep, some risk must be assumed in employing grades that will not result in exorbitant grading costs. However, slopes lighter than the recommended minimums should be used with caution, especially if the soil is nonporous. Grades used must be sufficient to "take up" minor inaccuracies in construction, including some slight settlement of fill and backfill.

The following tabulation shows maximum and minimum slopes considered desirable for what may be termed "average" conditions:

	Maximum Slope	Minimum Slope
Streets and drives - crowned section with curbs	8.00%	0.50%
Streets and drives - crowned section with combination curb and gutter	8.00%	0.50%
Service drives - inverted crown section	8.00%	0.60%
Collector and approach walks	7% to 8%[1]	0.50%[2]

[1,2] See footnotes at end of table.

	Maximum Slope	Minimum Slope
Entrance walks:		
Adjoining building platforms	2.00%	1.00%
Elsewhere	10.00%[1]	1.00%
Paved recreation areas, including sitting areas	2.00%	0.50%
Surfaced laundry yards	5.00%	0.50%
Tenant yards:		
Up to 4 feet from buildings	4.00%	2.00%
Elsewhere (except banks)	15.00%	1.00%
Management-maintenance areas:		
Up to 4 feet from buildings	4.00%	2.00%
Elsewhere (except banks)	25.00%	1.00%
Grassed playgrounds	2.5%	1.50%
Paved gutter, concrete	--	0.50%
Swales:		
With flow crossing over walk	(See Table on page 7)	2.00%
Other	(See Table on page 7)	1.00%
Earth banks	3 to 1	--
Preferred minimum slope -- all paved surfaces and lawns		1.00%

[1] 6% where icy conditions may prevail in winter season.
[2] For concrete only. Use 1% for bituminous.

17. GRADING DRAWINGS

The manner of showing finished grades on the drawings is most important both for accurate execution of the design and for use of the plans on the job. Following are brief suggestions on the nature and scope of grade design information.

a. Show datum used for all elevations.

b. Show elevations of existing and proposed roads: along center line and at top of curb at intervals not greater than 100 feet; at the apex, PT's, PC's, and at not greater than 25 foot intervals along vertical curves; at all connecting walks, breaks in grade, ends of roundings, at gutters where special sections are required.

c. Show walkway grades at all building entrances, walk intersections, walk and roadway intersections, breaks in grade, etc. Where necessary, indicate requisite warping of walk surfaces. Show by arrows the crowning and cross-slopes of walks and pavements.

d. Show finished grades for <u>surfaced areas</u> (other than roadways and walks) along their sides and at interior points as necessary to indicate shaping.

e. For lawns and planted areas, show finished grades at corners of buildings, breaks in grade, top and bottom of banks, catch basins, etc. Show cross sections of banks and swales, indicating roundings.

f. Show building first floor elevations and, as necessary, the number of steps and riser heights.

g. Show finished grades of surfaced areas, lawns, and planted areas by spot elevations; in addition show finished grade at one-foot contours (reformed contours) to indicate how the surface is to be shaped. On rolling and steep sites, contours (reformed contours) must be used in addition to the spot elevations to indicate the finished grading of all areas.

18. GRADING SUPERVISION

While site slopes must be sufficient to absorb minor inaccuracies in construction, the grade design cannot provide insurance against careless work, such as insufficient compaction of fill and backfill, irregular finished grading, and inaccuracies in setting walkway forms.

Such defects have been experienced, not infrequently and with costly results, in existing projects. The remedy obviously lies in thorough, competent inspection. Occasional checks should be made of the contractor's grades, and the inspectors and the engineer (to the extent of his supervisory services) should follow grading operations closely, especially the backfill compaction at buildings, structures, and utilities.

Before proceeding with topsoiling and planting work, the contractor should submit to the Local Authority a certificate that all the grading work has been accomplished in accordance with the drawings and specifications. In the event revisions have been made, they should be listed with a statement on whose authority such changes were made and the reasons.

19. TERMITE PROTECTION

Subterranean termites become most numerous in moist, warm soil containing an abundant supply of food in the form of wood or other cellulose material. They often find such conditions beneath buildings where the space below the first floor is poorly ventilated and where scraps of lumber, form boards, grade stakes, stumps, or roots are left in the soil. Most termite infestations in buildings occur because wood touches or is close to the ground, particularly at porches, steps or terraces. Cracks or voids in foundations and concrete floors make it easy for termites to reach wood that does not actually touch the soil. The termite problem is aggravated by the fact that some lumber on the market is from young, second-growth trees which contain large amounts of sapwood. Such lumber is susceptible to termite attack. In any specific locality the problem depends upon such factors as nature of soil, moisture conditions, local building practices, wooded areas, rotted wood, limbs, stumps, etc.

Check to determine if termite protection is necessary in the general area of operations. This should be done by or at the expense of the Local Authority. Assistance may be obtained from the local County Agricultural Agent, local or regional office of the U.S. Dept. of Agriculture, and local reliable exterminator organizations. Check with neighboring homeowners, particularly those of older buildings and buildings adjacent to the project site.

Thorough treatment of the ground and protection of foundations during planning and construction phases is much cheaper and more effective than treatment after completion of construction and subsequent infestation.

Remove all wood forms, waste wood, lumber, tree-roots and limbs from within the building, along walls, piers, from under slabs-on-grade areas, cellar floors, crawl spaces and from all fill against building walls, piers, porches, etc. Remove tree roots from within 5 feet of foundation walls. Do not bury wood beneath porches, steps, terraces, in crawl spaces, under cellar floors and slabs-on-grade. Before construction work is started on the site, remove stumps and other wood debris from the building areas.

Give proper consideration to termite protection for the specific type of construction of the project in establishing first floor levels and the grades around the buildings. All wood elements should be above finished grade. Where wood forms cannot be removed, use metal forms.

One of the most susceptible types of construction, and one that often gives a false sense of security, is the concrete slab-on-ground. Termites can gain access to the building over the edge of the slab through expansion joints, openings around plumbing, and cracks in the slab. Infestation in this type of building construction is most difficult to control. In this type of construction, pretreat the soil with chemicals before pouring the concrete. This will prevent termites from entering through these openings; also to reduce penetration through these openings, fill them with roofing grade coal-tar pitch or rubberoid bituminous sealers.

Soil treatment is generally with water emulsions at specified concentrations. The chemicals and their concentration vary in different parts of the country and soils encountered. Consult with Local Authorities concerning type and kind of treatment known to be effective in that area.[1] It is particulary important to check with health authorities for acceptable treatment methods when there is any possibility of contamination of ground water.

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[1] See also FHA publication No. 376, Home and Garden Bulletin No. 64, U.S Department of Agriculture January 1960 and PHA Bulletin No. LR-13, Division 2, for additional guidance.

PROJECT GRADE DESIGN

CHECK LIST FOR GRADE DESIGN

1. FOR EFFECTIVE DRAINAGE:

a. Give continuous adequate slopes to all parts of the site not occupied by buildings; provide positive slopes away from buildings; provide good longitudinal, as well as transverse, slope in walkways, unless they adjoin paved gutters.

b. Avoid draining surfaced areas onto grassed areas.

c. Do not hesitate to use one side adjacent to a walk as a drainageway where that is definitely the simplest and most economical method of drainage and where the storm water flow will not be excessive. Provide swales paralleling walks where practicable.

d. Avoid swales crossing walkways; any drains under walks should be provided with a permanent means for easy cleaning of drain.

e. Avoid pockets from which the stoppage of a drain would cause damage to buildings or serious wash across grassed areas. If such pockets are unavoidable, provide overflow areas or duplicate drains, or take other adequate design precautions.

f. Provide storm sewers and sewer inlets, so far as feasible, to intercept concentration of storm water flow.

(1) In grounds areas, locate inlets adjacent to, but not within, walkways; provide a paved border between the gratings and lawns or plantings; set gratings about 3 inches below adjacent finished grade in small depressions that will collect the storm water.

(2) In roadways, relate the spacing of inlets to their capacity to receive the flow.

g. Divert or intercept from the site (or that portion of it to be developed) any drainage from off-site or unbuildable areas on approval of Local Authority attorney.

h. Don't increase the storm water runoff onto adjoining properties without prior approval of Local Authority attorney.

2. FOR EROSION CONTROL:

a. Utilize underground drains to the greatest feasible extent.

(1) Connect downspouts to storm sewers if they are available and the cost is not prohibitive; or, where feasible, provide downspout connections to discharge through roadway or parking area curbs. For on-site surface disposal, provide precast concrete splash blocks for dispersion and reduction of erosion.

(2) Work out grades to minimize damage if storm sewers are surcharged.

b. Keep water diffused over grassed areas so far as possible.

c. Provide sodded or paved swales if and as necessary, in open drainage channels.

d. Minimize the use of steep earth banks by:

(1) Using sloping grade line along buildings, instead of striving for series of more or less level benches. Caution where buildings do not have cellars (basements), first floors are slabs-on-grade or over a crawl space. Do not establish finished grades that are higher than the lowest row of weep holes of building wall.

(2) Giving building entrance walks comparatively steep slopes, in preference to light grades which would necessitate steps down to main walks.

(3) Using perrons or stepped ramps where practicable, in lieu of steps.

(4) Substituting retaining walls for earth banks when cost limitations permit and conditions are favorable.

e. Round the top and bottom of banks.

f. Divert drainage away from the top of earth banks and steep slopes, except when the drainage area is very small.

g. Preserve existing ground cover on large open areas where practicable.

3. FOR SAFETY AND LIVABILITY:

a. Where icy conditions occur frequently during winter months, try to keep walk and roadway grades well within recommended maximums.

b. Where an entrance walk is steep, round off the top to give a grade not exceeding 2% where the walk joins the building steps.

c. Avoid steps in yard walks; never use a single step in the walks.

d. Carry service drives across street sidewalks at sidewalk grade, rather than depressing the roadways and using curbs; but provide storm sewer inlets, where feasible, to prevent excessive storm water flow across the walks.

e. Avoid sharp breaks in grade and wavy profiles in walks and roadways.

f. Work out grades to insure preservation of trees which are to remain in place.

g. Provide positive drainage for crawl spaces.

h. Avoid hillside cuts with slopes that are not certain to be stable.

4. FOR ECONOMY IN FIRST COST:

a. Drain project areas directly into adjacent public streets so far as possible.

b. Strive for a reasonable balance of cut and fill.

c. At building sites avoid deep fills which would add materially to the cost of foundations. (This is mainly a site-planning consideration; where deep fills are necessary, the areas can best be used for playgrounds or parking areas.)

d. Keep grades as high as practicable where rock or water-bearing soil will increase materially the cost of utility installation. (Filling, made to this end, may result in simplified grade design and less need for storm sewers.)

e. In low density projects, preserve topsoil in place where practicable, avoiding cuts of but a few inches. However, if these areas will be traversed by construction equipment or might be contaminated by the storage of construction materials, it would be advisable to strip and stockpile the topsoil for future spreading.

5. COORDINATION OF UTILITIES

a. The Site Engineer should coordinate the location and elevation of all utilities, including those not designed by him. The coordination is to assure proper cover from finished grades and ascertaining of clearance at their crossings, relative horizontal locations, interference with surface structure, play areas, etc. This pertains to water, sewers, gas, electric (overhead and underground), telephone, telegraph, heating lines, impulse wiring and all services.

b. It is the Architect's responsibility to ensure that this is accomplished and to obtain the cooperation of all concerned.

SITE ENGINEERING

PART II - ROADWAY AND PARKING AREA PAVEMENTS

1. INTRODUCTION

The general layout of project streets, drives, and parking areas is fixed in preparing the site plan. The ensuing engineering work consists of selecting proper surfacing materials, establishing lines and grades, drafting roadway cross sections and other details, and preparing construction specifications and estimates.

This work should be done by an engineer experienced in pavement construction. Since these notes are prepared mainly for his reference, they outline the conditions bearing on pavement design which are peculiar to low-rent housing or which project maintenance experience has proved require special attention.

To the greatest extent possible, all streets and service road access facilities should be designed to meet the mandatory local regulations for dedication to the Municipality for maintenance. This requires that an early and factual investigation be made of applicable local regulations and that the basic street and service system be determined with these requirements in mind. Actual dedication of these facilities should be accomplished at the earliest possible date. Therefore, streets and roads to be dedicated should have grades, all construction details, and utilities approved by appropriate Municipal officials. Where local regulations are considered excessive to project needs, effort should be made to obtain a waiver to permit adequate and more economical construction (see paragraph 7g of this Part II).

Obtain from the Local Authority information on any prior waivers of local codes or regulations obtained by the Local Authority affecting the design of the project; also statement of any work, such as street improvements, to be performed by others and, therefore, not to be included in the construction contract for the project.

2. SUBGRADE

The subsurface investigation of the project site[1], as carried out by the Local Authority, will supply information useful in pavement design. Such information will necessarily be supplemented by field investigation on the part of the engineer, who must be in possession of all facts necessary to determine the need for subdrainage, subgrade stabilization,

[1] See Bulletin No. LR-2, "Subsurface Soil Investigations"

or a subbase for the pavement. The extent of filling for roadways will be ascertained as project grading plans are developed, and precautions can be taken toward insuring stability of the pavement. Even though project roadways are of limited extent, the experienced engineer will not neglect subgrade examination.

3. ROADWAY CROSS SECTION

The crowned roadway section with curbs is most commonly used for project streets and main driveways and, with the exception later noted, is the most desirable. Curbs have been omitted in some earlier projects, but with consequent extra expense for maintaining shoulders, side ditches, and pavement edges.

The dished or inverted-crown section has been employed extensively for service drives. It is economical as regards storm drainage and is adapted to carry drives across sidewalks at the sidewalk grade--a desirable arrangement. However, the dished section has met with some disfavor, chiefly because of the difficulty of accurately grading the central gutter. If the dished section is given a fairly good longitudinal slope, there need be little hesitancy in using it. The section is not recommended for other than service drives or for paving material other than concrete.

The side-slope section, with drainage to one side, has been employed advantageously in (cross-slope) projects to obtain a better adjustment of driveways to topography and to reduce storm sewer costs.

Recommended roadway crowns per foot of roadway width are as follows:

Section	Average Crown	Form of Crown
Crowned--service drives	1/4 inch per foot	Parabolic
Crowned--streets	3/16 " " "	Parabolic
Dished	3/8 " " " (Max.)	Plane
Side-slope (Cross-slope)	1/4 " " " (Max.)	Plane

4. CURBS AND GUTTERS

Roadway curbs have four functions, each important from a project maintenance standpoint: to control drainage; to keep wheeled traffic on the pavement; to protect pavement edges, adjacent lawns, and plantings; and to promote traffic safety.

Curbs are obviously not required to control drainage along dished pavement or the upper edge of the side-slope section of road. However, experience has demonstrated the need of curbs to keep cars off lawns and to protect persons, planting, fences, clothes-line posts, etc., located close to project drives. "Rolled" curbs are not effective for this purpose. A concrete curb of 5 or 6 inches in exposed height is recommended.

For concrete pavement, an integral curb serves the purpose of a "thickened edge," and its cost is, therefore, more or less offset by greater pavement strength. For bituminous pavement, curbing provides permanent protection of the pavement edge. Combination curb and gutter is preferred to plain curb, not only because concrete is a better material for the gutter, but there is less tendency for the curb and gutter to draw away from the pavement and permit water to reach the subgrade. The same compaction, drainage and base material used under the pavement should extend under the curb and gutter.

5. ROADWAY GRADES[1]

The site plan, in its relation to topography, obviously fixes within rather close limits the grades to which roadways must be built. As a rule, the engineer (grade designer) must simply obtain the most satisfactory slopes, maximum and minimum, that the plan permits. The grade design is normally developed as a whole, adjusting and readjusting building, grounds and roadway elevations until the best possible balance of all considerations is obtained.

Eight percent may be cited as generally the steepest desirable grade for roadways, although the maximum will depend considerably on street gradients commonly used in the locality. A 0.50% grade is considered the minimum desirable for straight or integral curbs, while with combined curb and gutter, permitting more accurate finishing, a slope of 0.40% is admissible. A grade of at least 0.60% is desirable for pavement of the dished cross section.

Vertical curves should be used where the algebraic difference between the gradients of intersecting grade lines exceeds 2.00%.

6. CURVE AND CURB RADII

Horizontal curves in roadways are fixed roughly by the site plan, and the engineer works out the precise measurements, including the curve data required for field location and street dedication plats.

[1]See Part I, "Project Grade Design," of this Bulletin.

Minimum curb return radii recommended for street and driveway intersections are:

Widths of Intersecting Roadways	Minimum Curb Radius
10 feet and 10 feet	25 feet
10 feet and 16 feet	20 feet
10 feet and 20 feet	15 feet
16 feet and greater widths	15 feet (use larger radius when designing for truck and/or bus traffic.)

7. CHOICE OF PAVEMENT TYPE

Two groups of surfacings are unsuitable for use in low-rent projects -- one because of high first cost, the other because of excessive maintenance. The former group includes pavement such as brick, which normally is laid on a concrete base; the latter comprises surfacings like calcium chloride-treated gravel or water-bound macadam, without a bituminous wearing course.

The choice of pavement type, therefore, will lie between bituminous surfacing and portland cement concrete, and if the former is decided on the engineer must select the class which from the standpoints of cost and durability is best adapted to the project. As a general rule, pavement for streets, roads, drives and parking should be of the heavy duty type. The principal considerations are the following:

a. Character of Project; Wheel Loads. High-density projects usually warrant or require a higher type pavement than those of low density.

b. Pavement on Filled Ground. A flexible pavement (bituminous) is considered safer than a rigid pavement for laying over new fills of any depth.

c. Local Materials and Local Construction Practice. With particular reference to pavements, the best product for the money will be obtained by selecting a type that permits fullest use of locally available aggregates and that local contracting organizations are equipped to lay and are experienced in laying.

d. Pavement Cross Section. As previously noted, concrete should be used for pavements of dished cross section.

e. Durability; Low Maintenance. Housing management seldom has the personnel or equipment which city street departments have to carry out regular pavement inspection and repairs. Consequently, the need for project surfacing repairs may be overlooked until disintegration has become serious. It is most desirable to lay a durable pavement.

f. First Cost. The consideration just mentioned must of course be related to reliable construction cost estimates of the surfacing types considered.

g. City Requirements. Streets paved under a project construction contract are frequently dedicated to the city, thus relieving the project of their maintenance. When this is to be the case, the street improvements must obviously be constructed to meet city requirements.

8. BITUMINOUS PAVEMENT

Bituminous pavement for housing projects has the advantages of pleasing appearance, flexibility, ease of repair, and sometimes low first cost. The last is not attainable if the pavement must be comparatively heavy -- consisting, for example, of a 2-inch plant-mix wearing surface on a two-course crushed rock base. Such a roadway, with curb and gutter, is likely to cost about as much as portland cement concrete. But in some localities surface-treatment or penetration methods, successfully adapted to inexpensive locally available aggregates, produce comparatively low-cost and wear-resistant surfacing which the Local Authority can hardly afford not to use.

The use of crushed stone or crushed gravel is preferred for base material because of its interlocking nature. In areas subject to freezing, the base material should not have more than three percent (by weight) of silt and clay fractions.

To prepare proper specifications for bituminous paving, the engineer must not only be thoroughly familiar with site conditions, but should have first-hand knowledge of local practice and all related conditions. The Asphalt Institute, College Park, Maryland, is available for guidance in preparing specifications.

The main disadvantage experienced with bituminous pavement in low-rent projects has been its frequently high maintenance cost. In most instances this has been attributable to the use of too light a surfacing, either as to base or wearing course or both, poor drainage, improper preparation of subgrade, and compaction. In some cases the fault has been poor workmanship (lack of competent inspection). Since bituminous pavement construction is a specialized line of work, the Local Authority should arrange for the full-time services of a qualified inspector.

(The limited supervision furnished by the engineer under the terms of the Architect's Contract is not enough.) Emphasize proper subgrade preparation, compaction, and drainage.

9. PORTLAND CEMENT CONCRETE PAVEMENT

The recognized merits of concrete pavement for project roadways are durability, low maintenance expense, and in many cases a first cost in keeping with low-rent housing.

a. Base Course. Provide base course where required to obtain adequate bearing and always where frost-susceptible subgrade soils occur in areas subject to frost.

b. Design. The engineer should use local standards as a generally safe guide in concrete roadway design. In addition to the transverse expansion joints as provided in the referenced paving guides, provide premolded expansion joints around manholes, drainage structures, and utility appurtenances within the pavement areas.

10. PARKING AREAS

The preceding discussion of roadway pavement design is generally applicable to parking area surfacing. Wheel loading on the latter is lighter, however, and pavement thickness may be slightly less.

Concrete pavement for parking areas should be confined, as a rule, to small bays adjoining concrete roadways. Elsewhere, bituminous surfacing is preferable because of its generally lower cost and more satisfactory appearance. For resisting disintegration due to oil drippings, it is recommended that the bituminous surface be sealed with a coal tar pitch emulsion or synthetic rubber, modified tar, or asphalt emulsion.

Maintenance experience has shown the need for curbing around parking areas. Wood bumpers of one kind or another have been used in some cases, but they are not as satisfactory as concrete curbs.

11. DRAWINGS AND SPECIFICATIONS

The "architectural block plans" usually show construction contract information regarding the location, surface dimensions, and grade elevations of roadways, parking spaces, and other surfaced areas. However, a special site plan showing roadway location data may be needed when streets and drives have very irregular alignment.

Roadway profiles should form a part of the design studies. Vertical curve data as well as other road grades should be shown in full detail on the block plans.

Details for concrete pavements should include complete layouts of joints -- expansion, longitudinal, and transverse contraction -- for parking bays and roadway intersections.

Specifications for pavements and surfacings may be shortened greatly by stipulating construction in accordance with certain city or State highway department specifications. Some such standard or standards will usually fit the project needs, and lower costs are likely to result from directly specifying pavement types with which local contractors are familiar. However, the city or State specifications should be examined carefully, and exception taken to any requirements that would be impracticable or unnecessary for the project work. When stipulating city or State specifications, a concise general description should be included. See paragraphs 1 and 7g of this Part II.

12. INSPECTION OF CONSTRUCTION

The need for competent inspection was mentioned previously in connection with bituminous pavement, but poor workmanship in project roadway paving has not been confined to surfacing of this kind. From the preparation of subgrade to completion of surface course, close inspection should be provided for all pavement laid. Furthermore, even though project roadways are of limited extent, laboratory testing of materials should not be ignored. At a reasonable cost, it provides an important form of insurance against poor workmanship.

The most thorough and complete drawings and specifications are of little value if proper workmanship is not performed by the contractors and if adequate competent inspection of the work is not provided.

SITE ENGINEERING

PART III - RECREATION AREA SURFACING

1. INTRODUCTION

The importance of proper surfacing for recreation areas was recognized at the inception of the public housing program. For early projects, the principal design guide lay in public playground practice, although the surfacing problem there is not altogether the same as in housing.

Much valuable information on recreation area design has now been obtained. Although there remains some difference of opinion as to the best surfaces for specific play uses, the divergent views are based on experience under differing conditions, especially as to climate. Majority opinion, as reflected in this Bulletin, appears fairly clear.

Satisfactory surfacing for recreation areas can be had only by: (1) a proper choice of surfacing type, (2) good drainage, (3) competently drafted specifications, and (4) first class workmanship. A deficiency in any of these factors may result in seriously impaired usefulness of the surfacing or the need for costly reconstruction.

The locations, dimensions, and proposed uses of recreation areas are fixed in preparing the site plan. This Bulletin deals with the surfacing for such areas.

2. SURFACING USES

From a use standpoint as related to surfacing, recreation areas in low-rent housing projects may be classified as follows:

a. Sports fields for softball, football, etc.

b. Game courts:

(1) Those requiring a hard surface -- for basketball, shuffleboard, hopscotch, etc.

(2) Those requiring a soft surface -- for croquet, marbles, horseshoe pitching, etc.

(3) Those for which a hard or soft surface is optional -- for paddle tennis, badminton, volleyball, etc.

c. Areas for roller skating and other intensive use by school-age children and adults.

d. Water play areas.

e. Play areas for small children:

(1) Yards for supervised play (mainly in turf).

(2) Areas close to dwellings, for play under parental supervision (surfacing optional).

f. Local play areas:

(1) Paved courts between apartment buildings.

(2) Other areas, surfaced or unsurfaced, for recreational uses.

g. Areas under fixed playground equipment.

h. Sitting areas:

(1) At apartment building entrances.

(2) Elsewhere, for common use.

(3) At individual dwelling entrances.

A given area may, of course, serve different recreational purposes, but its principal use or uses must be known before selecting the surfacing type.

Not listed above are certain areas which should be hard-surfaced merely because it would be impossible to maintain grass on them. Examples are strips between sidewalk and curbs, and miscellaneous small plots which would suffer from pedestrian short-cutting. While such areas are not planned primarily for recreational use, the surfacing problem is much the same. The esthetic value of grassed strips between sidewalks and curbs is fully appreciated. However, management experience indicates that only under the most favorable conditions, including low project density, is it practicable to maintain grass on such areas.

3. DESIRABLE QUALITIES IN SURFACING

There is no perfect surfacing material. The problem in each case is to select the material possessing the best combination of qualities for the particular use in the locality. The following desirable qualities apply to surfacings for all uses:

a. Year-round utility.

b. Freedom from dust and material that will stain or track.

c. Non-abrasiveness, minimizing cuts and bruises from falls.

d. Pleasing appearance. (Use of colored pavements for some recreational areas, sitting areas etc.)

e. Durability.

f. Availability at reasonable cost.

For "hard" surfacing, the following additional qualities are important:

a. Requisite smoothness for the intended use -- for wheel toys, games with bouncing balls, roller skating, etc.

b. Firmness of footing (dry or wet).

c. A degree of resilience.

d. Sufficient hardness to prevent scuffing or permanent indentation under use.

For bituminous pavements possible use of vinyl or acrylic emulsion seals for color in local areas.

Also use of resilient materials as rubber-asphalt and asbestos-asphalt emulsion surface courses with above type sealer in local play areas. Higher cost, but good appearance -- possibly usable in small children play.

4. CLASSES AND TYPES OF SURFACINGS

Following are the principal surfacings which have been laid on recreation areas in low-rent housing projects:

Class	Type
Earth	Turf Loam Sand-clay Clay-gravel
Aggregate	Gravel Stone screenings Granulated slag Shell
Bituminous	Penetration macadam Bituminous concrete Cork-asphalt (bituminous concrete and surface treatment)

Concrete and Masonry	Monolithic concrete Precast concrete slabs Flagstones Brick
Playground Cushion	Rubber Matting, Form Pads, Tan-Bark, Sawdust, Sand

Marked differences in specifications have added greatly to the kinds of surfacing laid. Bituminous surfacing has been of both asphalt and tar; and the asphalt has been of various kinds and grades.

Table I, on page 5, a summary of recommendations on recreation area surfacings, relates the above-listed materials to the uses enumerated on pages 1 and 2. The recommendations are subject to considerable adjustment for local conditions, as explained in the following brief discussion of the various surfacing types.

5. SUBGRADE

A thoroughly drained subgrade is important for every kind of recreation area surface. With turf and other soft surfaces (loam, sand-clay, etc.), effective subdrainage will increase the number of hours the areas can be used and decrease maintenance costs. With hard surfacings, subdrainage will minimize damage from freezing and thawing.

Generally speaking, money is better spent in improving the subgrade than in combating an unfavorable soil condition by constructing a heavy base. On plastic clay soils that are unstable when wet, a subbase of material such as pit-run gravel or stone screening will provide subdrainage and serve as a cushion against soil movement. Tile drains should be provided in conjunction with such a subbase.

6. TURF

Turf is generally recognized to be the nearest-to-ideal surface for large playgrounds. Its principal disadvantages lie in its unsuitability for use when wet or when the ground is frozen or thawing, and the difficulty of maintaining a stand of grass on areas that receive intensive use. Consequently, with the exception noted below, turf should be employed as a play surface only on relatively large areas in low- and moderate-density projects.

Since playground turf will be subjected to more severe wear than will lawns generally, special care must be taken in soil preparation. Otherwise, maintenance cost will be increased and the value of the playground permanently impaired. If by any means practicable, the establishing of turf should be undertaken soon after building construction starts. If possible, a cover crop should be grown and plowed under. In any case, the specifications for soil preparation, seeding, etc., should be related

TABLE I

Recommended Surfacings for Recreation Areas, Related to Project Density and Type of Dwellings[1]

Kind of Area	Low- and Moderate-Density Projects (Twins, Row-Houses, and Flats)	High-Density Projects (Apartments)
Sports fields	Turf; loam	Turf
Game courts	Sheet asphalt; bituminous concrete; portland cement concrete; sand-clay; turf (according to intended use)	Sheet asphalt; bituminous concrete; portland cement concrete; sand-clay (according to intended use)
Areas for roller skating	Bituminous concrete; portland cement concrete	Sheet asphalt; bituminous concrete; portland cement concrete
Water play areas:		
Spray surface	Portland cement concrete	Portland cement concrete
Border	Bituminous concrete	Bituminous concrete; brick laid over concrete base
Play areas for small children (supervised play)	Mainly turf, but with some portland cement concrete	Bituminous or portland cement concrete with open digging areas
Paved courts between apartment buildings	-	Sheet asphalt; bituminous concrete; portland cement concrete
Areas under fixed playground equipment	Light loam; sand; tanbark; sawdust; shavings; rubber matting; foam pads	Light loam; sand; tanbark; sawdust; shavings; rubber matting; foam pads
Sitting areas	Portland cement concrete; brick or flagstones on sand cushion	Portland cement concrete; brick; flagstones; asphalt block

[1] Surfacings are listed roughly in the order of their desirability under average conditions. The recommendations are subject to some adjustment for soil and climatic conditions, materials available locally, etc.

to the project construction program and the area should not be open to play use until a good stand of grass is obtained. It generally takes 6 or 8 months from the time of seeding to establish turf vigorous enough to withstand playground use.

(Pertinent to the preceding is the fact that considerable investigation has been made of economical means for establishing turf for hard wear, "gravelled turf" being a development in that direction. As a result, some authorities now lean, under certain conditions, to using the right kind of grass and commercial fertilizer on hard or poor soil, in lieu of the customary topsoiling process.)

Play areas for small children should be mainly in turf, although up to 1/3 of the area may be hard-surfaced if the unpaved portion will provide 400 sq. ft. for free play and sufficient use space for apparatus. Since these areas are quite small, they may often be sodded, rather than seeded.

7. LOAM

Loam and natural soil have seldom been employed as playfield surfaces in low-rent projects. Their advantages and disadvantages are too obvious to require mention, although it should be noted that dust nuisance can be abated effectively by calcium chloride applications.

8. SAND-CLAY, CLAY-GRAVEL

Clay mixtures have found their principal use in southern states where bituminous surfaces became quite hot in the summer. Such mixtures have been laid in the North also, but with rather less satisfactory results, partly because the break-up from freezing adds to maintenance and makes the surfacing unsuitable for use during a greater proportion of the year.

Sand-clay is most likely to be advantageous in localities where a suitable natural mixture is available and is in common use for playground surfacing, since laboratory control and mechanical mixing add greatly to cost. However, if mechanical mixing is required, the specifications should provide for the advance preparation of sample plots with different proportions of materials, to determine the best combination. It is suggested that the test mixtures contain 30%, upward and downward, of sand.

Sand-clay should be laid on a subbase of cinders, gravel, stone or slag to permit using the surface more quickly after rains. It is sometimes so laid with a compacted thickness of only 2 inches.

9. GRAVEL

Gravel surfacing is low in cost and pleasing in appearance, but the loose material must be swept off pavements and raked out of lawns; children throw it around; and weeds must be cleared out frequently. Gravel is considered unsuitable generally for any use as surfacing in low-rent projects.

10. SCREENINGS

Limestone screenings, granulated slag, cinders, shell, and similar materials have some of the disadvantages of gravel; moreover, they are abrasive and detract generally from appearances. These materials also are considered unsuitable for recreation area surfacing in housing projects.

11. BITUMINOUS SURFACING

For intensively used recreation areas, bituminous surfacing properly laid has important advantages: year-round usefulness, smoothness, firmness of footing, a degree of resilience, and a surface that can be marked for court games. Moveover, it is easy to repair and generally reasonable in first cost. In housing project experience, however, bituminous surfacing has frequently proved far from satisfactory. The reasons for this are noted in the following discussion, which covers the principal points meriting consideration in the use of this class of surfacing:

a. Limitations on Use. Bituminous surfacing has met objection in some localities because of its becoming soft, sticky, and too hot for bare feet in the summer. With the proper grade of asphalt cement specified, bituminous concrete should not become sticky or objectionably soft in midsummer. Bituminous surfaces are heat absorbing and may be drab in appearance. However these disadvantages may now be eliminated by applying a sealer or color coating to the bituminous surface on recreational or sitting areas. Bituminous surfacing should not be laid on small or irregularly shaped areas all parts of which cannot be reached easily with a power roller. Compaction by tamping is likely to result in poor workmanship -- in a rough surface and one that indents easily. Further, in the case of small areas, the necessary permanent edging increases materially the per-square-foot cost.

b. Base Course. The base course for bituminous surfacing consists commonly of well-compacted crushed rock gravel or shell with fines swept and rolled into the surface voids, or of bituminous concrete. The thickness necessary to provide a firm foundation for the surface course obviously depends on soil and climatic conditions (see the previous discussion of "Subgrade"). Four inches is the recommended minimum depth. Latest AASHO tests indicate best performance using bituminous concrete bases. Cost studies should be made of different sections to obtain optimum section -- including different bases and surfaces.

c. Surface Course. The most common defect in bituminous surfacing as laid on recreation areas has been roughness and abrasiveness -- a defect due in part to inappropriate surfacing types, improper surface sealing, poor workmanship, and lack of competent inspection. The bituminous wearing surface should be smooth, dense, impervious and finegrained. Sheet asphalt and bituminous concrete are preferably laid in two courses, having a total thickness of 2 inches. Base must be accurate as to grade with sufficient screeds or blocks for grade control.

Specifications for bituminous surfacing should be prepared with a full knowledge of the kinds of such surfacing laid locally in streets and roads, that is, of the kinds which local contractors are equipped to lay and for which aggregates are readily available. The specifications may often be shortened greatly by stipulating construction in accordance with city or State highway department specifications. However, such specifications should be examined carefully and any requirements eliminated that are not entirely practicable in their application to the project work.

d. Permanent Side Supports. Unless bituminous surfacing is laid against buildings, walks or other solid construction, permanent side supports of concrete, brick or steel curbing should be provided. Otherwise, ravelling is quite certain to occur, even though the base course is extended slightly beyond the edge of the top course. Wood side forms may be heaved by frost and at best are impermanent; they have generally proved unsatisfactory and should not be used.

e. Workmanship in Laying. The usefulness of bituminous-surfaced recreation areas in low-rent project has often been impaired by inferior workmanship. Specifying a suitable mix is in itself no guarantee of a satisfactory job. Apart from the general supervision normally supplied by the civil engineer, bituminous surfacing should be laid under the constant supervision of an inspector thoroughly experienced in that line of work.

12. CORK-ASPHALT

Cork-asphalt surfacing of both the hot-mix and surface-treatment types has been laid in a number of low-rent projects; and specimen areas of the two types and of different mixtures were laid on a large play area in a Washington, D.C. project. The hot-mix specimens show no sign of disintegration after ten years of use. Based on these tests, the tentatively recommended formula for hot-mix cork-asphalt is:

	Percentage by Weight
Ground cork, 8- to 24-mesh	5 1/2
Sand, graded as for sheet asphalt	71
Limestone dust	7 1/2
Asphalt, 70 to 85 penetration	16
	100

Cork-asphalt is slightly more resilient (or soft) than standard bituminous pavements, and slightly superior to sheet asphalt as regards abrasiveness. However, it is considerably more costly and rather more difficult to lay than hot-mix asphaltic concrete or sheet asphalt. Consequently, there is greater risk of inferior workmanship; cork-asphalt surfacing inspected on certain public playgrounds was not standing up satisfactorily in all cases. The material is recommended for use in low-rent projects only when it has been laid in the locality and its use has proved generally successful.

13. PORTLAND CEMENT CONCRETE

The advantages and disadvantages of concrete surfacing are too obvious to require emphasis. The advantages include year-round utility, minimum maintenance expense, and a smooth surface for roller skating, wheel toys and various court games. Among the disadvantages are hardness on the feet (lack of resiliency), glare (which may be lessened by dark coloring), and the necessity for contraction joints in other than small areas. For comparatively large, intensively used play areas, bituminous surfacing has been laid in far more projects than has portland cement concrete. For small sitting areas, concrete is, as a rule, decidedly preferable to bituminous surfacing.

14. PRECAST CONCRETE SLABS

To lend variety, precast concrete slabs (about 16 inches square and 2 inches thick) have sometimes been used for sitting-area surfacing. Laid with open joints, such surfaces have proved unsightly, dangerous, and difficult to maintain. If used at all, the slabs should be laid with tight joints and on a sand cushion. However, their initial cost is little less than that of a monolithic concrete slab and maintenance costs are higher.

15. FLAGSTONES

Flagging laid on a sand bed should be in large slabs that can not be removed by children, and joints should be tight. As a rule, there is little justification for using this type of surfacing except on special areas in high-density projects. In such instances, the flags should be laid on a sand cushion over a concrete base.

16. BRICK

Brick on sand cushion does not provide a surface smooth enough for wheel toys, court games, etc. However, brick surfacing is satisfactory for sitting areas and it furnishes needed color in ground areas. It has been laid in numerous existing projects -- sometimes successfully, sometimes not. Tight laying is important; otherwise children remove the brick. Edges of brick areas should be protected by solid curbing of concrete, steel, or brick set on end in concrete. Brick laid on a mastic bed over a concrete base makes an excellent surfacing for sitting areas, but, as in the case of flagstones similarly laid, is rather too costly to be provided in other than exceptional cases in high-density projects.

17. GRANITE BLOCKS

Granite blocks salvaged from old pavements have been utilized in low-rent projects in several eastern cities. They have been employed mainly for walkway edging, for surfacing the space between sidewalk and curb, and for covering other areas subject to severe wear. The blocks are altogether too rough for most play uses and are not very satisfactory for sitting areas. Reports indicate that, if used, they should be laid on a sand bed and with tight joints, rather than with open joints filled with topsoil.

18. FINAL CHOICE OF SURFACING

The recommendations contained in Table I above are, as noted, subject to adjustment for local conditions, and these should be investigated carefully. Bituminous surfaces should be specified with caution for laying in the southern states.

Local practice in surfacing school yards and park playgrounds is often worth investigating. Some locally employed type not referred to in this bulletin may be found suitable for housing project use; or check may be had on experience reported in this discussion. Local practice is necessarily based on locally prevailing conditions of every sort -- climate, availability of materials, skill in laying certain kinds of surfacing, etc. -- and useful information may be obtained.

Care in the selection of surfacing types is important. Decisions should not be perfunctory and should not be made without field examination or firsthand knowledge of the kinds of surfacing proposed for use.

SITE ENGINEERING

PART IV - WALKWAYS

1. INTRODUCTION

The general layout and widths of project walkways are fixed in the development of the site plan, the details of which are discussed in other PHA bulletins. Thereafter, in project grade design, walk grades are established and walkway steps located and dimensioned. This disposes of a major part of the design work in connection with project walks.

Portland cement concrete has proved generally to be by far the best material for walkways in low-rent projects. Concrete walks are satisfactory in almost every respect from a "use" point of view, and they require a minimum of maintenance. Other walk materials are discussed in this bulletin, but mainly to explain why their use is not recommended.

The following text refers to walks within the project site. Sidewalks in existing streets, or in streets to be dedicated, must be built to comply with local municipal standards.

2. CONCRETE WALK CONSTRUCTION

Concrete walks are built to a variety of specifications, but the trend in recent years has been toward (1) one-course construction (a 4-inch slab thickness is commonly used in housing projects), (2) omission of any subbase unless soil conditions are unfavorable (see paragraph 8 below), and (3) premolded expansion joints at intervals generally not exceeding 30 feet, at walk intersections, at top and bottom of steps, abutting entrance platforms, building walls and metal structures (see paragraph 6 below). Such construction has proved satisfactory and should generally be followed.

There is no prevailing practice, however, as regards contraction joints. In some places, metal separation plates are used to form full-depth joints, often spaced close to 5 feet apart. Elsewhere, grooves (dummy joints) one or two inches deep are similarly spaced. This latter practice, which has become quite common, corresponds to that widely used in highway construction; longitudinal grooves (dummy joints) are placed in the center line of walks that are over 6 feet wide; for walks over 10 feet wide the longitudinal joint should preferably be formed by metal separation plates for the full depth. Surface finish generally is wood-float or carpet-float type.

From a construction-cost standpoint, it is desirable to specify construction methods that local contractors are accustomed to and equipped to follow. However, fairly closely spaced contraction joints are recommended for controlling the location of cracks.

Air-entraining cement should be specified in severe climates where salt or calcium chloride may be used frequently for ice removal. The use of coloring compound in project walks may be justifiable. Exposed aggregate concrete walks may be used to provide interest at nominal extra cost where attractive aggregate and competent workmanship are available. In critical frost susceptible areas, it is recommended that a vapor barrier such as subgrade paper or polyethylene be placed on the subgrade before placing concrete.

3. BITUMINOUS WALKS

Bituminous walks present a pleasing appearance -- when they are kept in good repair -- and they can sometimes be laid at a cost comparing favorably with that of concrete. But experience with them in low-rent projects has been unsatisfactory. Roller operation has been difficult, if not impossible, over narrow walkways having frequent sharp intersections. Further, permanent side supports to prevent ravelling have generally been omitted, and lack of expert inspection has been reflected in faulty workmanship.

If and when laid, bituminous walks should be of a mix that will produce a smooth, dense surface. However, such walks should <u>not</u> be laid without permanent side supports (steel or concrete) or unless local experience in walk construction, preferably in nearby housing projects, proves that the difficulties cited above can be overcome.

4. PRECAST CONCRETE SLABS; FLAGSTONES

Stepping-stones, about 12 by 18 inches, have been laid to form house-entrance and other minor walks in various existing projects. These are usually laid 26 to 28 inches on centers. They are sightly, when well laid and maintained, but the stones are hard to keep at grade; children dig them up; it is difficult to wheel baby-carriages over them, etc. Minimum-width concrete walks can be built at little more cost and are far more satisfactory.

Closely-laid concrete slabs or flagstones cost at least as much as concrete walks and, excepting possibly the matter of appearances, are less satisfactory than monolithic concrete and more costly to maintain.

5. GRAVEL WALKS

Experience with gravel walks in low-rent projects has been wholly unsatisfactory. Children scatter the pebbles around and the binder tracks into houses. No such walkways should be specified.

6. ROUNDINGS

Experience has shown that roundings (or splayings) are needed for lawn protection at all walk intersections, with the possible exception of those at house entrance walks. Radius of the rounding may be approximately half the greater walk width. As a rule, an expansion joint should be located at the end of each such rounding; thus, at a right-angled intersection of two 6-foot walkways, there should be four expansion joints, each 6 feet from the intersection of the walkway centerlines.

7. VERGES

In certain high-density projects walkway verges (or borders) have been required to prevent destructive wear on adjoining grassed areas. Old stone paving blocks have been used for the purpose; since they are uncomfortable to walk on, they keep pedestrians on the concrete surface. A low curb serves the same purpose, although this is not so effective and could cause tripping.

8. SUBBASE, SUBGRADE

A subbase of gravel, cinders or similar material, under concrete walks, is unnecessary unless drainage conditions are unfavorable or the soil is soft or unstable. If provided, it is important that the subbase have adequate tile drain outlets. Subdrainage is important for walks, as well as for roadways, where the ground-water level is very close to the surface.

9. WALKWAY SLOPES

The <u>minimum</u> grade recommended for project concrete walks is 0.50%--1.00% for bituminous and building entrance walks. A 1.00% <u>minimum</u> is preferred, however, for all walks. The recommended <u>maximum</u> is 7-8% for main and 10% for entrance walks -- 6% in each case where snow and ice may prevail during a long winter season; and due consideration should always be given to the nature of the terrain and to the slopes commonly used in the locality.[1]

Sharp breaks in grade should always be avoided, and the drawings should show typical details of vertical curves in walks. In main walks, such curves may be fairly long -- 25 feet or more -- with forms set in short straight chords. In steep entrance walks, the curves will necessarily be quite short -- 6 feet, more or less, with top of forms curved to fit. Providing vertical curves in walks requires additional care in design and in staking the work in the field, but it adds only slightly to construction costs, and appearances are improved materially. Show detailed vertical curve grades to obtain desired results.

As a safety provision, walks within about 2 feet from the top and bottom of steps should have very little slope -- say, only 1/4 inch per

[1] See also Part I, "Project Grade Design," of this Bulletin.

foot. This may be accomplished, where a steep entrance walk joins a building platform, by level tangent extending from the base of the steps to a point of intersection of vertical curve, about 3 feet distant.

Walks should be cross-sloped (or crowned) not less than 1/4 inch per foot. The direction of cross slope, to fit the drainage scheme, should be shown on the grade drawings by arrow points.

10. WALKWAY STEPS

Avoid steps in collecting walks, if at all possible. While walkway steps, and the earth banks that go with them, are extremely undesirable, they are frequently unavoidable. When required, their location, rise and run are fixed in the project grade design. The rise obviously should be based on a uniform step throughout the project. A 6-inch rise and 12-inch tread, corresponding to a 2 to 1 slope, are commonly used although, where ground space permits, 3 to 1 banks with 5-inch by 15-inch steps may be considered preferable. (These observations do not apply to steps at building platforms. Where approach walks are laid quite close to row houses, steps at all such building platforms can seldom be kept of the same dimension.) Steps should be pitched slightly for drainage. An intermediate landing is desirable when a flight of steps rises more than 6 feet. Short sections of walkway should be provided between ends of steps and adjacent cross walks or drives.

Cheek walls along the sides of steps serve as beams and aid in keeping the adjoining bank in good condition. When not provided, erosion often leaves the step corners protruding in an unsightly and unsafe way.

Where there will be much storm water flow to the top of a flight of steps, it is recommended that a concrete gutter be cast integrally with the cheek wall on the down-hill side of the steps, that is, on the side toward which the connecting walk from above is cross-sloped. At its top, the gutter should be spread to intercept the storm water flow. Controlling erosion at the side of steps has always been a difficult problem, not only due to surface drainage but because children play and run their wheeled vehicles up and down slopes in these places.

Handrails are generally considered necessary for flights of yard steps containing 5 or more risers -- 3 or 4 where snow and ice are common during the winter months. A double rail is desirable so that one pipe will be low enough for small children.

Foundation walls (or posts) at top and bottom of steps should be carried down to undisturbed soil.

11. PERRONS AND STEPPED RAMPS

Stepped ramps, or perrons, are adapted to slopes up to about 5 to 1, over which a power mower can be operated. They are better for passage of bicycles and perambulators than are ordinary steps, but are recommended for use only where a walkway, without them, would definitely be too steep. The longitudinal slope of perron treads should not exceed 1/2 inch per foot, preferably 1/4 inch. For stepped ramps, the preferred is a 6-inch riser and 5-foot tread.

12. INSPECTION

Although walks comprise a simple phase of project construction, poor workmanship has caused trouble in various existing projects. Probably the most serious defects have resulted from poor finishing and inaccurate grading of forms, particularly where grades have been light. To this and other details of walk construction the engineer and inspectors should give close attention. (See Part II, paragraph 12, of this Bulletin.)

SITE ENGINEERING

PART V - SPRAY POOL DESIGN

1. INTRODUCTION

Water play facilities such as spray pools, wading pools, and improvised sprays are in use in many low-rent housing projects. Properly designed and constructed facilities are very popular with children and are a worthwhile addition to large high-density projects not served by comparable community or municipal facilities. Small low-density projects consisting of detached and semi-detached housing usually find little need for a special facility. The decision as to the need for a facility, as well as the kind of facility to be provided, should be made as early as possible in the project's design and only after consultation with the responsible municipal authorities. Failure to reach a timely decision in this matter usually results either in resorting to a makeshift facility at a later date, or in providing a prohibited facility. As a general rule, spray pools are preferable to wading pools, since the latter are considered to be a health hazard and are even prohibited in some localities.

Spray pool design is dealt with here for the sole purpose of pointing out design considerations which experience has shown to be significant. The principles set forth are appropriate to any water play facility.

2. POOL PAVEMENT AND BORDER

Field opinion is unanimous as to the need for a paved border at least 8 feet wide around the spray area. This border may be of bituminous material, concrete, or brick, and should pitch away from the pool. In no case should grassed or planted areas drain onto the spray pool pavement.

3. CONTROL VALVES

The water supply control valves must be secure from tampering by children, reasonably accessible, and within sight of the spray area. They may be located in a masonry pit with indestructible cover and lock, or in the basement of a nearby community building.

In addition to the cut-off in the supply line, there should be a globe valve, or a pressure-reducing valve, which can be adjusted to the proper flow (see Figure 1). When more than one large spray head is used, an individual control should be provided for each, as well as a valve on the main supply. The water piping must slope to a small drain valve which will permit draining the water from the piping after the water play season is over.

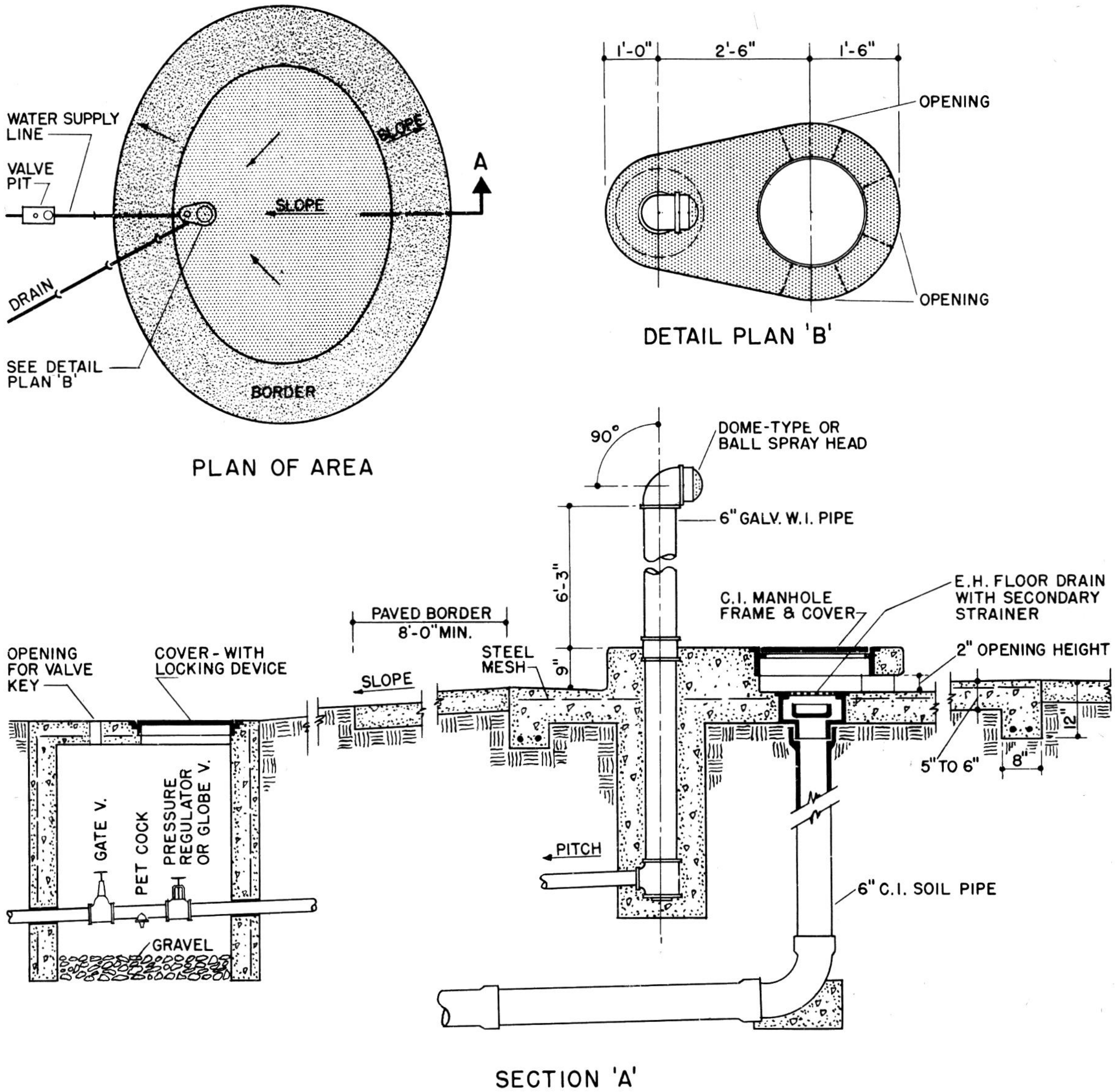

FIGURE 1 SPRAY POOL DETAILS

4. DRAIN

The spray pool drain should be of an anti-freezing type, and adequate in capacity to take the spray-head discharge without impounding more than an inch or so of water. Moreover, it should be secure against tampering by children and stoppage by sticks and stones. It may consist of a heavy, lock-type strainer with a secondary strainer, or a lock-type strainer set over a small catch basin; or it may be of some special design as illustrated in Figure 1. Long gratings, such as are used to intercept drainage from driveways onto sidewalks, may also be used.

The lock-type strainer should be a fine grating or a perforated plate, to keep the area as smooth as possible for other recreational use. If a catch basin is provided, it should be trapped, but a basin is recommended only when the pool drain must be connected to a combined sewer, since the standing water may provide a breeding place for mosquitoes.

It is important that sand boxes and spray pools be well separated; otherwise children will carry sand onto the pool area, from which it will be washed into the drain.

SITE ENGINEERING

PART VI - MISCELLANEOUS SITE IMPROVEMENTS

1. RETAINING WALLS

a. Where Needed. Housing projects on steep sites are usually planned in a series of terraces, with the transition from one to another made in part by the project buildings and in part by earth banks or retaining walls. The banks, because of their far lower first cost, are generally used.

In high-density projects, however, where land costs are high, retaining walls may conserve valuable space needed for recreational use, laundry drying yards, etc., space that otherwise would be occupied by banks. Moreover, retaining walls are sometimes essential in fitting a site plan to rugged terrain; and such walls, to the extent they are used in any project, eliminate the costly maintenance of earth banks.

Determination of the need for retaining walls is a combined site-planning and grade-design problem. In visualizing project grades as the plan is developed, the site planner can, to a large extent, determine if and where walls will be necessary. Then, as finished grades are established, the site engineer can make the final determinations and, in the detailed design, fix top, base, and footing elevations.

b. Special Considerations. Since civil engineers generally are familiar with retaining wall design, no discussion of wall stability, expansion joints, contraction joints, drainage, etc., is included in this bulletin. Noted below, however, are several considerations, based on planning and maintenance experience, concerning the provision of such walls in low-rent projects.

(1) Retaining walls with footings carried below frost line are comparatively costly structures. They have been used in some locations where they could have been avoided satisfactorily by finished grade adjustments.

(2) Reinforced concrete is generally the most economical material for retaining walls.

(3) Dry stone masonry, however, where suitable stone is available, is an economical and suitable material for walls of up to moderate height. As a rule, dry walls need not extend much below finished grade, although they should rest on undisturbed soil. See Part I, paragraph 10d, of this Bulletin.

(4) Where a slope must extend down sharply from a building to an adjacent walk or roadway, a low wall may be advantageous at the base

of the slope, to give needed berm along the building and/or decrease the length of slope. For such purpose, a dry wall, or a concrete wall in the form of a high curb, may be adequate.

(5) Elsewhere, at the base of a long steep slope, a low wall with a swale behind it is useful in intercepting storm water and containing eroded material.

(6) Fences should be provided along the tops of retaining walls, except in the case of low walls such as referred to in subparagraph (4) above.

(7) Again excepting low walls, also those of dry stone masonry, surface water should not be permitted to flow down the wall face.

(8) Fitting the ends of walls to finished grade usually requires wings extending back into the bank.

(9) Existing retaining walls, if any, to be left in place should be investigated for stability.

c. Retaining Wall Plans. In addition to showing wall sections, joint details, provisions for drainage, etc., the drawings should include an elevation (or profile) showing original ground line and finished grades along each retaining wall. This facilitates taking off quantities and checking wall dimensions.

2. CLOTHESLINE SUPPORTS

a. Planning Considerations. The layout of outdoor clothes-drying facilities is properly a feature of the site plan. Site engineers on low-rent projects should be familiar with recommended minimal requirements for these facilities and with certain data useful in their design.

(1) In tenant yards, clotheslines should never be strung from hooks set in the building walls. Where rear yards are very shallow, multiple lines may be strung parallel to the buildings and supported on posts with cross arms. Recommended line lengths, height, etc., are as follows:

Line length: 60 feet for one-bedroom units, 75 to 100 feet for larger units.

Line height: 6'-2", measured above finished grade at posts.

Spacing between parallel lines should be 18 inches.

Line Sag: Due consideration should be given to clothesline sag in order to minimize damage to clothes poles. Although the increase in clothesline sag will not particularly increase the length of the line, it will materially decrease the strain on the clothes poles. A sag of approximately 1/40th of the span will provide a safety factor over a clothesline without sag.

(2) In community drying yards, post-supported rails should be located on two sides of the area and wires strung between. Intermediate supports should be provided if the line length exceeds about 35 feet. Recommended details are as follows:

Line length: At least 20 feet per dwelling unit served.

Line Height: (As above).

Spacing between parallel lines: Alternately, 18 inches and 30 inches.

Space between posts and adjacent drying-yard fence or other obstruction: 36 inches.

b. Post Dimensions. Clothesline supports, in project design, have generally been sized largely by guess but on the whole fairly satisfactorily. Instances of flimsy section, requiring subsequent reinforcement by means of concrete piers, have been experienced; however, a minimum of 2-1/2 inch galvanized steel pipe has given satisfactory service.

Rolled H and I sections, as used by fence manufacturers, have been utilized as clothesline posts in numerous projects. Weighing slightly over 4 pounds per foot, their section modulus (around their major axis) is approximately 0.80. These sections have the advantage of practically indefinite life if they are galvanized. Steel angles and tees are not efficient sections for posts.

Steel posts should be galvanized after fabrication, although the latter is not necessary if galvanized materials are used and the members are not welded in fabricating.

3. FENCES

The location of project fences is fixed in the development of the site plan. While these notes deal mainly with design details, the subject can not be separated from certain planning considerations. The latter include fencing costs, project appearance, and the need for fencing as related to project maintenance and to the customs of the people to be housed.

TABLE I
Fencing Types and Heights

Fencing Uses	Appropriate Types[1]	Suggested Heights
1. On retaining walls	Chain link	4 feet
2. Boundary barricades along railroads, private property, around L.P. tanks, master gas meters, electrical transformer stations, maintenance material open storage, etc.	Chain link	6 feet
3. Clothes drying yard enclosures	Chain link	4 to 5 feet
4. Principal recreation area enclosures	Chain link	6 feet (more for special uses)
5. Pre-school children's play area enclosures	Chain link or wood	3-1/2 feet
6. Temporary protection of lawns and planting	Wire strand, one to three wires	2 to 3-1/2 feet
7. Permanent protection of lawns and planting	Wire strand, chain link, or post and chain	2-1/2 to 3-1/2 feet for wire strand; 3 to 4 feet for chain link; 2-1/2 feet for post and chain
8. Garbage collection platform enclosures	Chain link	4 feet
9. Tenant rear yard enclosures	Wire strand or chain link	2-1/2 to 3-1/2 feet for wire strand; 3 to 4 feet for chain link

[1] Discussion of each type is on the following pages.

a. Fencing Uses. Table I gives suggested fence types and heights for various uses. For uses 1 through 6 as listed, fences are as a rule considered extremely desirable, if not necessary. Permanent protective fencing (use 7) is generally needed around lawn and planted areas in multi-story-building projects, also often in special locations in row-house projects, such as diagonally between building corners and main walkway intersections, to prevent corner-cutting. Ultimate economy is best served by foreseeing where fencing will be needed, rather than by constructing it later, after lawns and planting have been damaged. However, decisions in the matter must often be influenced by construction cost limitations.

b. Tenant Yard Enclosures. There is considerable difference of opinion due to local conditions, as to whether tenants' rear yards should be fenced, or the plots marked off in some other manner, such as by shrubs, trees, clothes line supports, or markers in walks and building walls. Yards in the rear of a building are sometimes enclosed as a group, with no divisions within the group. Whenever tenant yard fencing is considered, management experience on operating projects (if any) in the locality should by all means be investigated. The most important consideration, however, will be that of cost limitations. As a rule, chain link fencing of individual yards must be regarded as an extravagant item and one which can be considered only (1) when local experience proves it is extremely desirable, and (2) when site improvement and other project development costs will be unusually low.

c. Temporary protective fencing may be provided by the lawns and planting contractor or by the Local Authority, depending on whether the contract calls for maintenance. In either case, such fencing may be required for a somewhat extended period and it is desirable that a uniform, sightly and adequate type of fence be erected.

d. Structural Screen Walls. Whenever the service side of a dwelling unit (kitchen-utility) is exposed to the street, a structural screen service area should be provided. Basic material used in the building should be reflected in structural screen walls. Two dwelling units should share one enclosed service area and it should be large enough and high enough to accommodate drying area, garbage cans and temporary storage for wheel toys and yard tools.

e. Chain-link fencing, although too costly to be employed for any and all purposes, is by far the most useful type in low-rent projects. Its advantages are a fairly long life and a tight barricade where such is required. Its disadvantages lie in reported high maintenance cost in some projects (with particular reference to yard gates) and appearance when used for tenant yard enclosures. Gates are generally considered unnecessary in openings in chain link fencing around laundry-drying yards, general play area, and garbage collection stations. However, despite maintenance considerations, gates are usually regarded as an important feature of tenant-yard fencing, if and when built. Chain link fabric should terminate 4 inches above finished grade. Vinyl-clad or aluminum chain link fence No. 9 gauge wire may reduce maintenance in some locations.

f. Wire-strand fencing, although sometimes extremely difficult to maintain, has been used successfully in many projects. It is often advantageous from the standpoint of appearance as well as cost, and has proved satisfactory built as follows:

Posts: 1-1/2 to 2-1/2 inch I.D. galvanized steel pipe with screw cap, or 2.7-lb. galvanized steel H or I section; posts 6 to 8 feet apart, with 2-1/2 to 3-1/2 feet exposed and 2-1/2 feet in concrete setting.

Strands: Two 1/4 to 3/8 inch, 7-wire twisted strands, at least 12 inches apart, top strand 2'3" above finished grade; strands strung through holes drilled in posts or, preferably, securely clamped to posts.

g. Wood fencing is not in all cases as durable and as sound an investment as steel or aluminum fence, but may be preferred for appearance, privacy, and to fit architectural concept. It is subject to defacement, burning, insect attack, and vandalism in some areas. Main connections should be bolted and the lumber should receive preservative treatment by a method that will not interfere with its being painted. Wood fencing may be of locust, cedar, or redwood posts set in concrete footings, with cedar or redwood rails, pickets, or slats--depending on locality. Red cedar posts and pickets do not require preservative treatment.

h. Post and Chain Fence

Posts: 1-5/8 inch O.D. galvanized steel welded or seamless pipe set in concrete footings.

Post caps on all posts should be gray cast iron and fastened to posts with a 5/8 inch cadmium plated drive screw.

Chain: Galvanized 3/16 inch steel link chain with approximately 10 links to the foot.

4. REFUSE AND GARBAGE FACILITIES

Selection of an appropriate refuse and garbage facility cannot be taken lightly since an ill-considered choice can result in an unsatisfactory and/or insanitary situation after occupancy of the project. Because projects vary as to size, building types, and location, no single type of facility--incinerator, individual, or group garbage station--can be considered appropriate for all situations. In addition, variances in municipal practices and capabilities in collecting and disposing of refuse and garbage add further complications to finding an appropriate solution. The optimum choice will usually be the one which provides a reasonable balance between initial costs and long-term maintenance requirements, encourages proper use and care by tenants, is compatible with the local municipal system, and does not present either an unsightly or potentially insanitary situation.

In what follows, there is no intent to express preference for any particular facility:

a. Incineration. The design considerations for incinerators are covered in Low Rent Housing Bulletin LR-7, Part XIX, and are therefore not covered in this Bulletin.

b. Individual Garbage Stations. When provided, the individual garbage station for each dwelling unit should consist of a substantial and elevated pad or pipe mounted rack. Its location should be convenient to the user and as unobtrusive as possible. The area around the station should be well drained with a durable, non-dusting surface, since there will be above average traffic at this area. In this connection, underground stations have shown themselves to be unsatisfactory because of the difficulty and expense of providing adequate drainage, their susceptibility to rodent intrusion, the difficulty of keeping the well clean, and the high rate of corrosion of containers.

c. Refuse Collection Stations

(1) Scope. The following notes consist of brief recommendations on the design of refuse collection stations when and where they are to be built--without reference to site-planning considerations and without discussion of the advantages and disadvantages of these stations in low-rent projects.

(2) Design Features. The principal elements of a well designed refuse collection station are:

(a) A concrete-paved platform, preferably with ridges or wood cleats on which the cans will stand, sloped to a central drain.

(b) Concrete foundation walls at least 18 inches deep and extended below frost line, with an outward projection of approximately 12 inches, as a barrier against rats' burrowing under the platform.

(c) Enclosure walls of brick or concrete, at least 3-1/2 feet high, with entrance through one end, or chain link fence and screen planting. (A wall is preferred--and one which harmonizes with building exteriors. At best, refuse collection stations detract in some degree from project appearance.)

(d) Water and sewer connections for cleaning and drainage. Drains should be properly trapped. See Part IX, paragraph 6, of this Bulletin.

Furthermore, some means should be provided, such as chain attachments to the walls, to prevent the loss of can lids.

(3) Quantity of Refuse. Data on the quantities of garbage and rubbish, the main components of refuse, from low-rent projects are not as complete as might be desired. The amounts vary in different sections of the country, and every effort should be made to obtain reliable information locally, especially from any existing projects. The following are believed to be fairly representative estimates of peak quantities, suitable for checking purposes:

Garbage (bulk, unwrapped): 2-1/2 gallons, or approximately 5 pounds, per family per day.

Rubbish: 3-1/2 gallons, or approximately 1-1/4 pounds, per family per day. (Ashes not included).

Combined Garbage and Rubbish: 5 gallons, or approximately 6-1/4 pounds, per family per day.

(4) Collection Station Capacity. Garbage is collected semi-weekly, if not more often, in most cities, although rubbish collection may be weekly. Having ascertained local requirements as to the separation of garbage and rubbish, knowing the collection intervals, and having made the best possible estimate on quantities (including ashes, if any), can capacity and requisite station dimensions for varying numbers of dwellings can be computed.

Twenty-five gallon cans (18" diameter x 26" high) are suggested as the maximum size for garbage, and 33-gallon cans (20-1/2" diameter x 33" high) as suitable for rubbish, or combined garbage and rubbish. The municipal department having jurisdiction should be consulted on can size, however.

The collection station platform should be of ample size. A little extra floor area and a few additional feet of wall will increase cost but little, while inadequate capacity will quite certainly result in unsightly and insanitary conditions. Moreover, refuse containers last longer and involve less maintenance and clean-up of spillage, if sized for at least 25% more than peak quantities. Provide concrete step or steps so that children may deliver refuse without spillage.

(5) Conclusion. Refuse collection station design should be undertaken only after obtaining all pertinent information available locally concerning refuse quantities and other conditions affecting the design. Collection stations, concededly far from an ideal means of getting rid of project refuse, have caused operating difficulties on many projects, and every precaution should be taken to minimize such difficulties when this method of disposal is to be employed.

SITE ENGINEERING

PART VII - WATER DISTRIBUTION[1]

1. INTRODUCTION

An ample supply of potable water is indispensable to "decent, safe, and sanitary housing" built under the United States Housing Act. Water must be available at adequate pressure, as well as in sufficient quantity, for domestic consumption, fire fighting, lawn sprinkling, and incidental uses. Stand pipes and tanks should be avoided as far as possible.

Urban low-rent projects are always supplied from operating water works systems and it is expected that nearly all rural nonfarm projects will be so served. Should a project be proposed in a place where there is no operating utility, decision as to source of water supply must obviously be made at the time of site selection. The responsibility of operating a water supply plant is one which the Local Authority should avoid, if possible.

Since water supply works, if any, in low-rent housing will be exceptional, these notes deal with water distribution only, and this generally is a simple engineering problem. Nevertheless, competence and attention to detail are essential in developing an efficient layout and specifying proper materials. The engineer's work should include a check on and an evaluation of the adequacy of the public water supply at the site.

2. EXISTING MAINS; WORKING PRESSURES

The site utility map furnishes certain information on existing water mains and working pressures needed for distribution system design. However, it ordinarily shows only the mains within or immediately adjacent to the site and unless these lines are of ample size and are connected to nearby feeders, they may not provide an adequate supply for the project, particularly for fire protection. If existing water mains require extensions to the site, or larger sizes, or other improvements in public streets, early knowledge is needed concerning what part, if any, of the cost must be borne by the project.

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[1]See also Part II, paragraph 1, of this Bulletin.

NOTE: This Part supersedes Part VII dated 2-20-51. The material has been brought up to date.

In any event, the engineer must be accurately informed regarding working pressures and capacities of existing mains, and the most reliable information can be obtained by fire-flow tests made at hydrants near the site. Upon request by the Architect, the Local Authority may have such tests made by the local water works or fire department.

3. METHOD OF WATER SERVICE; METERING[1]

Local regulations, unusual rate structures, or other conditions sometimes necessitate installing a meter on the service to each dwelling unit or to each building. Usually, however, water can be purchased at considerably less cost through a master meter by the Local Authority than through individual meters by tenants; so the former is the method commonly employed and, for the most part, that referred to in this discussion. Generally speaking, check meters on tenants' services, when water is supplied by the project, are not economical.

Water may be supplied (1) through a single master meter, (2) through two or more meters off different mains, with the lines interconnected for security against interruption of service, or (3) through "group meters" -- a separate meter for each group of buildings or dwellings. Under the last two methods arrangements should be made, if possible, to consolidate the meter readings and thus obtain a lower rate. In principle, the problem in each case is to determine the method of water service which, within the rate structure and any concessions negotiated, will result in minimum annual costs--water rentals, operating costs, and debt service considered. The distribution system design obviously cannot be undertaken until agreement is reached with the water department (company) as to the method of water service and the point(s) of delivery and metering.[2]

4. DOMESTIC WATER SUPPLY

a. Water Consumption. The average daily water consumption in low-rent projects varies widely with climatic conditions, type of dwelling, and habits of occupants, ranging from about 100 to 300 gallons per dwelling. For a specific project, the figure can best be based on records from existing projects (if any) in the locality, although 200 gallons is a fairly safe allowance except in more or less arid regions. Check with the Local Authority and the local water supply agency.[3] Water consumption, however, is usually not an important figure

[1] See Bulletin No. LR-11, "Selection of Utilities."
[2] See Bulletin No. LR-11, Part I.
[3] See Bulletin No. LR-11, Part II.

in project distribution system design. It is employed in studying the methods of water service described above, and in rare instances in considering special water storage facilities.

b. Peak Domestic Demand. Domestic water supply lines are sized to furnish the "maximum momentary demand" which may be expected to occur occasionally, due to the simultaneous opening of a number of faucets. The peak varies with local conditions such as climate, type of project, operating pressure in the mains, tenants' customs and occupations, etc., and cannot be estimated with any accuracy. Nevertheless, from data derived from various sources, Figure 1 has been prepared to show roughly, for design purposes, the maximum flows for varying numbers of dwelling units. The indicated flows are doubtless somewhat liberal for high-density projects and probably light for low-density projects in semi-arid regions, where the lawn-sprinkling demand is quite heavy. For cold-water distribution only (hot water distributed from central or group heating plants), about 25% may be deducted from the demands shown. It is advisable to check local experience before setting a value for peak demand.

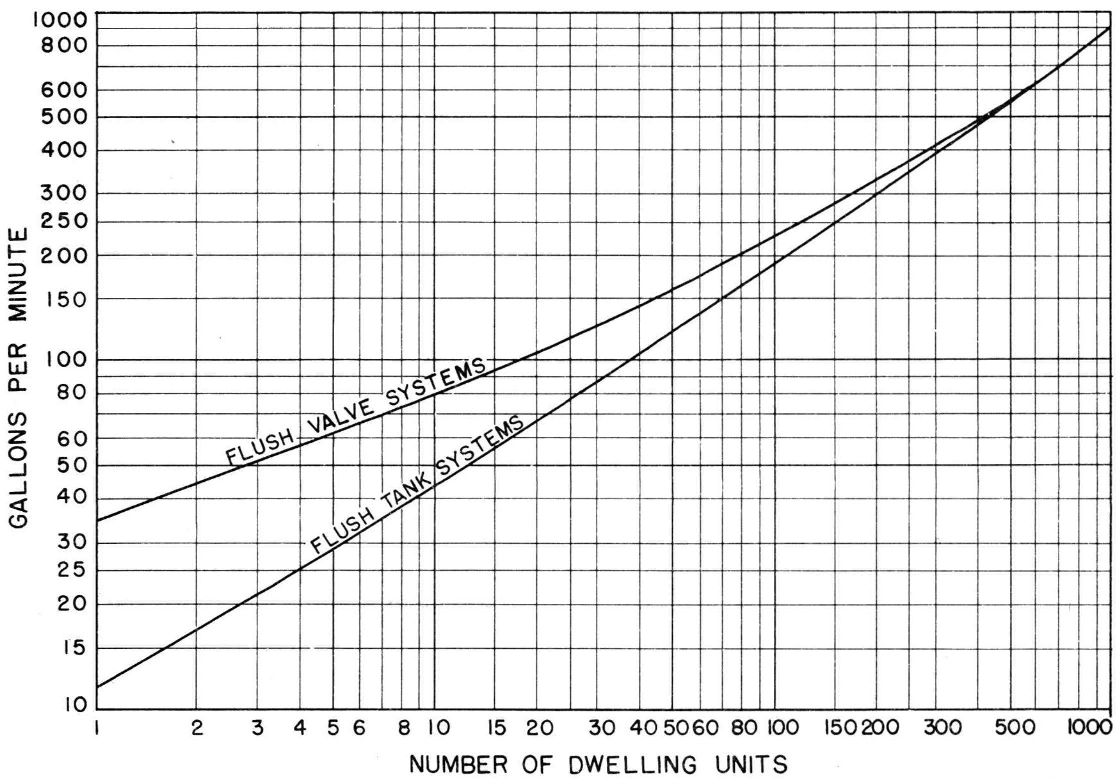

FIGURE 1 ESTIMATED PEAK DEMANDS FOR DOMESTIC WATER SUPPLY

c. Residual Pressure.[1] For sizing domestic water supply lines, the requisite minimum pressure at the building wall must be determined for each type of building proposed. This involves decision (or agreement between the distribution system designer and the building piping designer) as to how the available pressure drop will be split up, that is, how much will be expended in the distribution system and how much within the building. It will generally be found desirable, when practicable, to supply the peak domestic demand at building walls, at not less than the following pressures:

Service to one or two dwelling units only: 25 p.s.i. for 1-story buildings; 30 p.s.i. for 2-story.

Single service to a 2- or 3-story building: 30 p.s.i. for 2-story; 35 p.s.i. for 3-story.

Service to multi-story building: A pressure as high as feasible, that is, with negligible pressure drop in service line.

5. WATER SUPPLY FOR FIRE PROTECTION

a. Fire Flows. The flow of water required for fire protection depends on the characteristics of the project--its size, type and spacing of buildings, nature of construction, etc.; also on fire risks from adjoining properties and on the capacity of available pumpers. Subject to adjustment for these conditions and to modification in the light of advice received from the local water department or from engineers of the fire insurance bureau in the State, the following flows may be regarded as average requirements:

Type of Project	Fire Flow (Single Fire)
Three-story apartments or combinations	750 GPM from any one hydrant 1500 GPM from any two adjacent hydrants
Two-story row houses or flats	(Same as preceding)
Single-story row houses or two-story closely spaced	750 GPM from any one hydrant[2] 1000 GPM from any two adjacent hydrants
Detached or semi-detached houses, generally	750 GPM from any one hydrant[2]

[1] See Bulletin No. LR-7, Part XI.

[2] Adequate protection may be afforded by 500 GPM, especially if housing is of fire-resistant construction. However, most fire department pumpers are of 750 GPM capacity, and the supply at each hydrant should be such that a pumper cannot cause negative pressure in the mains.

Multistory building projects are usually in metropolitan areas where requirements regarding fire flows are well established. Rural nonfarm projects may be in places having limited water supply and distribution facilities. In such cases the designer should (1) provide a degree of fire protection consistent with that generally available in the community, and (2) recognize the fire risk in spacing buildings and choosing building materials.

b. Total Fire Demand. The preceding discussion referred to the flow at any specific location. For a large project, especially one on an outlying site, the total demand for water for fire protection should be related to the size of the project. This demand can be approximated from the following table:[1]

Approximate Number of Dwelling Units	GPM Required
250	1,000
500	1,500
1,000	2,000
1,500	2,500
2,500	3,000

c. Residual Pressure. At fire hydrants, the residual pressure at times of maximum fire flow can hardly be figured safely at less than 15 p.s.i. for engine streams. It should not be so low as to cause negative pressure at any plumbing fixtures in the project. When hydrant streams are direct, the residual pressure at hydrants should, if possible, be not less than 50 p.s.i.

d. Fire Hydrants and Hydrant Spacing. Fire hydrants in housing projects are commonly spaced 300 to 400 feet apart and, when practicable, are so arranged that every building can be reached from two hydrants with a maximum hose length of 300 feet from each. A good check on hydrant spacing may be made by noting the area served by each hydrant: it should not exceed 120,000 sq. ft. for low-density and 100,000 sq. ft. for high-density projects. (The preceding statements apply to fire protection by engine streams. For direct hydrant streams, a special determination, based on the available residual pressure, is necessary.) It is important that fire hydrants be connected to unmetered water mains.

To permit pumper connection by a single length of suction hose, hydrants should be located not farther than 7 feet from a surfaced roadway. However, when the roadway does not have curbing, it will be to the interest

[1] Based on "Table of Required Fire Flow," the National Board of Fire Underwriters' "Standard Schedule for Grading Cities and Towns."

of safety to set hydrants back about 6 feet from the edge of the surfacing. Hydrants should never be located within 25 feet of the building protected; 50 feet is the preferred distance. Do not install fire hydrants where parking areas and loading areas will become inoperative by reason of their existence there.

It is important that the local fire department be consulted regarding the type of fire hydrant and the hose-coupling thread to be specified, also the proposed locations of hydrants. Hydrants installed in housing projects usually have a 5-inch valve opening, two hose nozzles, one pumper nozzle, and 6-inch connection to the main. Hydrants along the boundary streets should usually be installed by the municipality (check the Cooperation Agreement).

6. GENERAL LAYOUT OF WATER LINES

a. Fire mains, as a rule, can best be located along streets and main drives, since that is where the hydrants are set. To facilitate repairs, they should be in the grassed area at one side of the pavement and at a generally uniform distance from the curb. An irregular layout, with mains angling here and there across yard areas, should be avoided. Preferably fire mains should be looped, in order to eliminate dead ends. Consultation with the local fire or water department regarding water main location and sizes is generally advisable.

b. Domestic supply lines should, in general, be laid out in whatever way will minimize pipe quantities, but their location must be carefully coordinated with that of other utilities--sanitary sewers, storm sewers, electric, heating lines, and gas. For row-house projects, comparative layouts and estimates are needed to determine the arrangement of utilities that will be most economical, with building spacing and grade conditions taken into account. The various utilities should be spaced sufficiently to permit laying each in a separate trench. Avoid street washers in play areas. Wherever possible, water mains and services should not be under pavements (to facilitate maintenance).

7. HYDRAULIC CALCULATIONS

a. Flow Diagram. For convenient reference, a comprehensive flow diagram, Figure 2, "Flow of Water in Pipes," based on the Hazen and Williams formula, is included in these notes.

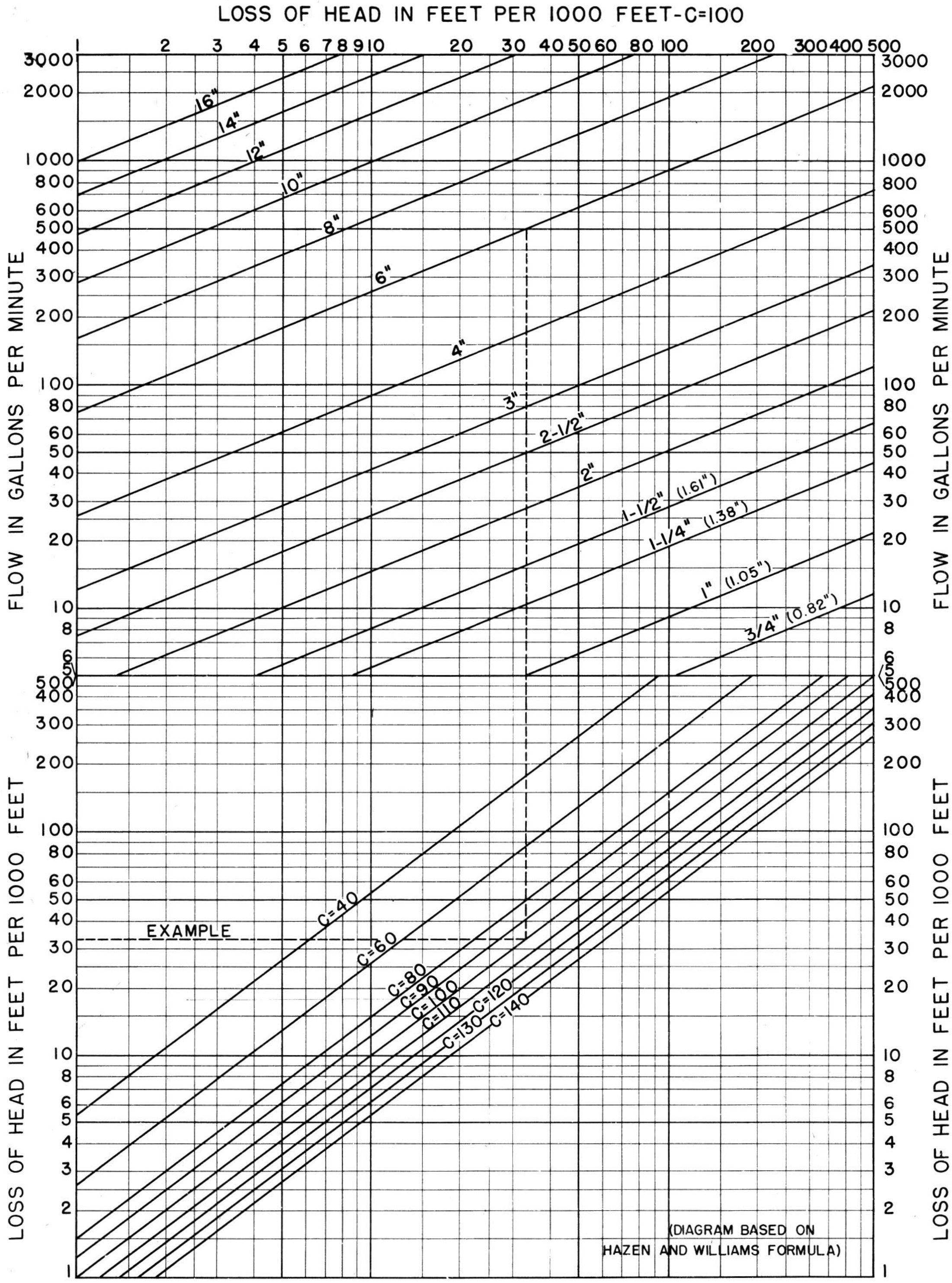

FIGURE 2. FLOW OF WATER IN PIPES

The value of the coefficient "c" to be assumed in using the diagram must take into account the probable reduction in carrying capacity of the pipe during a period of at least 40 years. While this is quite difficult to estimate, the determination must obviously be made jointly with the selection of pipe materials[1] and it should be based on information as to how city distribution lines have sustained their carrying capacity over long periods. Such experience cannot supply conclusive evidence concerning pipe that has come into use during comparatively recent years. For the latter, the chemical analysis of the water, its aggressiveness as measured by its action on other kinds of piping, and any short-term experience will serve as guides. In any event, conservative assumptions are warranted, since water lines lose capacity from sedimentation, mineral deposits, and vegetable and animal growths, as well as from corrosion. Moreover, the coefficient must cover loss of head due to valves and fittings; and cement lining, when used, reduces appreciably the sectional area of flow. It is suggested that except where there is good evidence to the contrary, the coefficient assumed for tar-coated cast iron pipe be not higher than 80, and that for no other material be higher than 110.

b. Available Loss of Head. Pipe sizing is of course based on the available pipe-friction loss between the point of supply and that of delivery within the project. The loss is fixed by (1) the initial pressure, that is, the minimum pressure which ordinarily may be expected at the point of supply during hours of high water consumption, (2) the pressure loss through the master meter, (3) the requisite residual pressures at building walls and at fire hydrants, and (4) the pressure gain or loss due to difference in ground elevation.

c. Pressure Loss Through Meters. Figure 3, "Pressure Loss Through Water Meters," shows approximate pressure losses through disc, compound and fire-service meters at different rates of flow. Compound meters are most often installed as master meters in housing projects. Meters may frequently be one size smaller than the line in which they are installed.

d. Line Sizing. It may be assumed safely that the domestic water supply demand will be comparatively light in case of a serious fire in the project; and that, for other than large projects, the average domestic demand is negligible in comparison with the maximum fire demand. Generally, therefore, mains on which fire hydrants are located may be sized for the peak fire demand; then, with the sizes of these mains known, the remaining lines may be sized for the maximum domestic demand, with no allowance for fire flow. The following is a suggested procedure for determining domestic supply pipe sizes:

(1) Select first the longest run of piping from the point of supply to a building or dwelling unit.

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[1] See paragraph 8 below.

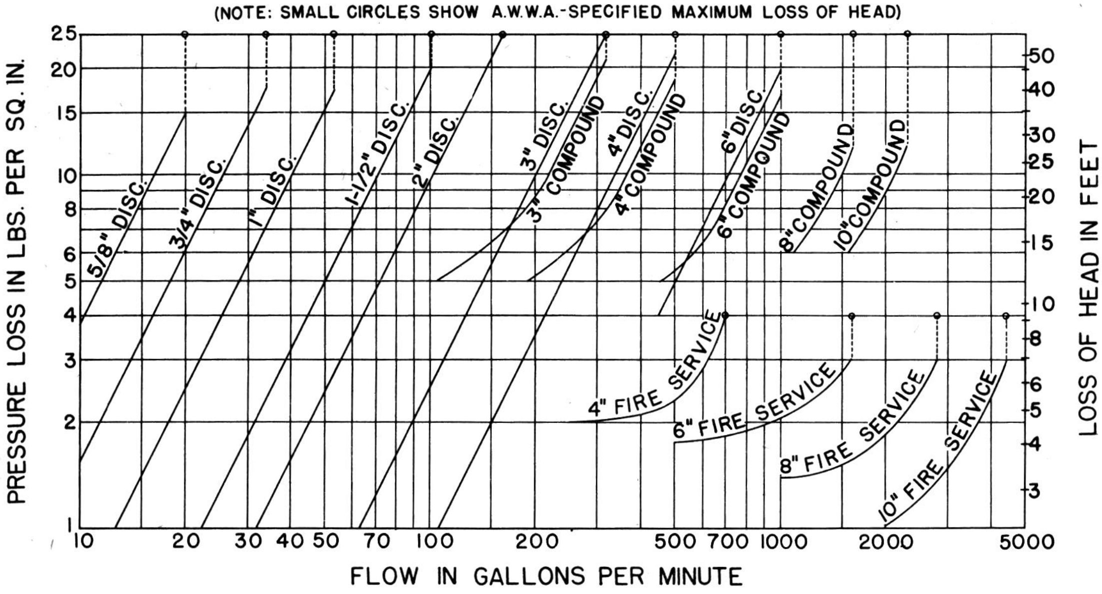

FIGURE 3. PRESSURE LOSS THROUGH WATER METERS

(2) Note the number of dwelling units served at critical points along this line and from Figure 1 find the maximum momentary demand at each such point, thus determining the maximum flows in various sections of the line.

(3) Assume pipe sizes and determine corresponding pressure drops, repeating the process until the total drop approximates the available pipe-friction loss in the line.

(4) Follow the same procedure for shorter runs in the system, but maintain reasonable uniformity in sizing.

8. PIPE MATERIALS

Obviously, underground water pipe should, if practicable, be of materials which will not require replacement for a period of at least 40 years. In principle, the selection of materials should be based on comparative estimates of annual costs - interest, replacement and maintenance. Practically, the most economical pipe materials are generally those which quite certainly give the longest service. Trenching and pipe laying comprise a considerable part of the total cost of the pipe installed, and a definitely superior material may add but a small percentage to total cost. It is most important to avoid a perfunctory choice of pipe materials, without thorough consideration of all available information. Any discussion of the theory of corrosion or the various conditions (of soil and water) influencing its rate is beyond the scope of these notes, which are confined to a brief summary of special considerations and suggestions as to practice.[1]

a. Internal Corrosion and Incrustation. Generally speaking, soft waters (1 to 60 p.p.m. of hardness), such as found in New England and along the south Atlantic coast, are quite corrosive, while harder waters are less so, the alkaline salts being precipitated to form a protective coating on the pipe wall.

(1) For water mains, cast iron pipe has been used generally in projects. The pipe has been cement-lined in some cases, but more often has had coal tar pitch coating. Tar-coated pipe is known to tuberculate rapidly with very aggressive waters. Unless local experience indicates that with such pipe the coefficient "c" will not drop below about 80 during a 40-year period, cast iron pipe with cement (or enamel) lining, or cement-asbestos pipe, may best be used. It should be practicable, economically, to specify a material for mains that will render satisfactory service for the life of the project. Cement-asbestos pressure pipe for mains is in successful use.

(2) For services and other small-sized lines (3/4-inch up to 2-1/2-inch), the problem may be more difficult, as to both perforation and chokage. Small piping used in existing projects has, in large part, been Type K copper tubing. However, lead, brass, galvanized wrought iron, cast iron, Commercial Standard 197 flexible polyethylene and Commercial Standard 207 rigid unplasticised polyvinyl chloride pipe have been laid in a number of cases. (The use of galvanized steel pipe for underground lines was confined mainly to war housing.) Lead pipe is generally limited for use as goose-necks.

(3) The possible effect of pipe material on the quality of the water, due to the dissolving of minute amounts of the metal (iron, lead, or copper) requires consideration in some cases. Protection against iron discoloration ("red water"), where such protection is necessary, can be had by cement lining. Lead pipe should be specified only when local experience or experiment has proven that it can be used safely, since lead may be picked up by very soft waters high in carbon dioxide and its salts are very poisonous. (U.S. Public Health Service Drinking Water Standards state that lead present should not exceed 0.1 p.p.m.) Copper also may be attacked by soft, acid waters. The amount of metal dissolved is unlikely to approach the 3.0 p.p.m. permitted under U.S.P.H.S. Standards, but a much smaller quantity may be objectionable in staining fixtures and laundry; also in causing perforation of the tubing.

b. External Corrosion. This topic refers mainly to soil or galvanic corrosion, as electrolysis is seldom a problem in piping laid within project sites.

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[1] See Part VIII, paragraph 11, of this Bulletin.

(1) Resistance to Corrosion. Extensive tests have shown that: (a) the commonly used ferrous pipe materials do not differ greatly in their resistance to soil corrosion; (b) the rate of pitting, however, decreases with time -- hence additional thickness of metal adds, in greater than direct ratio, to the life of the pipe; (c) in most soils, copper and red brass (85% copper, 15% zinc) corrode much more slowly than do iron and steel and the corrosion is more uniform; (d) wet, organic soil in which sulphites are present is especially corrosive to copper; (e) lead generally corrodes more rapidly than copper but more slowly than ferrous metals; and (f) Commercial Standard 197 flexible polyethylene plastic pipe and Commercial Standard 207 rigid unplasticised polyvinyl chloride pipe have shown no visual corrosion due to soils of any degree of corrosiveness.

Soil corrosion, like internal corrosion, should seldom be a serious problem with water mains, since the wall thickness of the pipe (if cast iron) is sufficient under ordinary conditions to withstand pitting for a long period. With services and other small domestic supply piping, wall thicknesses are less and the possibility of complete penetration is much greater.

(2) Conditions accelerating soil corrosion include variation in moisture content and in soil characteristics, and dissimilarity of materials (electrically connected). An example of the latter is copper tubing connected, without insulating coupling, to cast iron pipe. Corrosion of the iron will be accelerated. However, when the copper (cathodic) area is very small in comparison with the iron (anodic) area, e.g., a brass valve in a ferrous service line, the corrosive effect may be slight.

(3) Cathodic Protection.[1] When the soil at the project site is known to be corrosive, the Local Authority may well retain a corrosion engineer to (a) advise regarding gas and water distribution system materials, (b) determine whether cathodic protection is necessary and, if so, (c) decide whether for the gas system only or for both gas and water, and (d) design and supervise the installation of the cathodic protective system.[2]

Cathodic protection of water lines will become far more important should emergency regulations prohibit the use of copper pipe. Although the cathodic protection may not be installed until some time after general construction is completed, the possible need for it must be foreseen when the distribution system is installed, so that jumper wires

[1] See Bulletin No. LR-7, Part V and Local Housing Authority Management Handbook Part V, Section 7, Maintenance of Underground Utilities.

[2] See Part VIII, paragraph 11, of this Bulletin.

can be provided around cast iron pipe joints and the project piping can be insulated from the public water works system.

c. Local Experience. The corrosion of underground water lines, internally and externally, is caused by numerous interrelated factors, and it is impossible to predict with accuracy the effect of a given water or soil on different pipe materials. However, the city water works system is in effect a laboratory in which various kinds of piping have been tested, often over long periods, and the results of such tests should comprise the most reliable guide in the selection of pipe materials. This is not to imply that local practice should be followed perfunctorily, that all pipe materials will have been tried out adequately, or that recommendations received may not be influenced by personal preferences. Expert interpretation of results may be needed, with attention to special soil conditions at the site and to possible future changes in local water purification methods.

A few Local Authorities have initiated corrosion detection and control programs and may have formed sound opinion as to the kinds of water piping that should be installed for additional projects.

9. DISTRIBUTION SYSTEM APPURTENANCES[1]

a. Meter Installation. Master meters are provided sometimes by the water department, sometimes by the Local Authority; in either case, the installations must meet water department requirements. Master meters should have by-passes and, if service is through two or more meters at different points in the project and with interconnecting lines, a check valve should be provided at each meter. Meters are occasionally located in building basements, but more often in concrete vaults. Vaults should be drained by a pipe leading to the ground surface nearby or to a storm sewer (if there is no possibility of backwater); or a dry well may be provided.

b. Valves. Valves (including stops) are recommended (1) at intervals of not more than 800 feet in all mains, (2) in branch lines near their points of take-off from larger lines, and (3) in all services. Valves in hydrant branches should be provided according to local practice. A uniform position of valves throughout the project--for example, in line with curbs, street sidewalks, or buildings--should be maintained. Pressure reducing valves should be installed on water mains to keep the water pressure as near 50 pounds as possible in dwelling units. Individual pressure reducing valves should not be used unless design precludes use of main line reducing valves.

[1] See "Fire Hydrants and Hydrant Spacing," paragraph 5d above.

c. Provision for Watering Lawn Areas. Hose bibs should be located around the perimeter of buildings in such a manner that all lawn and planting areas can be reached by 100 feet of hose.

10. PROTECTION OF WATER SUPPLY

Since water for low-rent housing projects is obtained almost always from public water works, it may be assumed to meet local health department standards and to be safe and potable. While the possibility of its becoming contaminated within the project distribution system may seem negligible, water mains are not necessarily always under pressure and they cannot be kept absolutely watertight, especially at joints. The following precautionary measures are, therefore, recommended:

a. Design Measures. These consist of items to be incorporated in the drawings and specifications.

(1) Lay water, electric, and gas lines and sewers in separate trenches and keep the trenches well separated.

(2) In the event sewer and water lines must be laid in the same trench, bench the water piping on undisturbed earth well above the sewer and make the sewer water-tight.

(3) Lay water lines, so far as practicable, at a higher elevation than sewers; provide adequate support where one line spans the trench of another. However, minimum depth of water mains and services should be below frost line and at such a depth that the pipe will not be damaged by traffic, equipment, planting and utilities.

(4) Avoid using stop-and-waste cocks; in any event, do not install them below ground water level or at less than adjudged safe distance, soil conditions considered, from a sanitary sewer.

(5) Avoid any direct connection between the water distribution system and the sanitary sewer system. (This refers to water connections to flush tanks, sewage pumps, etc., and sewer connections to meter vaults, fire hydrant drains, etc.). Provide proper supports for pipes and appurtenances in unstable ground.

(6) Size fire mains large enough to deliver, under positive pressure, the maximum draft that will be imposed on them by fire department pumpers -- this to obviate the possibility of polluted ground water being drawn into the mains through minute leaks.

(7) Use sterile yarning material; if braided hemp, sterilize it on the job. Do not use jute.

(8) Provide for thorough flushing and effective sterilization of the distribution system after completion.

(9) To retard corrosion, protect all underground steel and wrought iron piping in accordance with the provisions of Low-Rent Housing Manual Section 207.1, paragraph 8.

b. Precautionary Measures in Distribution System Installation. These include all customary precautions to keep pipe and appurtenances reasonably free from dirt and trench water while they are being installed.

c. Health Board Regulations. The drawings and specifications for the water distribution system should, of course, comply with State or other health board requirements and any requisite approval obtained.

SITE ENGINEERING

PART VIII - GAS DISTRIBUTION[1]

1. INTRODUCTION

Gas main extensions in urban areas can seldom be sized with precision since population growth and future uses of gas are extremely difficult to foresee. It is considered better practice to install pipe a little larger than necessary than risk its proving too small. In public low-rent housing, however, the situation is somewhat different: the exact number of families to be housed is known and the uses of gas are predetermined. From this basic knowledge a reasonable approximation of the peak demand is possible and a closer determination of pipe size is warranted. Gas lines must be sized amply as a safeguard to life and property, but wasteful overdesign avoided.[2]

The sizing of mains, however, is but one feature of the preparation of drawings and specifications for gas distribution systems. The task should not be performed perfunctorily, as careful study and investigation are required in many details. The principal points to be considered, together with recommended practice, are outlined in these notes which refer to piping for natural and manufactured gas distribution. Liquid petroleum gas systems should be designed and installed in accordance with National Fire Protection Association Standards, current edition of Pamphlets Nos. 58 and 59. Where local codes are more restrictive, the local code should be used.

2. EXPLANATION OF TERMS

a. Gas distribution pressures are classified as follows:

<u>Low</u> -- up to about 15 inches of water column, generally 3 to 9 inches (one inch of water column equals 0.578 oz. per sq. in.)
<u>Intermediate</u> -- from 1 to approximately 15 lbs. per sq. in.
(<u>High</u> pressure mains, which generally carry pressures of 50 lbs. per sq. in. or more, are not used in public housing projects.)

b. The specific gravity of gas is the ratio of its weight to that of air, with air at 1.00. Manufactured gas generally has a Sp. Gr. of

[1] (See also Part II, paragraph 1, of this Bulletin)
[2] See Bulletin No. LR-11; Bulletin LR-7 Part V; and Local Housing Authority Management Handbook Part V, Section 7.

NOTE: This Part supersedes Part VIII dated 4-3-51. The material has been brought up to date.

from 0.40 to 0.70; natural gas from about 0.55 to 0.65 for "dry" gas, and 0.65 to 0.85 for "casinghead" gas. The capacities of meters and regulators, and the flow of gas through piping, vary inversely with the square root of the Sp. Gr. of the gas. Thus, with equipment capacity ratings based on 0.60 Sp. Gr., factors such as follow should be applied to the ratings:

For Sp. Gr. of 0.45, a factor of 1.15
For Sp. Gr. of 0.85, a factor of 0.84

c. The heating value of gas is expressed in BTU per cubic foot at a reference temperature and pressure base at which a utility company sells gas. The standard cubic foot will be defined in the utility company tariff. A few of the more commonly used standard cubic feet are:

Temperature Base	Pressure Base
60 deg F	14.65
"	14.7
"	14.73
"	14.9
"	15.025

The heating value of natural gas will normally vary at the point of sale from 950 to 1050 BTU (per cubic foot).

d. <u>One therm</u> equals 100,000 BTU.

3. METHOD OF GAS SERVICE[1]

a. <u>Project Purchase</u>. The gas supply for public housing projects is usually obtained by project purchase, the utility company delivering the gas at a metering station or stations located near the border of the site. These notes apply mainly to that method of service.

b. <u>Number of Connections</u>. Gas may be supplied through a single connection, with its master meter or meters, or through several independent connections - one for each block or group of buildings. Where there are existing gas mains in various abutting streets, the "group-metering" method may result in considerable saving in initial cost. However, unless meter readings can be consolidated, the resultant higher gas cost may far outweigh the possible saving in first cost. A centrally located point of delivery will minimize project distribution system costs, but no one existing main may be of sufficient capacity to deliver the entire supply at a single point.

[1] See also Bulletin No. LR-11, "Selection of Utilities"

c. Service Contract. The service contract or published tariff under which the utility company furnishes gas service will usually stipulate (1) the point or points at which gas will be delivered, (2) whether existing gas mains require extensions to the site or other improvements, and the part, if any, of the cost which must be borne by the project (see Low-Rent Housing Manual Section 205.1), (3) the maximum and minimum pressures that will be maintained on the project side of the meters at the delivery point or points, (4) the minimum BTU content of the gas, (5) the price of gas under one or more rate schedules, (6) whether there is to be firm or interruptable service, and (7) the basis of interruptable service including standby equipment requirements. This information is prerequisite to distribution system design.

4. LOW-PRESSURE vs. INTERMEDIATE-PRESSURE DISTRIBUTION

Intermediate-pressure distribution permits using much smaller piping than for low-pressure, whereas with the latter pressure regulators are not required and there is less possibility of gas leakage. In general, intermediate pressure (where it is available at the site) gives a much more economical installation. Further, the smaller mains which can be used with intermediate pressure cost less to protect cathodically against corrosion.

5. LAYOUT OF MAINS AND SERVICES

a. Single Metering. One master meter provides for the flow of gas by one route only. It results in the most direct runs of piping from the point of supply to the buildings served and, therefore, in lowest costs. (See Bulletin No. LR-11)

b. Multiple Metering. Two or more gas delivery points into a common distribution system will provide a continuity of service in event of failure of one to provide service or if one is shut out for maintenance. However, a distribution system should not be designed to deliver the entire peak-hour through one meter. This is unnecessary and adds to the construction costs as well as increasing the monthly gas cost unless conjunctive billing is agreed to by the utility company.

c. Coordination with Other Utilities. The location of gas lines must be coordinated carefully with that of other utilities -- water, sanitary sewers and storm sewers, telephone, telegraph, steam, electric and private service lines. For row-house projects, comparative layouts and estimates are needed to determine the arrangement that will be most economical with building spacing and other conditions taken into account. Wherever possible, gas mains and services should not be under pavements, to facilitate maintenance.

d. Separate Trenches for Gas Lines. Gas piping should not be laid in the same trench with any other utility and should be laid below frost line. Leaking gas, if any, may enter sewers and sewer manholes, endangering life and property by possible fire or explosions. Further, gas may seep through backfilled earth in trenches for considerable distances. When the gas lines are laid in separate trenches, adequate precautions can be taken to prevent such seepage from entering basements or crawl space.[1]

e. Natural or Liquefied Gas. When natural or liquefied petroleum gas is to be supplied, service connection, from outside gas lines should rise above grade before entering the crawl space or basement of a structure; where the first floor is slab-on-grade, such gas piping should enter the structure above the first floor slab. When manufactured or mixed gas is supplied, service connections may enter the crawl space or basement without rising above grade; where the first floor is slab-on-grade, such gas piping should enter the structure above the first-floor slab and be adequately protected against freezing temperatures and damage to insulation.

6. PEAK-HOUR GAS DEMAND FOR COOKING, WATER HEATING, AND REFRIGERATION

a. Peak Demand. The peak demand for gas varies with climate, customs, occupations, etc., and is not susceptible of accurate estimate. Some gas companies have done considerable research on demand rates, and their practice should be a reliable guide in project design in their localities. For use elsewhere and for checking purposes in any case, Figure 1, based on information obtained from numerous sources, shows approximate peak loads for varying numbers of dwelling units and different uses of gas (except space heating). Although the loading is expressed in peak-hour rates, the maximum rate of demand may occur for only a few minutes.

b. Ratings. Appliance ratings, on which the peak demands shown in Figure 1 are based, are noted on the diagram. They are approximate averages for appliances of different makes. Variations from them will ordinarily not affect pipe sizing.

c. Range Ovens for Space Heating. The demands derived from Figure 1 can be considered to include but little allowance for the incidental use of ovens for space heating. If dwellings will be "tenant-heated" and gas for cooking "project-supplied," some allowance should be made for this possible extra demand.

[1] See Bulletin LR-7, Part V.

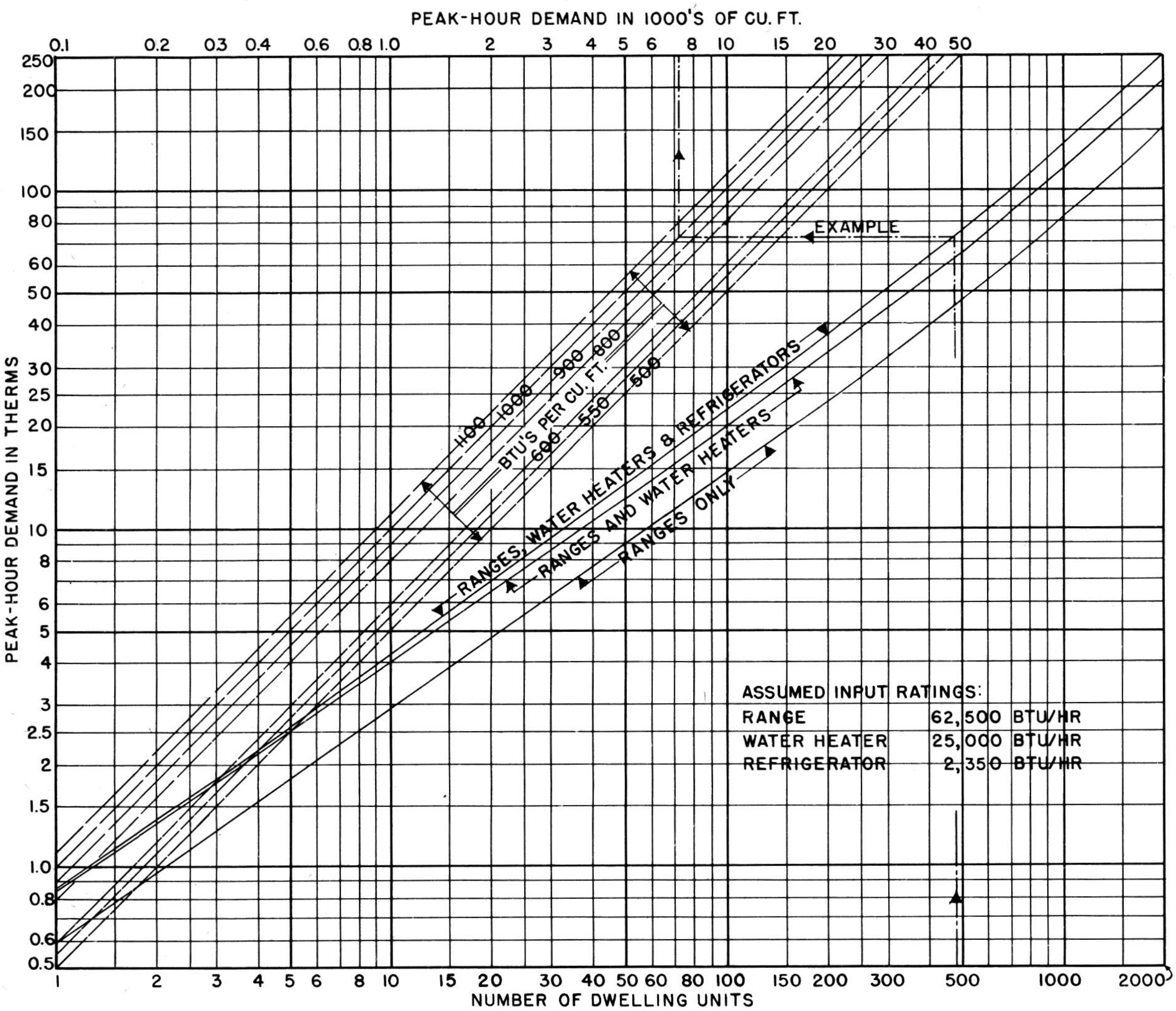

FIGURE 1 PEAK-HOUR GAS DEMAND FOR COOKING, WATER HEATING AND REFRIGERATION

7. PEAK-HOUR DEMAND FOR SPACE HEATING

It must be assumed that in extremely cold weather practically all space heating appliances will be operated simultaneously during early morning hours. However, it is extremely improbable that the peak heating load will occur simultaneously with the peak cooking load, except possibly in very small groups of units. It is recommended, therefore, that the combined peak-hour demand be determined; (1) by applying the percentages noted below to the total of the input ratings of connected heating appliances, and (2) by adding to the peak-hour load for heating, the amount for other uses of gas as derived from Figure 1 (or as otherwise estimated):

Number of DU's	Percentage of Total Input Ratings of Heating Appliances
1	100%
10	90%
100	85%
1000	80%

Obviously the designer must be informed as to the input ratings of all space heating appliances to be installed, including those in community facility buildings. The input ratings of gas-fired space heaters in low-rent projects vary from about 30,000 to 45,000 BTU, those of gas-fired furnaces from 60,000 to 80,000 BTU, per dwelling unit.

8. AVAILABLE PRESSURE DROP

a. Residual Pressure. The available pressure drop to be used in pipe sizing is, of course, the guaranteed delivery pressure on the project side of the master meter less the requisite residual pressure at the building wall (or house regulator). For intermediate-pressure distribution, a minimum pressure of 2 lbs. per sq. in. at the house regulator is recommended. For low-pressure distribution, the minimum desirable pressure at the building wall may be determined as follows:

	Inches of Water Column	
	Manufactured gas	Natural gas
Minimum pressure at appliances	2.3*	4.6*
Pressure drop in building piping	0.3	0.3
Pressure drop through check meter	0.5	0.5
Total	3.1	5.4
or approximately	3	5 1/2

* These figures should be checked against local practice in adjusting appliances.

b. Differences in Ground Elevation. Gas pressure increases roughly 0.1 inch of water column for each 15 foot rise in elevation. Obviously this has a measurable effect in low-pressure distribution and in multi-story buildings, or in the unusual case of buildings being materially lower than the point of gas supply. This factor should be taken into account.

9. GAS-FLOW FORMULAS

With the exceptions noted below, the gas-flow diagrams, Figures 2 and 3, are based on the Spitzglass formulas for "end-to-end" flow of gas in pipes:

(1) for low pressures (not exceeding 1 lb. gage):

$$Q = 3550\ K\left(\frac{h}{SL}\right)^{1/2}$$

(2) for intermediate and high pressures (exceeding 1 lb. gage):

$$Q = 4830\ K\left(\frac{Pa}{SL}\right)^{1/2}$$

in which:

Q is the quantity of gas in cu. ft. per hour, at 30 inches mercury and 60 degrees F.
K is a constant based on the pipe diameter (see below)
h is the pressure drop in inches of water column
P is the pressure drop in lbs. per sq. in.
a is the average pressure (absolute) in the pipe line, in lbs. per sq. in. (absolute pressure in gage plus atmospheric; latter is 14.7 p.s.i. at sea level)
S is the specific gravity of the gas
L is the length of pipe in feet

K is equal to $$\left(\frac{D^5}{1 + \frac{3.6}{D} + 0.03D}\right)^{1/2}$$

D is the actual internal diameter of the pipe in inches.

For low pressures, however, the "Pole" formula is used for pipe sizes larger than 4 inch, since in those sizes it gives more conservative results than the Spitzglass formula. The Pole formula (symbols as above) is:

$$Q = 2338 \left(\frac{D^5h}{SL}\right)^{1/2}$$

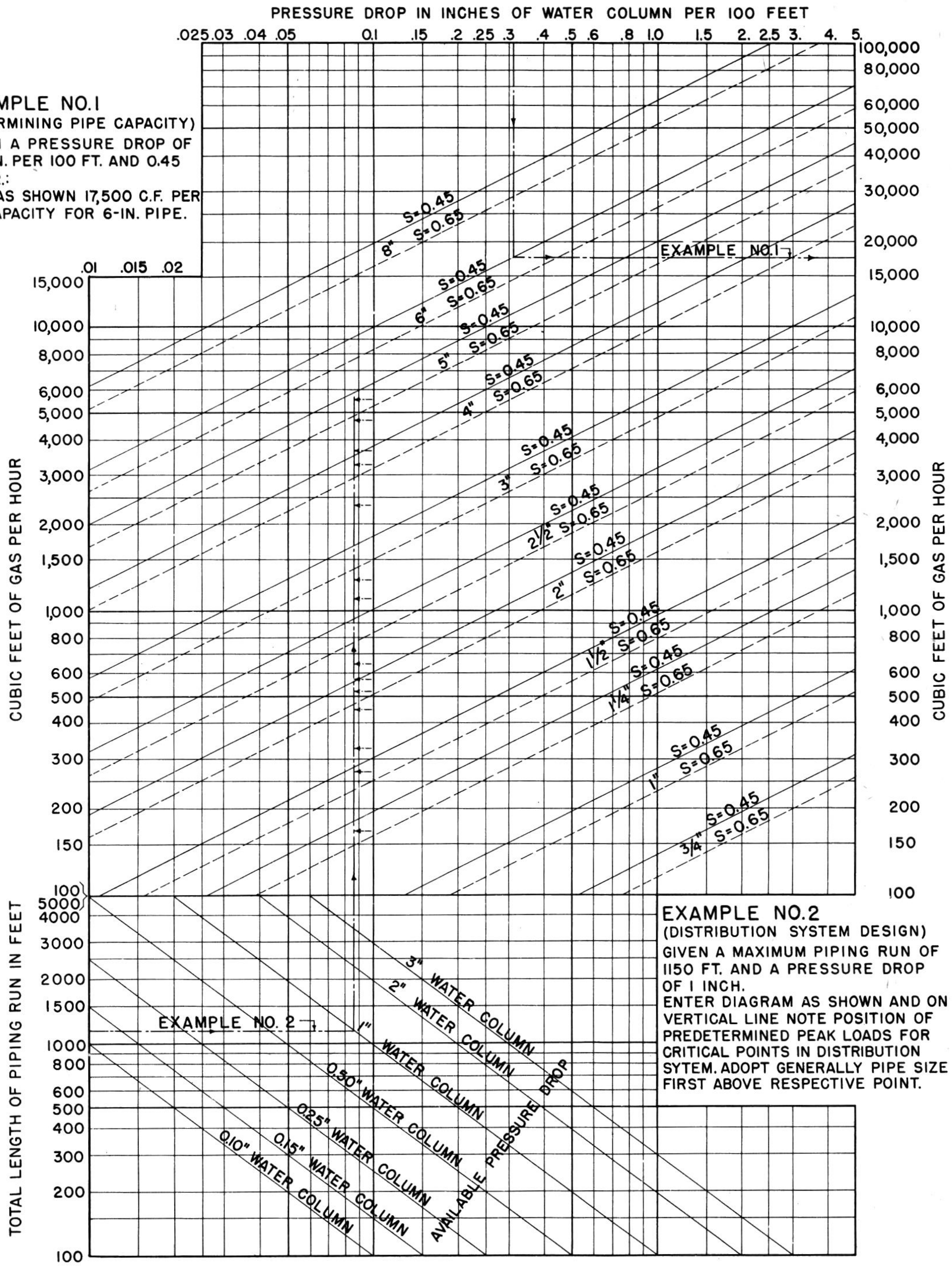

FIGURE 2 GAS LINE SIZING DIAGRAM-LOW PRESSURE

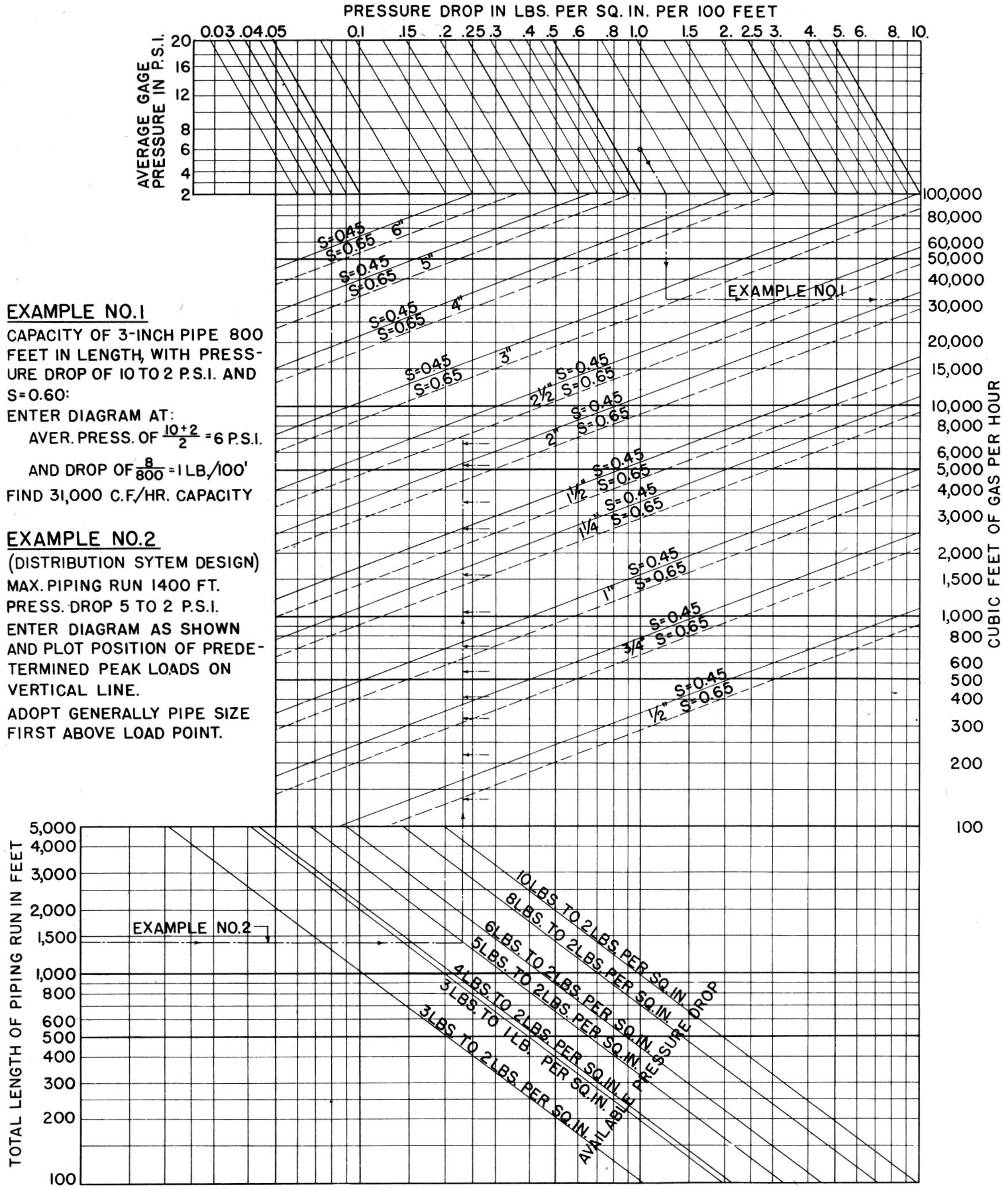

FIGURE 3 GAS LINE SIZING DIAGRAM-INTERMEDIATE PRESSURE

10. PIPE SIZING

a. Gas-Flow Diagrams. Figure 2 is for low-pressure distribution, Figure 3 for intermediate. Example No. 1 in each diagram shows the solution of a simple gas-flow problem, and Example No. 2 illustrates the practical use of the diagram in distribution system design.

b. Procedure. Following is a recommended rational procedure for distribution system pipe sizing:

(1) Determine as described above, the available pressure drop in the system.

(2) From Figure 1, and with adjustment for space-heating appliances if any, determine the peak gas demands above all "critical points" (principal junctions of lines, etc.) in the system, thus determining the flow for which each line should be sized.

(3) Select first the principal (and preferably the longest) run of piping in the system and, proceeding as illustrated in Example 2 in each diagram, read off pipe sizes for every section of the line.

(4) (Optional) Increase slightly the diameters thus determined for piping near the point of supply and decrease those toward the upper end of the line. Compute pressure drop section-by-section, readjust sizes if necessary, and recompute, until the total drop approximates that available. (This step tends to give more uniformity in the computed sizes of branch lines. The procedure corresponds to that usually employed in sizing water lines.)

(5) Note the "remaining pressure drop" at each of the above-mentioned "critical points," thus fixing the available pressure drop for each branch.

(6) Size the branch lines in the same general way as the principal line.

c. Sizing Looped Lines. It was previously noted that loops may serve to absorb unbalanced demand and maintain a supply of gas from one end of the loop, should that from the other be cut off. To insure fulfilment of the latter function, the following procedure in pipe sizing is suggested:

(1) Find by inspection the approximate location of the "point of no velocity" in the loop.

(2) Size each leg as though it were an independent line.

(3) Increase the size of the intermediate part of the loop so that, with a load approximating 50% of the peak, service can be maintained through either leg.

11. PIPE MATERIALS; CORROSION CONTROL

It is obviously desirable that the project distribution system be installed so as to serve without extensive replacements for a period of at least 40 years. In most projects this can be accomplished, practicably and economically. Gas leakage with its attendant hazards can be minimized and general relaying of lines (with resultant damage to site improvements and inconvenience to tenants) can be avoided. The principal problem is that of controlling soil corrosion, and the solution lies in proper pipe coating and, in many instances, in cathodic protection. This Part VIII contains no discussion of the theory of soil corrosion, the characteristics of corrosive and non-corrosive soils, or the design of cathodic protection systems.[1] It outlines, rather, certain steps to be taken, in connection with gas distribution system design, to gain effective corrosion control.

a. Corrosion Engineering Service. When the distribution system will be laid in corrosive soil, the Local Authority should, as a general rule, obtain competent corrosion engineering advice at an early stage of the project planning. The services (not a part of those rendered under the Architect's Contract) which a corrosion engineer can perform include (1) making resistivity tests, (2) supplying expert advice on the need for cathodic protection, (3) determining the type of protective system (galvanic anodes or rectifier), if any, to be provided, (4) checking on available and suitable locations for anodes, and (5) advising regarding pipe materials and coatings. (These services may cover both the gas and water systems.) Further, if a cathodic protection system is found advisable, the corrosion engineer can design it (after project construction) and supervise its installation. Moreover, he can train management personnel in its inspection, testing and maintenance.

In the case of very small projects, the employment of a corrosion engineer during the project-design stage may not be considered entirely necessary, even though the soil on the site is known to be corrosive. In such instances, the utility company may be able to make preliminary soil tests and furnish a report; otherwise, the tests can be deferred until the completion of project construction. In the latter event, specifications for the underground piping and coating will necessarily be based on general local experience, and the piping installation should be adapted to cathodic protection. The protective system, if and when later determined necessary, can be designed and installed at such time.

b. Pipe Material. This discussion is predicated on the use of steel pipe, since that is the material generally specified for underground gas lines in public housing projects. Steel costs less than cast

[1] See Local Housing Authority Management Handbook Part V, Section 7; Bulletin No. LR-7, Part V; and Low-Rent Housing Manual Section 207.1, paragraph 8.

iron and copper, and is safer against fracture than cast iron. Moreover, in most projects, the major part of the piping is small-size, not obtainable in cast iron; further, the development of cathodic protection has worked to the advantage of steel pipe. Nevertheless, the fact that the Guide Specifications cover steel only is not to be construed as a recommendation against the other materials, which generally have a longer life than steel without cathodic protection.[1] Pipe should not be laid without taking proper precautions for hazards such as unstable ground, cinders, wet organic soil, rock, peat, water-table, bacterial corrosion and stray electrical currents.

c. Pipe Coating. The amount and kind of pipe coating required on steel pipe depend on soil corrosivity and mechanical soil action (soil stresses). On the other hand, in alkaline soils of very high electrical resistivity, bare steel pipe may last indefinitely. Most engineers, however, prefer some sort of coating under practically all circumstances. Ample protective covering is particularly desirable for service lines, since these have less wall thickness than mains and they are generally laid close to the surface, where they are more liable to attack due to surface water (from lawns and roofs) percolating through the soil. There are two general types of coatings: (1) factory-applied bituminous enamel with tar-impregnated felt and kraft paper (the latter to protect the coating and to show up damage in handling), and (2) a field-applied, coal-tar-base coating. However, there are many other more or less widely used protective coverings on the market, and specifications may be drawn in the light of local experience, with special regard to possible coating damage from soil movement. It is preferable to avoid reference to proprietary products. Field-applied coating is likely to be more practical than factory wrapping for very small projects requiring limited quantities of pipe.

There is no unanimity of opinion as to the coating that should be used in connection with cathodic protection.[2] Some engineers consider bituminous enamel with one layer of asbestos felt, or glass wrap, sufficient. A good degree of insulation is desirable to minimize the electrical energy required for the protection and increase the life of sacrificial anodes.

d. Protection of Pipe Coating. The Guide Specifications include the customary requirements for uniform bearing for pipe, refilling with sand the trench bottoms cut in rock, care in pipe handling, careful backfilling around pipe, etc., all directed toward preventing damage to the pipe coating and obtaining an even distribution of earth pressure against the coated surface. The enforcement of all such requirements is most important.

[1] See Local Housing Authority Management Handbook Part V, Section 7.
[2] See Low-Rent Housing Manual Section 207.1, paragraph 8.

e. Adapting the System to Cathodic Protection. Unless local experience or resistivity tests prove, beyond doubt, that the gas distribution system will be laid in non-corrosive soil, the system should be installed to facilitate cathodic protection. The requisite measures (covered in the Guide Specifications) include: (1) insulation of the system from the gas company supply main, (2) provision of jumper wires around mechanical couplings or other joints that do not provide electrical contact, and (3) installing insulating couplings in service lines at buildings (unless both gas and water systems will be cathodically protected). The cost of this work is negligible in comparison with the expense of doing it at a later time. Where distribution pipe lines pass under a right-of-way having heavy traffic, precautionary measures should be taken to protect the pipeline from impact and shock loadings by use of casing that is vented and cathodically protected.

12. DISTRIBUTION SYSTEM APPURTENANCES

a. Master Meter and Regulator Station. The master gas meters and the pressure regulators (if any) on the main supply are usually provided by the gas company. Housing for the equipment is sometimes provided by the company, sometimes by the Local Authority. The housing, whether it consists of a separate building or of a utility room or rooms in the project, should be of fire-resistant construction with special provision for ventilation. Meters and regulators should be of ample capacity.

b. Valves and Cut-Offs. Valves are little used in low-pressure mains because the flow of gas can be stopped effectively and easily by means of bags or stoppers. They may be provided, however, in small secondary distributors near their point of connection to mains. In intermediate-pressure lines, valves are recommended (1) at convenient intervals in loops, and (2) in secondary distributors at their points of connection to the mains. A stop should be provided in each service, whether low-pressure or intermediate pressure, at point where it will be accessible in case of fire.

c. Service Regulators. Service (or house) regulators, as needed in intermediate-pressure systems, may generally be placed to serve two, four or more dwelling units. However, careful check should be made of the manufacturers' recommended working capacities of the regulators against the maximum rate or gas demand. It is important that the specifications state accurately the requisite capacities and pressure reduction for the regulators required.

d. Drip Pots. To prevent accumulation of condensate which will obstruct the flow of gas, distribution lines for gas should be sloped to drip pots at low points. Gas services also should be sloped, if possible, so that condensate will flow back to the mains. Otherwise, a drip pipe, outside the building or in the basement (if any), should be provided.[1] Provision should be made to pump drips, especially where the gas is being oil or steam fogged. Drips should be provided at a sufficient number of low points to permit blowing out all lines.

13. LOCAL PRACTICE

While the responsibility for the efficient planning of the gas distribution system lies with the engineer, the advice of local gas company officials on various matters should be obtained. The company's experience under actual conditions of soil, climate and gas characteristics will be most valuable, and its practice concerning various details can often be followed to advantage. Following is a summary, in part covering points mentioned in the preceding pages, of the information which it is generally desirable to obtain from the local company.

(1) Description, including rated working capacities, of the master meters and regulators which the company proposes to install for serving the project.

(2) Specific gravity of the gas.

(3) Peak-hour gas demand data, if any available; extent to which range ovens are commonly used in the locality for incidental space heating.

(4) Corrosivity of local soils; experience with different pipe coverings.

(5) Type of pipe and pipe joints used for mains and services.

(6) Minimum pipe size used for house services.

(7) Depth to which mains and services are laid.

(8) Pressure for which appliances are customarily adjusted.

(9) Practice as to provision of drip pots in intermediate-pressure mains; design of drip pots.

(10) Makes of service regulators employed (if any are to be used in the project); minimum pressure maintained at service regulators.

[1] Failure to observe this design precaution was a contributory cause of an explosion wrecking a multi-family building in a low-rent project.

The preceding is in addition to the information to be set forth in the contract for gas service, namely, (1) the point or points at which gas will be delivered, (2) the maximum and minimum pressure of supply to the project, and (3) the minimum BTU content of the gas.

14. FOUNDATIONS FOR PIPES

Provide proper supports for pipes and appurtenances in unstable ground.

SITE ENGINEERING

PART IX - SANITARY SEWER DESIGN[1]

1. INTRODUCTION

A water-carriage system of sewerage is recognized as necessary for "decent, safe and sanitary dwellings" constructed under the United States Housing Act. The need has been met generally, in completed projects, through connection to public sewerage systems, although in occasional instances other means of sewage disposal have been employed. Experience has shown that if public sewers are not available, the sewage disposal problem should be solved at the time of site selection. A feasible method of disposal, acceptable to local health authorities, must be found and adopted if the site is to be utilized.

The discussion comprises, first, some observations regarding alternative methods of project sewage disposal, noting points to be investigated during site selection and project planning; and, second, an outline of recommended bases of sanitary sewer design, together with suggestions derived from project maintenance experience.

This work should be done by an engineer experienced in design and construction of sanitary and storm sewers, and of sewage treatment and disposal plants. These notes are prepared for his guidance and reference. There are involved numerous considerations, details of design, variable local conditions and requirements, etc. Design charts for various values of n, also a number of design procedures, are available in standard references and publications. Therefore, it is considered more appropriate not to incorporate in this Bulletin what could at best be only very meager design information and procedures, flow charts for a limited value of n, and other limited design factors.

2. PROJECT SEWAGE TREATMENT PLANT

Rarely have permanent public housing projects been built on sites where "project" sewage treatment plants were required, although this method of sewage disposal was of necessity widely used in the war housing program. It may be necessary to employ it for some rural nonfarm, if not urban, projects under the current program. However, the method involves relatively high initial cost and operating expense and, generally speaking, can be justified only for a site which, lacking public sewerage facilities, otherwise possesses remarkable advantages. If and when such a

[1] See also Part II, Paragraph 1, of this Bulletin

NOTE: This Part supersedes Part IX dated 4-11-51. The material has been brought up to date.

site is considered for acquisition, an experienced sanitary engineer should be retained and information obtained as to the type and cost of a sewage treatment plant which will meet the approval of local health authorities. Design of the plant should also, if the site is selected, be entrusted to a competent sanitary engineer. In the event of unfavorable soil conditions and/or lack of available space for subsurface sewage disposal -- which should normally be sufficient cause for not selecting the site -- consideration may be given to the use of a sewage treatment plant on the site. Provision must be available for the disposal of the treated effluent into a public stream, etc. The treatment will have to be such as to produce an effluent satisfactory to the health authorities and so that the Local Authority will not be subject to legal action and claims arising therefrom. This type of plant will, of course, require operation and maintenance, and there are certain psychological considerations (objections by the residents) if the plant is near the residence buildings. Many types of camouflage have been used (tight fences, ornamental garden walls, etc.), as well as the use of partial or completely subsurface structures (where subsurface conditions permit). The costs and all the factors must be evaluated by the engineer and the Local Authority in terms of the ramifications involved. There are a number of package sewage treatment plants produced by several manufacturers. Some of these are still being modified and perfected. A number of plants are in successful use. A recent survey of these plants in use by public housing projects in the southeastern part of the country resulted in the following recommendations:

(a) Package sewage treatment plants cannot be economically operated at small projects and, therefore, should not be installed at projects of less than 20 dwelling units.

(b) Experience proves that these sewage treatment plants need more frequent inspection and servicing than is claimed necessary by the manufacturers. A minimum of three visits a week to each sewage plant is required, and more frequent visits are preferred. The best operations invariably receive the most visits by the maintenance men.

(c) If possible, do not use lift pumps upstream of the treatment plants. Place plants lower in the ground (subsurface conditions permitting), so as to have gravity flow wherever practical.

3. SUBSURFACE SEWAGE DISPOSAL

Sewage from a few projects has been disposed of by means of small septic tanks and tile beds, each installation serving a single dwelling or, more often, a group of three or four units. The results have been generally unsatisfactory, notwithstanding successful use of the method for private houses in the same localities. In varying degrees, the fault apparently has lain in inadequate soil investigation, inadequate space for tile beds, and tenants' carelessness. Where subsurface sewage disposal is planned, the site should be of ample size for disposal fields plus sufficient area for 100% expansion. (See Low-Rent Housing Manual Section 205.1.)

Nevertheless, consideration may occasionally be given to sites, especially for rural nonfarm projects, that have outstanding merit, but no public sewerage facilities. In any such instance, it is strongly recommended that: (1) subsurface sewage disposal be considered only for a very small project - so small that a project treatment plant would be too costly to build and operate; and (2) the method be adopted only after competent engineering investigation, and when soil percolation tests, topographic conditions, and ground water levels indicate strongly that the method will prove satisfactory and there will be no possibility of contaminating any water supply, public or private. Percolation tests should be made, if possible, in the presence of the engineer's and/or health department representatives.

Prior approval of the method should be obtained from the local health authorities and other authorities having jurisdiction. Approval by the authorities concerned for on-site sewage treatment and disposal is mandatory. Such approval, however, does not guarantee desired results, does not assume responsibility for successful operation for any reasonable length of time, etc. The designing engineer, the Local Authority, and the contractor must, in their fields of activity, accomplish the work in a proper manner.

4. CONNECTION TO PUBLIC SEWERAGE SYSTEM

Sanitary sewers available at public housing sites are usually adequate to serve the projects. (A few exceptions, not discovered or fully recognized before project completion, have caused serious difficulty in the past.) Reliable answers to the following questions should be obtained at the time of site selection and verified during project design:

a. Are existing sanitary (or combined) sewers of sufficient capacity and in satisfactory condition to receive project sewage?

b. Are existing sewers deep enough to serve the entire site by gravity flow? If not, from what portion of the site must sewage be pumped or buildings excluded?

c. If existing sewers require extensions or other improvements in public streets, what part (if any) of the cost must be borne by the project?

d. If public sewers are available only at some distance from the site, will it be economically feasible to provide the necessary connections to them?

e. If additional sizing and depth of sewers will be required to service areas outside of project limits, will provision be made for the beneficiaries to make payment for the extra cost?

Project sewage should be discharged into a public sewerage system unless the cost is prohibitive. Only under extraordinary circumstances should the Local Authority assume the responsibility and expense of sewage disposal by any other means.

5. TYPE OF SEWERAGE SYSTEM

When storm water drains are required, the type of system, "separate" or "combined," to be constructed in the project will generally be that in use locally. However, if the municipality is working toward separation of sewage from storm water, public interest may be better served by paying the necessarily higher cost of separate sewers, even though public sewers at the site are of the combined type. This is a matter for special determination. A separate system of sewers within a project may afford better protection against sewage backing up into basements.

6. MAXIMUM RATE OF SEWAGE FLOW

While water supply systems must be capable of meeting the maximum momentary demand, sanitary sewerage systems have an impounding capacity which levels off all minor peaks. (The cubic contents of the sanitary sewers in a project may equal the average sewage flow for a period of three hours or more.) Thus, the maximum rate of sewage flow is much less than the maximum momentary demand for water, except in the case of very large groups of dwellings.

The sewage flow consists not only of domestic sewage, but of infiltration and surface water entering the sewers around manhole lids or elsewhere. While, in general, there should be no storm water connection to sanitary sewers, it is preferable, if municipal regulations permit, that garbage collection platform drains, properly trapped, connect to sanitary sewers rather than to storm sewers.

Recommended design rates of flow in sanitary sewers serving public low-rent housing projects are as follows:

from 400 gallons per capita per day, or approximately 0.25 cu. ft. per second per 100 DU's, for 100 DU's or less.

to 300 gallons per capita per day, or approximately 0.19 cu. ft. per second per 100 DU's, for 1000 DU's or more.

The above flows are for sewers flowing full and should be sufficient to cover a moderate amount of infiltration. When sewers are to be laid below the ground water level or in areas subject to flooding, the maximum allowable leakage should be stipulated in the specifications. A maximum infiltration of 8,000 to 12,000 gallons per day per mile of sewer, depending on soil conditions, is suggested. (The figure may be fixed by local regulation.)

7. MINIMUM GRADES FOR SANITARY SEWERS

The following are slopes which will produce a velocity of at least 2 feet per second in sanitary sewers flowing full, (for n = 0.013:)

Pipe Size	Minimum Grade
4"	1.10%
6"	0.60%
8"	0.51%
10"	0.29%
12"	0.22%
15"	0.16%
18"	0.12%
24"	0.08%

However, when little additional trenching cost will result, it is desirable to base minimum grades on n = 0.015. Such grades are approximately 50% higher than the preceding. Pipe should be designed and laid on a grade so as to produce a velocity of at least 2-1/2 ft. per second flowing full. The use of asbestos cement pipe will be helpful where flat slopes are necessary; n = 0.011 may be used for this pipe thus permitting flatter grades.

8. MINIMUM DIAMETERS FOR SANITARY SEWERS

Four inches is the recommended minimum diameter for house connections, and 8 inches minimum for other lines. Under standard practice in many cities, 6-inch minimum is used in house connections and 8-inch or larger in all laterals.

9. SANITARY SEWER LAYOUT

Design objectives which are in part peculiar to low-rent housing projects include the following:

a. Locating sewer mains and laterals in street areas, preferably not under pavements, where practicable, so that the project will be relieved of the maintenance of the lines if the streets are dedicated.

b. Locating the sewers to avoid existing trees, and coordinating the sewer layout and the planting design so that new trees will not be planted over or near sewer ditches. Provide proper supports for pipe and appurtenances in unstable ground.

c. Coordinating the sanitary sewer lines with the locations and grade elevations of other utilities: storm sewers, electric, steam and hot water conduits, and gas and water lines. The various utilities should be spaced sufficiently to permit laying each in a separate trench and, where possible, sewers should be laid below water lines.

10. MANHOLES AND CLEAN-OUTS

The usual practice of providing manholes at all breaks in line or grade, and at all junctions in lateral sewers, should be followed rigidly in public housing projects. The maximum recommended manhole spacing is 300 to 400 feet, depending on the grades at which connecting sewers are laid and the diameter of the sewer.

Cleanouts can generally be substituted for manholes at the upper end of sanitary sewers and at changes in the alignment of short laterals. Provide locking devices on all cleanout covers and on manhole covers within the project site (not in public streets). See Figure 1 for two types of cleanouts.

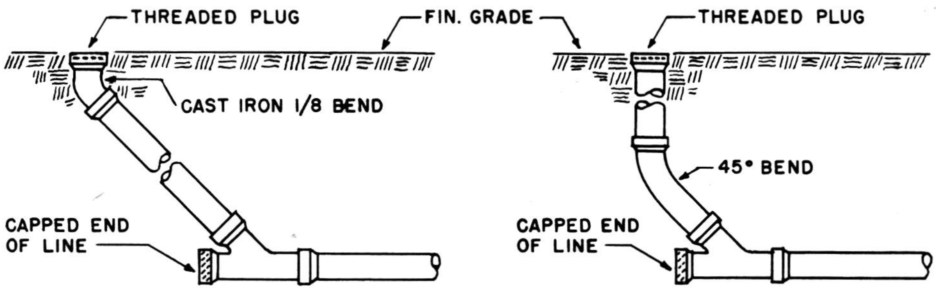

FIGURE 1. TYPICAL ALTERNATE CLEANOUTS FOR SANITARY SEWERS

11. SEWER PIPE AND PIPE LAYING

Engineers for public housing have usually specified only pipe and bituminous joint material for sanitary sewers. Specifications should also provide for pipe joints of watertight preformed rubber gaskets securely locked against displacement (it is a labor saving item).

<u>Pipe in deep trenches</u> requires special attention in both design and construction supervision. The trench load varies with the square of the trench width at the top of the pipe; hence, the trench should be as narrow as practicable at that level. Generally speaking, if the trench load will exceed about 3/4 of the "sand-bearing" crushing strength of

standard-strength clay sewer pipe, extra-strength pipe should be employed or concrete cradles provided.[1]

Pipe in shallow trenches may require protection against damage by construction operations (grading and trucking), if not afterward. On flat sites, sewer house connections and the upper ends of laterals must often be laid quite close to grade. When existing ground levels or finished grades are such that sewers will have less than about 2-1/2 feet of cover at all time during construction, it is recommended that the pipe be encased in concrete or cast iron pipe substituted. (Breaks in pipes have remained undiscovered in some cases until long after project occupancy.)

Adverse soil conditions have been a source of difficulty in a number of projects. It is the engineer's responsibility to inform himself fully on site soil conditions and to design accordingly. Sewers in very unstable soil may consist of cast iron pipe supported on two-pile bents or hung from building walls, or of tile pipe with continuous concrete beam supports. When conditions are less severe (for example, when trenches are in saturated sand) a base of gravel or crushed rock on a floor of 2-inch plank may afford a satisfactory bearing.

12. SEWAGE PUMPING STATIONS

Project maintenance experience has shown that the following points merit special attention in the design of sewage pumping stations, when such are required:

a. Investigating the possibility, where the sewage lift is slight, of avoiding pumping entirely. This may sometimes be accomplished by deep trenching, additional length of sewer line, or omitting buildings from the lowest part of the site. Obviously, the point should be investigated at the time of site selection.

b. Selecting a pumping station location as far from dwelling buildings as practicable, especially if the station will have screens which require cleaning, and locating the station where it will be accessible from a surfaced roadway.

c. Preparing a complete and accurate statement of operating conditions in order to obtain equipment which will operate most efficiently.

d. Using the dry-well, rather than wet-well, type of centrifugal pumps.

[1] See "Trench Loading Tables," published by the Clay Sewer Pipe Association, Inc., Columbus, Ohio.

e. Providing, where feasible, an overflow from the wet well, for use in emergencies.

f. Providing stand-by power, where an overflow is not feasible. (This may not be essential in all cases, but the possible need for it should be considered. Check requirements of local health authorities and other authorities having jurisdiction.)

g. Keeping the motor room floor well above possible flood level of sewage, should the pumps fail.

h. Constructing a superstructure over the station to facilitate proper care of the equipment.

i. Providing a positive system of ventilation of the pump room, also the motor room unless it is within the superstructure enclosure.

j. Providing a bar or basket screen in the wet well, unless pumps or ejectors are of a type not requiring screens; providing a manhole in the wet-well roof directly above the screen.

k. Extending valve stems, including those on the drainage sump valves in the pump pit, to the motor room floor or to a platform located above the highest possible sewage level.

l. Using guides, in lieu of tubes, for the floats.

m. Providing flexible pipe connections on the suction and discharge sides of the pumps; using no sewage piping smaller than 4-inch.

n. Avoiding connection of any kind between potable water lines and the pump or sewage piping.

The preceding points apply principally to centrifugal-pump installations. When only a small amount of sewage will be handled, pneumatic ejectors may be preferable.

For the usual duplicate-pump installation, it is recommended that the capacity of each pump be 25% to 50% greater than the maximum estimated sewage flow. However, when sewers will be laid generally above ground water level, it should be safe to base pump capacity on a rate of flow about 20% lower than that recommended for pipe sizing. Between high and low sewage levels, the wet well should provide at least 10 minutes' storage at the average rate of flow, but the width of the wet well should be not less than 5 feet. Dimensions of the dry well should provide adequate working space around the pumps.

SITE ENGINEERING

PART X - STORM SEWER DESIGN[1]

1. INTRODUCTION

Drainage conditions have frequently received too little attention in site selection, and have occasionally not been understood fully during project design. Moreover, although storm sewers are not essential on all projects, efforts to economize by their omission have sometimes been ill-advised.

For these reasons, in part, numerous projects have been damaged by flooding or erosion, and costly corrective work has been necessary; tenants have been inconvenienced; and, in a few instances, sewage from combined sewers has backed up into basements or flooded yard areas, creating insanitary conditions.

This Part X consists mainly of: (a) a brief discussion of basic information on drainage conditions needed in site selection and project design, and (b) recommendations on other features of storm sewer design, all based largely on project maintenance experience. Storm sewers are also referred to as storm drains.

2. DISPOSAL OF STORM WATER

Storm water from projects is disposed of by one, or a combination, of the following means:

a. By discharging it through project storm sewers into existing storm or combined sewers. This method is almost always employed to some extent where existing sewers are available. It is essential for large, high-density projects.

b. By discharging it through project storm sewers into a nearby open water course. This method is employed occasionally, when a well-defined water course is available. The observation, often made, that a site has "good natural drainage" is no indication that there is a water course into which project storm sewers can be discharged. (See Part I, paragraph 4, of this Bulletin.)

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[1] See also Part II, paragraph 1, of this Bulletin

NOTE: This Part supersedes Part X dated 4-16-51. The material has been brought up to date.

c. By merely grading the site to permit surface drainage into abutting public streets. This method is employed to a greater or less extent on all sites. It can be used as the sole method of disposal only for comparatively small sites where topographic conditions are entirely favorable.

d. By drainage wells. Deep drainage wells have been used in only one locality, where certain rarely found conditions exist. Generally speaking, shallow "dry wells" are altogether ineffective for surface drainage, including that from roofs. However, in favorable subsurface conditions, properly designed dry wells, leaching wells, and similar structures of sufficient number to provide required storage pending percolation have been successfully used. The economic maximum depth of these structures is 20 feet and the effective minimum is approximately 6 feet, both depths from the finished grades; leaching basins serving drainage structures for any given area should be cross-connected. Thorough inspection of this work is essential.

3. EXISTING DRAINAGE FACILITIES

The following is a brief check list covering points on which general but reliable information is required in site selection, and detailed accurate information is indispensable for project design:

a. If existing storm or combined sewers are to be utilized for project drainage, are they structurally and otherwise in good operating condition?

b. About how often and to what extent are such sewers surcharged? (Neighborhood inquiry may be necessary to obtain a reliable answer to this question, particularly as to whether back-flow into basements ever occurs during heavy rains.)

c. Just how will the surcharge of existing sewers affect the planning and operation of the project? More specifically, will any part of the site be subject to flooding and, if so, can the project be so planned that the storm water will cause no appreciable property damage or serious inconvenience to tenants?

d. If existing sewers are of the combined type, would their overloading cause insanitary conditions in the project?

e. If existing sewers are inadequate to serve the project, to what extent, if any, will their enlargement be provided without cost to the project? If existing storm or combined sewers require extension to the site, or other improvements in public streets, what part, if any, must be borne by the project?

f. If a natural water course or open ditch is the obvious and only outlet for project storm sewers, is it at a low enough elevation to serve that purpose? Can project drainage, if and as increased by the site development, be discharged into such water course or ditch without causing damage to the site or adjoining property? (See Part I, paragraph 4, of this Bulletin.)

4. EXTENT OF PROJECT STORM SEWERS

The need for storm sewers is, of course, related to physiographic conditions - soil, topography and rainfall. However, the extent of the storm sewer system in a specific project is governed more directly by: (a) the grade design, which establishes automatically the locations of most sewer inlets, and (b) the decision as to whether sewer connections are to be extended to downspouts, and to crawl spaces, if any. The storm sewers must be laid out in the most economical way to reach the predetermined points of storm water collection.

The sewer designer should be alert to the possibility of grade changes that would simplify the storm sewer installation. (The grade study and the storm sewer design, both basically concerned with site drainage, may be regarded as largely a single design operation.) Further, some adjustment in the site plan may be found advisable to accommodate storm sewers and other utilities in the most efficient manner. (See Part I, paragraph 2, of this Bulletin.)

5. RAINFALL FREQUENCY AND INTENSITY

a. In housing projects, as in cities generally, cost considerations usually preclude building storm sewers large enough to handle the runoff during rains of maximum intensity. In principle, the rainfall frequency employed in storm sewer design should result in an approximate balance between first cost and probable future damage. Obtain from the local or regional Weather Bureau office information pertaining to rainfall intensities and frequencies for use in design work.

b. If the surcharge of a certain sewer would surely cause basement flooding or severe erosion, a rainfall frequency of 25 years or more may justifiably be adopted. If, conversely, it would result in little more than ponding of storm water between street curbs, a frequency of about 10 years may be assumed. A surcharged condition is likely to be more objectionable in combined sewers than in storm sewers.

6. COEFFICIENT OF IMPERVIOUSNESS

The "coefficient of imperviousness" should be determined for each project (or each part of it separately considered) by taking off the surfaced and building-coverage areas from the approved site plan.

7. COEFFICIENT OF RUNOFF

a. For impervious areas, recommended runoff coefficients, depending on slopes and various other conditions, are:

With downspouts connected to sewers	0.75 to 0.85
With downspouts not connected to sewers	0.60 to 0.75

b. For pervious areas, the coefficient will vary widely with surface slopes and nature of the soil. However, the following should serve as a reasonable design guide, although the upper and lower limits may not meet extreme conditions:

For very light slopes and sandy soil	0.10
For moderate slopes and clay subsoil	0.25
For steep slopes and nonporous subsoil	0.50

Factors may be higher for design for longer storm frequency.

c. The combined coefficient of runoff is the weighted average of those for pervious and impervious areas respectively:

Density	For very light slopes; sandy subsoil	For moderate slopes; clay subsoil	For steep slopes; non-porous subsoil
10	0.30	0.45	0.60
20	0.375	0.50	0.65
30	0.45	0.55	0.70
40	0.50	0.60	0.725
50	0.55	0.65	0.75

The combined coefficient should be carefully computed for each project -- preferably for each part of it considered in pipe sizing. The preceding values are suggested for checking, preliminary estimates and similar uses.

8. STORM SEWER SIZES

Storm sewers should be of sufficient diameter, not only to handle estimated storm water flows, but to be reasonably secure against stoppage by grit, stones, trash or other material that can get into them through the particular type of inlet provided. Gratings, of course, afford considerable protection in this regard, at least as compared with open-throat inlets, but catch basins with trapped outlets are the most effective. Following are recommended minimum diameters for storm sewers connected to different types of inlet:

Sewers receiving drainage from catch basins with trapped outlets	12 inches
Sewers receiving drainage from plain inlets with grating type opening	15 inches
Sewers receiving drainage from plain inlets with side opening (open throat)	15 inches

In sizing sewers, the designing engineer should put his calculations -- covering pervious and impervious areas, run-off coefficients, discharges, etc.,--in suitable tabular form for checking uses and permanent record.

9. MINIMUM GRADES FOR STORM SEWERS

To be self-cleaning, storm and combined sewers should be laid at grades which will produce a velocity of at least 2-1/2 feet (preferably 3 feet) per second with pipes flowing full. (See Part IX, paragraph 7, of this Bulletin.)

10. SEWER PIPE AND PIPE LAYING

Engineers for low-rent housing projects have usually specified clay pipe for combined sewers to include 24 inch diameter with reinforced concrete for large sizes, and either clay or concrete pipe for storm sewers. Design problems related to trench loading and adverse soil conditions are identical with those described in Part IX of this Bulletin. Provide proper supports for pipe and appurtenances in unstable ground.

For pipe culverts, pipe described above is used and, in addition, for 15 inches and over, considerable use is made of corrugated metal pipe (CMP), coated and lined, of proper gauge for the loadings at locations involved. For clay and concrete pipe, use concrete headwalls and for CMP use standard end sections. The use of concrete splash aprons on the outflow ends to reduce erosion and assist the flow is recommended. For culverts over 12 inches, install locking removable gratings in the headwalls to prevent accidents to children, animals, etc.

11. SEWER INLET TYPES AND LOCATIONS

a. Types. Storm sewer inlets may be catch basins or plain inlets, and either such form of chamber may have a grating or a side-opening (or curb) inlet, or both. These types, illustrated in Figure 1, are discussed briefly below.

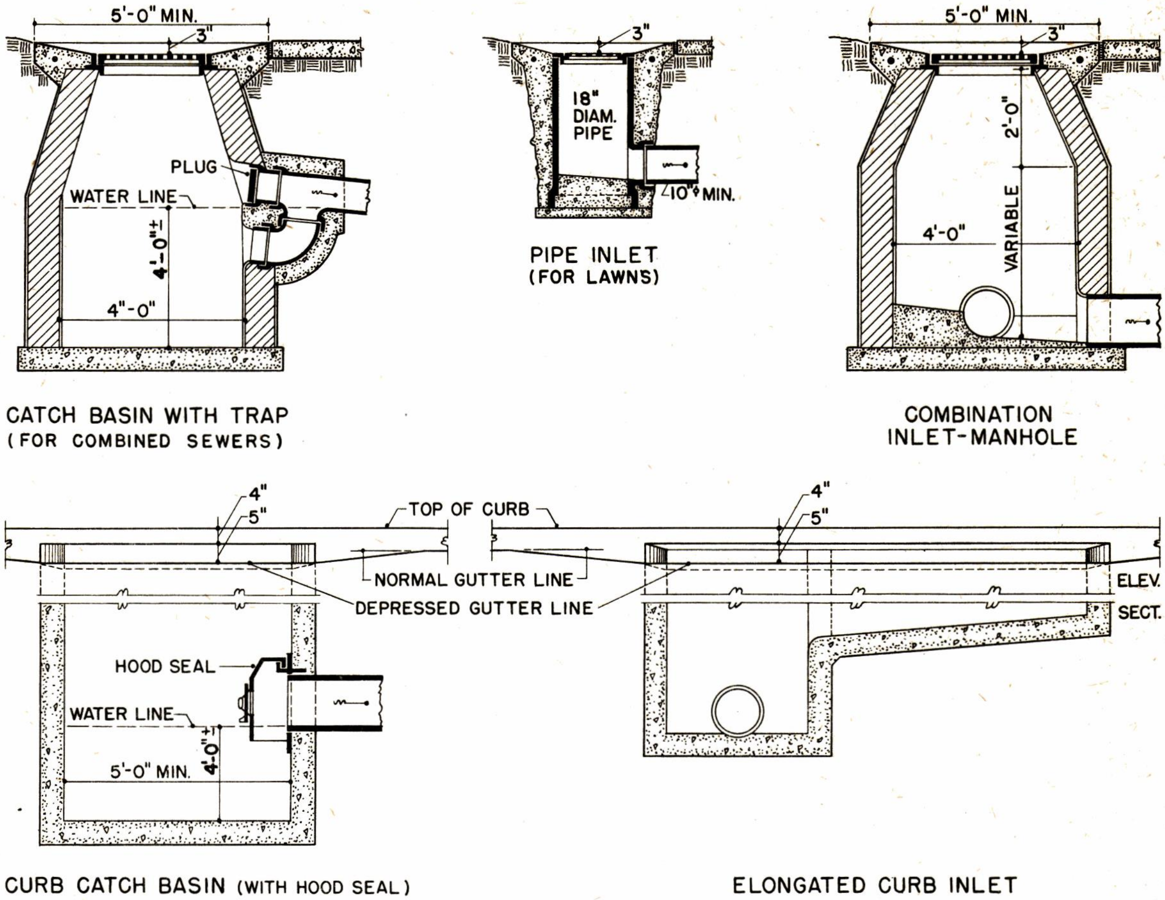

FIGURE 1 DRAINAGE STRUCTURES

b. Inlet locations, as previously noted, are fixed largely in the project grade study. Nevertheless, the storm sewer design should include a check on the locations proposed, in both yard areas and streets, to ascertain whether: (1) the inlets will be necessary and effective at such points, and (2) the locations are the best possible for economy in the sewer layout. Further, inlet capacity should be checked against the calculated storm water flow at each inlet location. Inlets at street intersections are, as a rule, better located at one end of the curb return than near its center.

12. INLET CHAMBERS: CATCH BASINS vs. PLAIN INLETS

a. Catch basins with trapped outlets are necessary on combined sewers; and catch basins, with or without trapped outlets, should be used on storm sewers having grades which may not produce a self-cleaning velocity of flow. A trapped outlet is useful in preventing the entrance into the sewers of toys and sticks pushed through gratings by children.

However, catch basins are decidedly objectionable in several respects: they require occasional cleaning; cleaning is sometimes neglected until stoppage occurs; the basins are likely to become foul and breeding places for mosquitoes; and the water seal in the trap may freeze during severe winter weather.

b. Plain inlets afford little protection against sewer stoppage, but they do not have the objectionable features of catch basins; and plain inlets may serve as manholes (which catch basins can not), with one inlet connected to another, thus effecting considerable economy. Such inlets are recommended, therefore, when: (1) sewers are not of the combined type, (2) sewer grades will produce a flow velocity of at least 2-1/2 feet per second, and (3) sewers are amply sized as protection against clogging (see paragraph 8). Provide catchment 4 ft. deep in drainage structures (lawn basins and road catch basins) that discharge into leaching basins; this is necessary to intercept dirt, leaves, shavings, etc. from washing into the leaching basins. At street intersections, inlets should discharge into a catch basin (with catchment and cast iron hood seal), which then discharge into the combined sewer. When storm sewers are used, a similar scheme can be employed but the hood seal may be omitted.

c. Inlet chambers in surfaced areas should be of concrete or brick; in grassed areas they may be of such materials or of tile pipes set on end. However, it is preferable that inlets be large enough for a man to enter. Pipes with gratings resting in their bells are not satisfactory.

13. GRATING-TYPE INLETS

Grating inlets are of necessity used in grassed and plane surfaced areas, also in roadways of dished cross section, and may be used in gutters along curbs (either solely or in conjunction with curb openings). Several points regarding their design merit emphasis:

a. Except in gutters along curbs, a circular grating is preferable to a rectangular one, since the circular casting can not fall through the frame.

b. To allow for partial stoppage by leaves, paper, etc., the grating area (gross) should be not less than about three square feet per sec. ft. of storm water flow.

c. Gratings should be heavy enough not to be removable by children. Provide locking devices on all gratings and manhole covers within the project site (not in public streets).

d. The design should permit using standard gratings, cast in the locality. The engineer should check on the form, dimensions and weights of such products. Use heavy duty type in roadways, traffic areas and at curbs. Drainage gratings at walks and in lawns should be of a type that will not permit childrens usual toys to fall in, also in which womens' normal type heels would not be caught.

e. Gratings should always be set in depressions 2 to 3 inches below finished grade. This applies to gratings in lawns, roadways, and other surface areas. (Lack of attention to this point, in project drawings and construction, has resulted in poor drainage in many cases.)

f. Grating frames in grassed areas should have concrete collars not less than 12 inches wide. When adjoining walks, the outer edge of the collar should be about 1/4 inch below the walk edge.

g. Rectangular gratings in roadway gutters should have their bars parallel to the direction of flow. This gives maximum inflow capacity and non-clogging characteristics. Such gratings should be of ample length. Inlet castings should always be gratings--not perforated covers.

h. Occasionally, where service drives cross sidewalks at sidewalk grade, a grate-covered trough (such as used around gasoline service stations) may be extended wholly or partially across the drive. This will generally intercept the water more effectively than a standard sewer inlet, and may cost no more.

14. SIDE-OPENING INLETS

Side-opening inlets usually provide more effective openings than do gratings, and are much less subject to stoppage, but they are obviously suitable for use only in roadways or other paved areas having curbs. The most important objective in their design is diversion of the flow from the gutter into the curb opening. This involves forming a shallow depression in front of the inlet and, especially on slopes, adjusting the length of the opening to the flow. It is essential that the storm water flow to each inlet be calculated.

Only comparatively recently has the subject of inlet capacity been receiving the attention it needs, and much research remains to be done. Following, however, are approximate figures on the intake capacity of side-opening inlets located along gutters with different longitudinal slopes:[1]

Length of Inlet	1% slope	3% slope	5% slope	10% slope
4 feet	0.75 c.f.s.	0.50 c.f.s.	0.40 c.f.s.	0.30 c.f.s.
6 feet	1.30 c.f.s.	1.00 c.f.s.	0.75 c.f.s.	0.55 c.f.s.
8 feet	1.85 c.f.s.	1.50 c.f.s.	1.15 c.f.s.	0.80 c.f.s.
10 feet	2.40 c.f.s.	2.00 c.f.s.	1.50 c.f.s.	1.10 c.f.s.

[1] Based largely on data contained in Engineering Experiment Station Bulletin No. 30, North Carolina State College.

The preceding figures should be used with caution, and only for conditions which approximate the following:

a. An inlet slot at least 5 inches high and without vertical bars or other obstruction.

b. An 18-inch gutter having a cross slope of 1-1/2 inches to the inlet slot.

c. The gutter depressed an additional 3 inches immediately in front of the inlet opening, with adjoining pavement surface warped accordingly. (With a 6-inch curb elsewhere, this gives a curb height of 9 inches--the maximum desirable--in front of the inlet.)

If the inlet is located in a pocket in the roadway, with flow to it from both directions, its capacity may be double or more than that given in column (2) above.

Side inlet capacity may be increased materially by a grating set in the gutter, and this combined type of inlet is standard in many cities. It is more costly than the simple side inlet and becomes less effective with increasing slopes.

There is generally some advantage in following local standards, and it is necessary to do so in the case of streets to be dedicated; but this does not lessen the importance of checking inlet capacity against storm water flow.

Weep holes for subgrade drainage are sometimes provided in roadway inlets on the roadway side of the chamber. Located just below subgrade level, they are especially desirable in the case of inlets located at low points in the street grade.

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SITE ENGINEERING

PART XI - ELECTRICAL[1]

1. INTRODUCTION

This Part XI contains no discussion of the numerous details of design or construction of the electrical work for the housing projects. It is intended only to call particular attention to several items of importance affecting the site.

Bulletin No. LR-8 discusses in detail the considerations and methods of design and construction. Part I deals with Interior Installations and Part II deals with Exterior Distribution. Guide Specifications for this work are available.

Bulletin No. LR-11 contains additional information of value to the electrical designing engineer concerning selection of utilities.

2. OVERHEAD vs. UNDERGROUND DISTRIBUTION

This subject is discussed in considerable detail in Bulletin No. LR-8, Part II. Recent trend in numerous parts of the country is that utility companies are more sympathetic and agreeable to absorbing all or part of cost for full or partial underground services. Such action will depend on a number of considerations and is an item subject to negotiation.

3. NEGOTIATIONS WITH UTILITY COMPANY

It is important that the Local Authority complete the negotiations with the utility company pertaining to extension of services to the site (if necessary), metering, rates, point or points of delivery, type of service, and other items as discussed in Bulletins LR-8 and LR-11, before proceeding with design work. If possible, some of these items, such as extension of service, metering, and rates, should be agreed upon before site selection.

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[1] See also Part II, paragraph 1, of this Bulletin.

4. COORDINATION WITH OTHER SITE IMPROVEMENTS

The design of the exterior distribution, both overhead and underground, should be coordinated with the site plan, project grading scheme, and with all other site improvements, including sewers, gas, water, paved areas, recreation areas, trees, and plant material. If feasible, locate electric vaults, manholes, and similar structures so that their drainage may be discharged into the storm drainage system.

5. EXTERIOR LIGHTING

Coordinate exterior lighting with entrances to buildings, sitting areas, recreation areas, pedestrian and vehicular access, and parking areas.

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