USE OF INNOVATIVE SMALL DIAMETER GRAVITY SEWERS TO SOLVE CONVENTIONAL PROBLEMS

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INTRODUCTION

The term "Small Diameter Gravity" (SDG) sewers refers to several "non-conventional" sewer system concepts that are being used in the world today, though not extensively in the United States, to provide sewer service to small communities. The SDG concept includes Variable Grade Effluent (VGE) sewers, Minimum Grade Effluent (MGE) sewers, and Septic Tank Effluent Pumping (STEP) systems.

Each of these non-conventional methods utilizes septic tanks located at the resident (or other source of wastewater) and small diameter gravity sewers (typically 4-inch and 6-inch diameter) to collect and carry effluent from each septic tank to interceptor sewers or wastewater treatment plant for further treatment.

VGE sewers are gravity sewers which may have short segments of reverse grade (uphill) and some sections flowing full where the hydraulic grade is above the sewer. MGE sewers in contrast have no uphill segments. Pipe sizes for both MGE and VGE sewers are selected based on the concept that since the septic tank removes

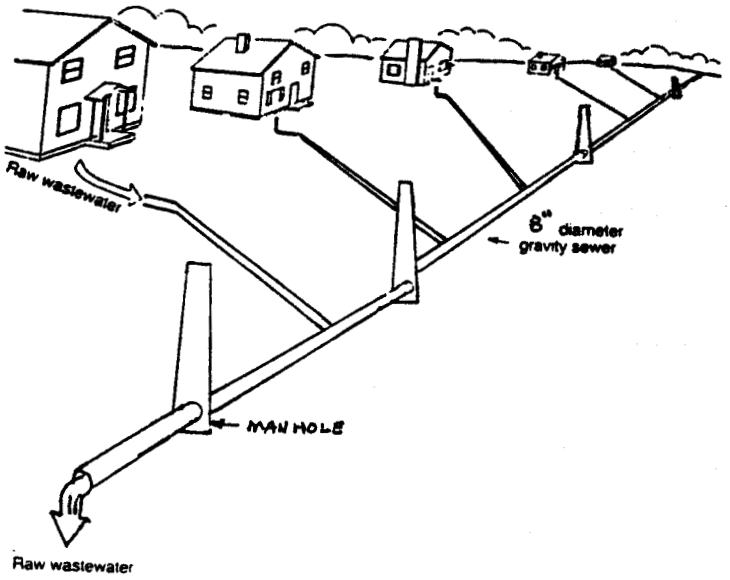
solids and trash from the raw sewage, minimum velocity and clogging are not considerations and pipe sizes of 4-inches and 6-inches diameter can be used. The STEP system is somewhat different in that it incorporates a pump to transfer septic tank effluent from the tank to a gravity segment of the collection system or to a wastewater treatment plant for further treatment. STEP systems can be used in conjunction with VGE or MGE sewers to lift effluent from individual or groups of homes in low lying areas.

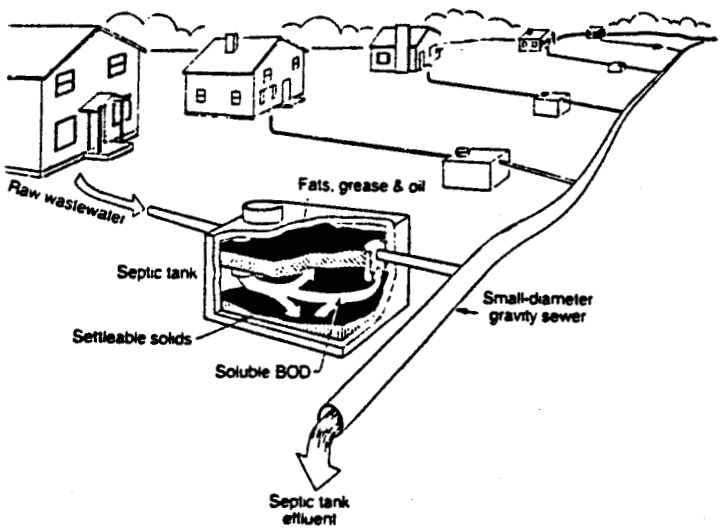
The septic tank included in all three types of SDG sewers provides primary treatment for removal of solids and trash at the wastewater source. SDG sewer systems allow the use of smaller pipe sizes, installation at shallower depths and the use of clean-outs instead of manholes. Conceptual diagrams of the three SDG types are shown on Figure 1.

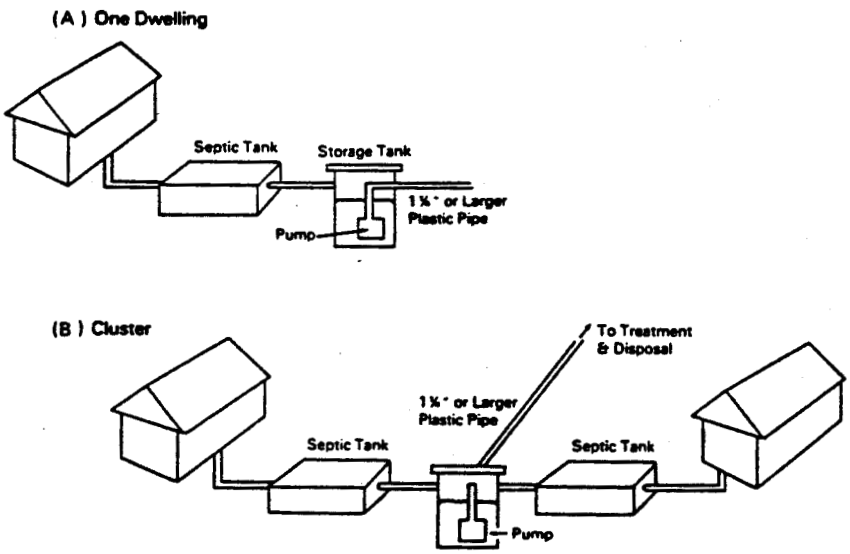
CASE EXAMPLE - STALLINGS AND INDIAN TRAIL, NORTH CAROLINA

For many years, the officials of Union County, North Carolina have been working to develop a feasible plan to bring sewer service to the western portion of the county. This rapidly growing portion of the county, adjacent to Mecklenburg County and Charlotte, North Carolina, includes the Towns of Stallings and Indian Trail.

The area has been continually plagued by malfunctioning septic tank systems due to the tight clay soils and shallow rock in the







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COLLECTION SYSTEM TYPES

diameter sewers is ineligible for EPA funding, a "non-conventional" system constructed with small diameter gravity (SDG) sewers is eligible for up to 75% funding. A prerequisite for funding is that, based on a present worth analysis, the cost of the "non-conventional" system proposed must be less than that of a "conventional" system to serve the same area. In addition, only wastewater facilities serving homes or commercial establishments constructed prior to December 15, 1975 are eligible.

A combination of 8-inch diameter "conventional" sewers and MGE "non-conventional" 4-inch and 6-inch diameter sewers was selected for the Stallings/Indian Trail sewage collection system. Conventional sewers were designed primarily along major roadways such that future expansion of the collection system would accomodate either "conventional" or "non-conventional" sewers. MGE sewers were designed to provide service to the remaining area which included many subdivisions.

The combination conventional/SDG sewer system will serve 1150 residences and commercial establishments using approximately 8 miles of conventional 8-inch diameter gravity sewer and 13 miles of 4-inch and 6-inch SDG sewers. The system includes 694 interceptor tanks. Seven STEP systems were designed to serve homes located below the hydraulic gradient.

Construction bids for the conventional and SDG collection sewers were received in August, 1988. Construction of the collection sewers, the related interceptors and a 0.65 MGD advanced wastewater treatment plant is scheduled to be completed in spring, 1990.

SDG SEWER DESIGN CONCEPTS

Early in the conceptual design process, it was decided that none of the existing septic tanks would be incorporated into the SDG collection sewer system. The location of the existing tanks were in many cases unknown and the condition of existing tanks would be difficult to determine. Based on tank ages and investigations into similar projects, it was expected that most existing tanks would likely require replacement. Based on other projects in North Carolina which used existing septic tanks and experienced severe infiltration problems resulting from leaking septic tanks, the NCDEM concurred that 100 percent of the tanks should be replaced and that new tanks would be eligible for I&A funding.

New tanks, termed "interceptor" tanks to more adequately describe their purpose, were designed. The objectives of the tank design were to remove solids, provide some surge capacity, allow venting of the sewer through the house stack vent, and provide easy access for pumping and maintenance. Each tank was installed below grade just outside of the road right-of-way on the front lawn of each resident or business such that the majority of SDG sewers could be layed within the road right-of-way with minimal

disruption to residences. Because of the proximity of the tanks to the roadway and driveways, each tank was designed to withstand a AASHTO H10-44 light traffic load. A typical arrangement for SDG sewers and interceptor tanks is presented on Figure 2.

The interceptor tank design is shown on Figure 3. The tanks consisted of two chambers with a 4-inch vent opening between the dividing wall. The tank volumes were specified along with permissable dimension ranges to allow tank manufacturers to provide several economically competitive shapes and designs, although size restrictions were specified. A minimum volume of 1000 gallons was specified within the "normal liquid level" of the tank, with a reserve capacity (the volume between the tank inlet and the "normal liquid level" of the tank) of 200 gallons. Also, the volume of the first compartment was to be between 2/3 and 3/4 of the total tank volume. The minimum tank length and width were 8 feet and 3 feet respectively, with the length at least twice the width. The depth of the tanks was to be between 3 and 4 feet.

Three parallel 2-1/2-inch riser pipes were designed to transport wastewater from the first chamber to the second. These pipes, set at a 45^0 angle, would act as clarifier tubes. The center tube could be easily rodded from above grade through a cleanout. A second clean-out positioned over the first chamber would allow monitoring of sludge levels and access for pumping tank contents without excavation of the tank. A clean-out located at the

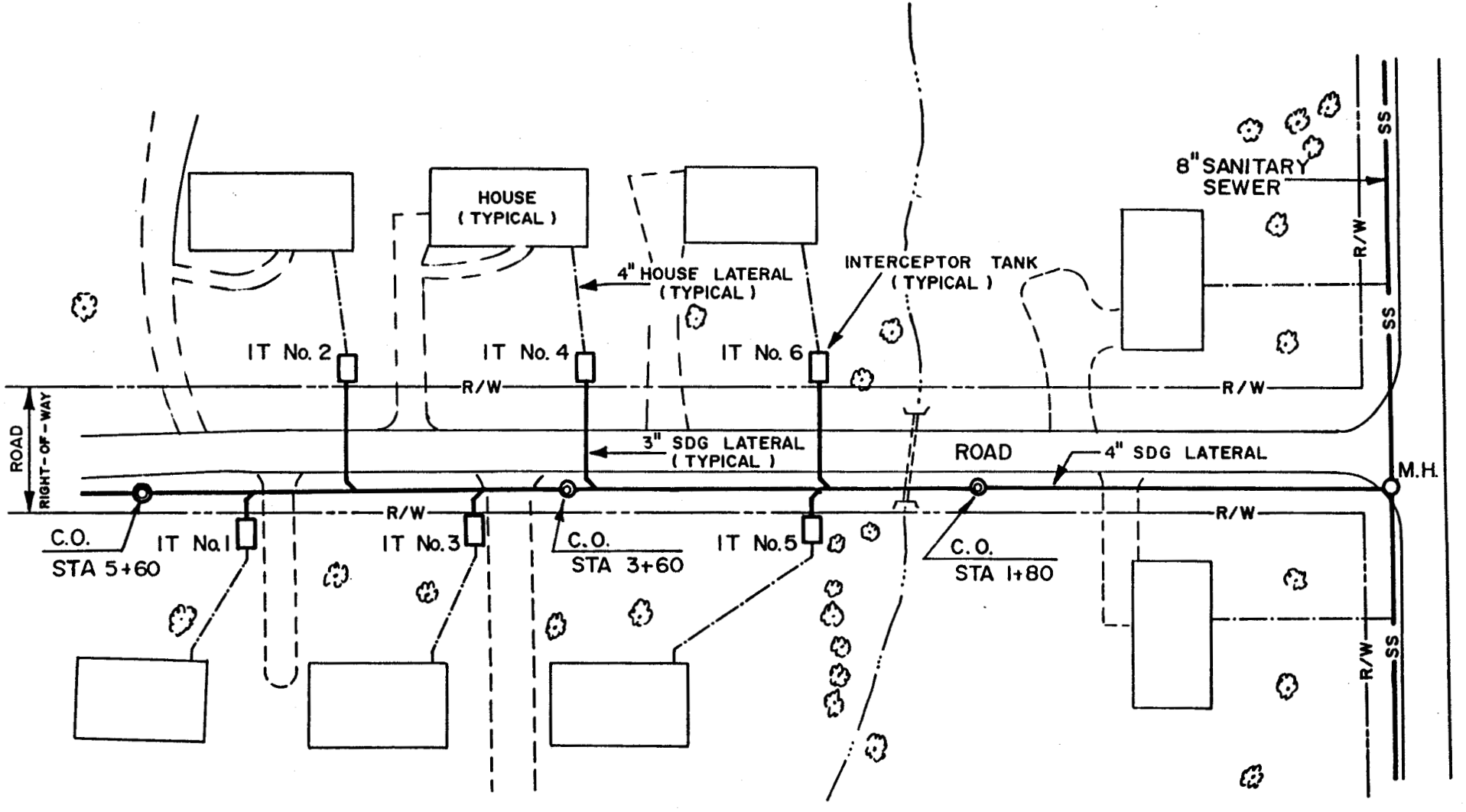
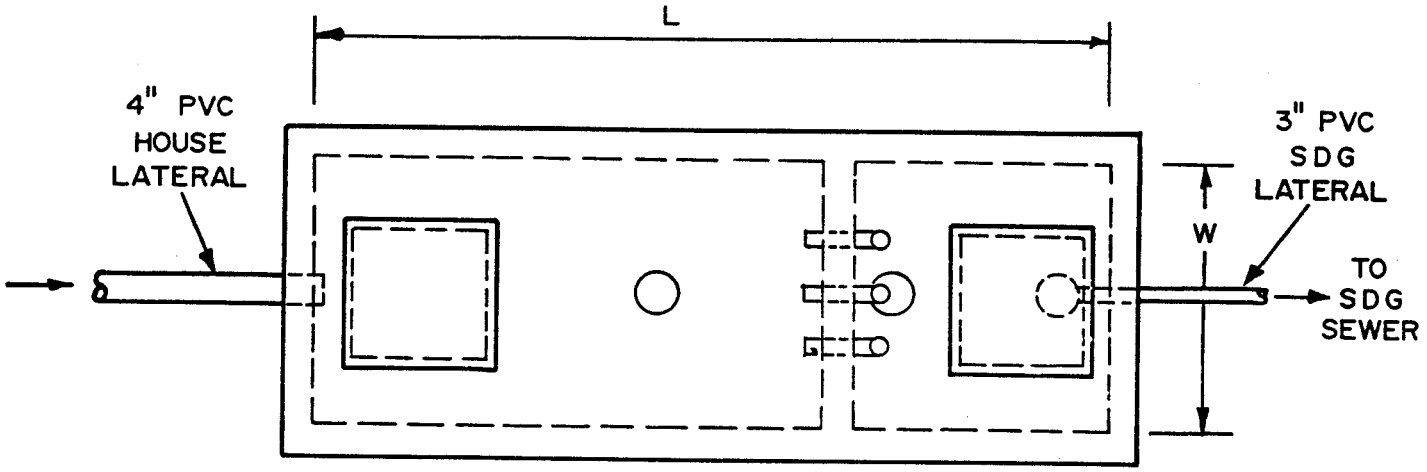
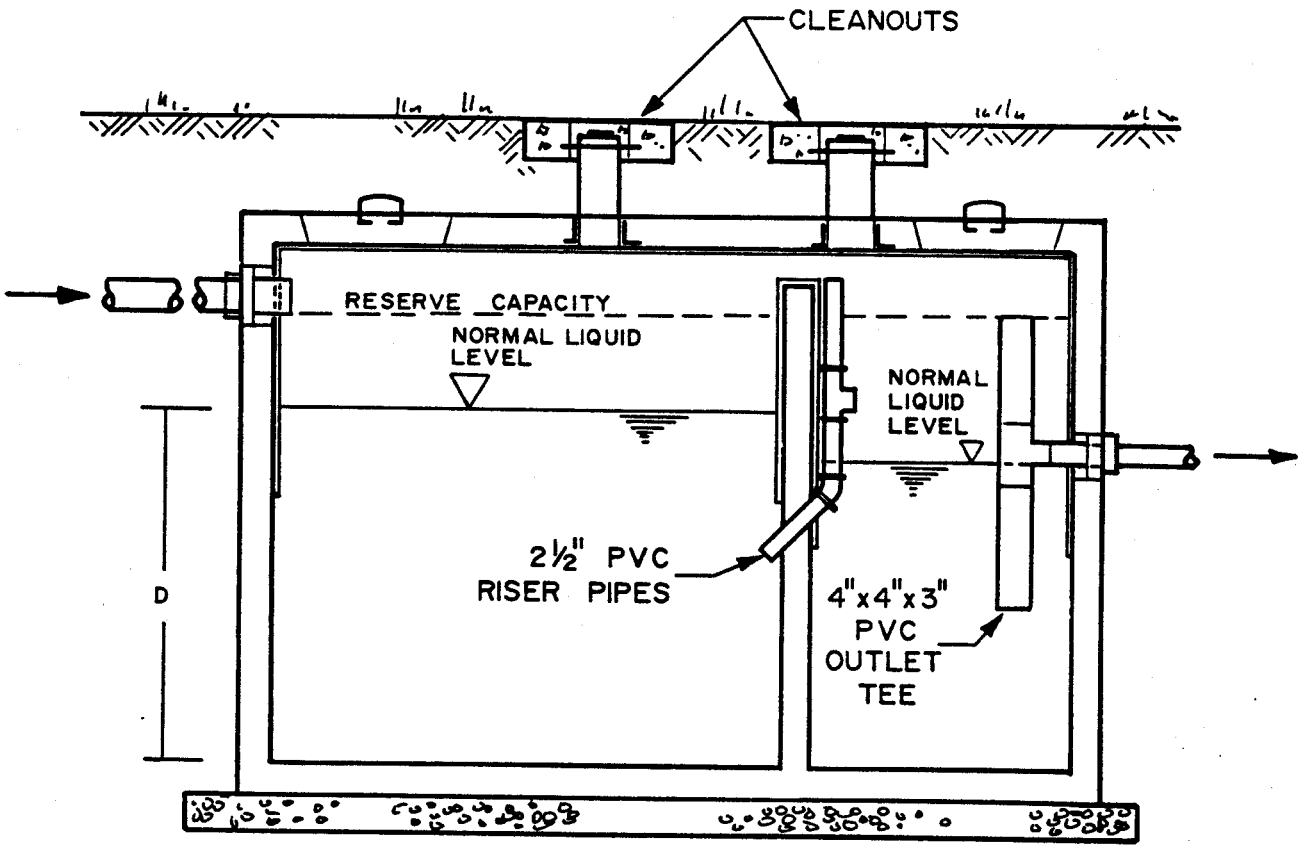


FIG. 2 – PLAN, TYPICAL SDG SEWER ARRANGEMENT



PLAN



PROFILE

FIG. 3 — SDG SEWER INTERCEPTOR TANK

lateral connection to the main SDG sewer was provided for rodding of the lateral from the sewer back into the tank. Interceptor tanks were to be leakage tested in the field prior to backfilling.

All SDG sewers were sized based on lot counts and a design flow of 192 gallons per day per resident. A minimum design velocity of 1 fps was selected. Sewers were designed to flow one-half full at the 20-year projected design flow with a minimum size of 4-inch diameter. In a few isolated lines, a two-thirds full pipe flow was used in lieu of one-half full where doing so prevented increasing the pipe size to 8-inches in diameter. To facilitate cleaning, PVC cleanouts were used every 300 linear feet, at all bends, sewer intersections, changes in pipe diameter, and at the junction of each collection effluent lateral with the sewer. Details of SDG bends and cleanouts are presented on Figures 4 and 5, respectively. ASTM D-3034, SDR-35 PVC pipe was specified for the sewers. The 3-inch diameter SDG service laterals are ASTM D-1785, schedule 40 PVC.

Interceptor tank elevations were selected to allow gravity flow from the resident to the tank. These elevations were plotted on the profile of the ground elevation along the centerline of the proposed sewer. The invert of the sewer was then designed to provide a minimum drop of 1 foot below each interceptor tank invert. A typical sewer profile utilized on the project is shown on Figure 6.

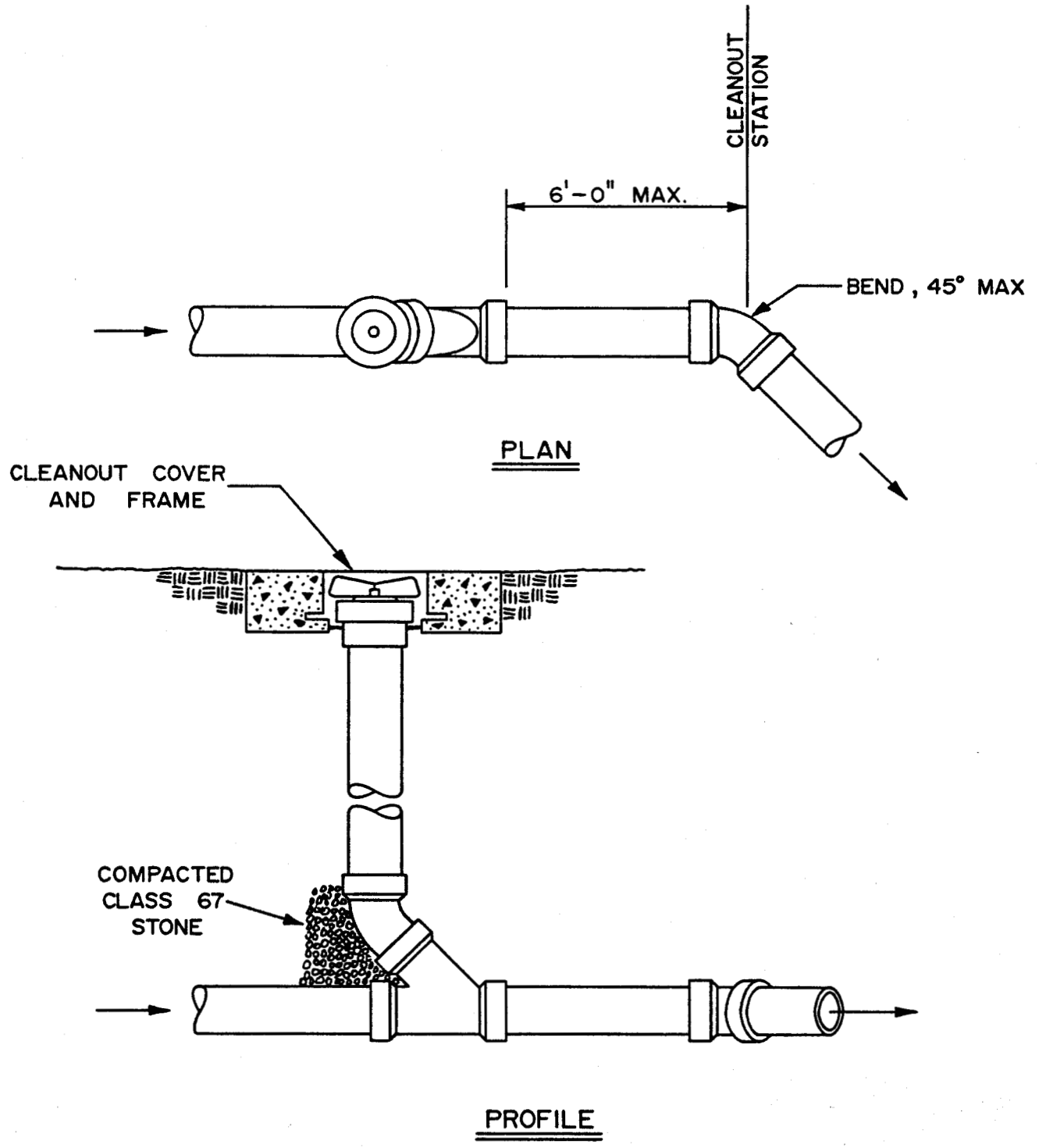
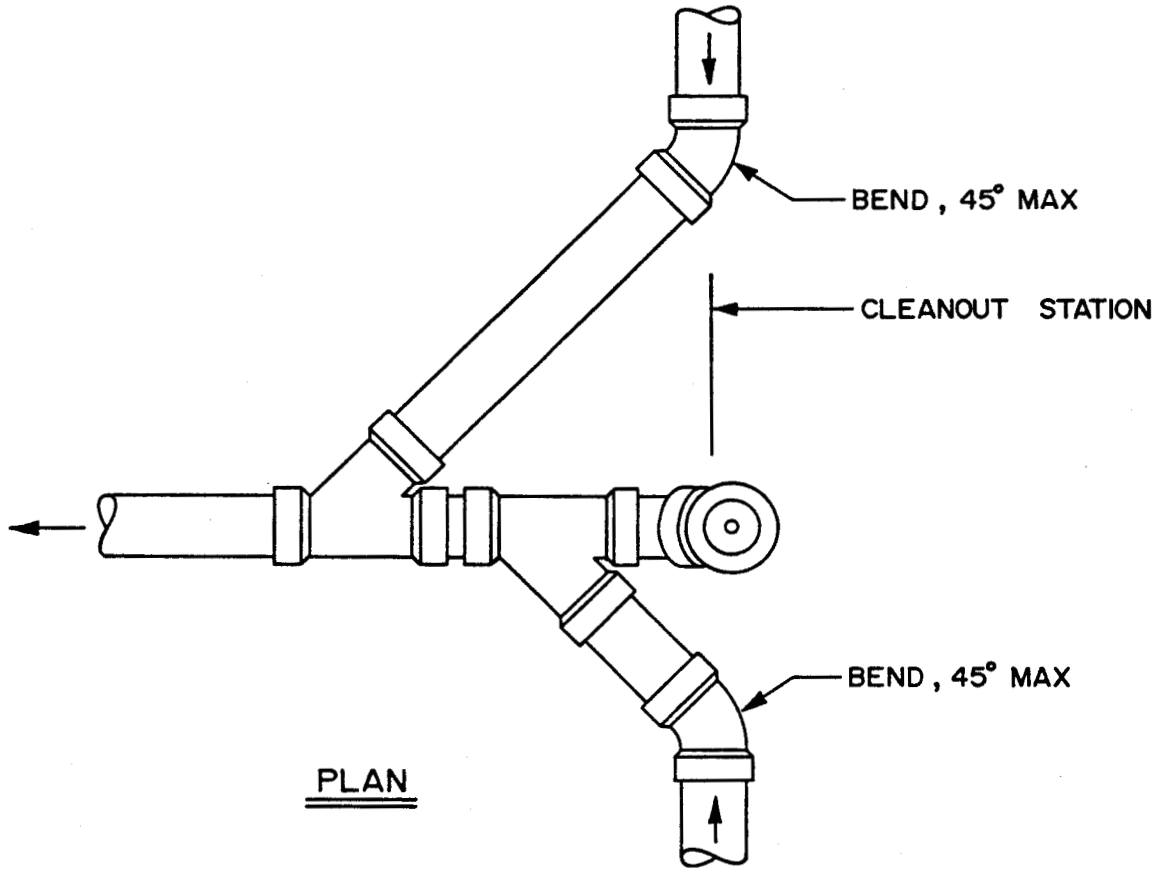


FIG. 4 - SDG SEWER LINE BEND



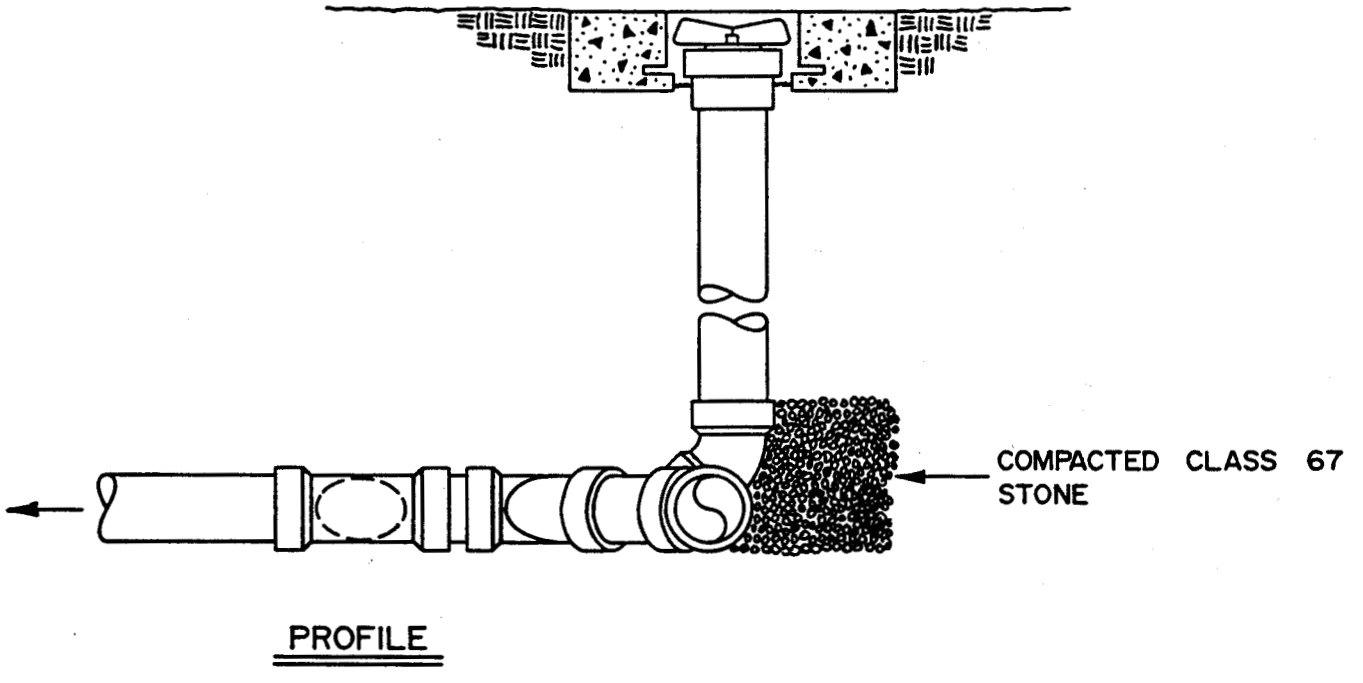


FIG. 5 — SDG SEWER CLEANOUT

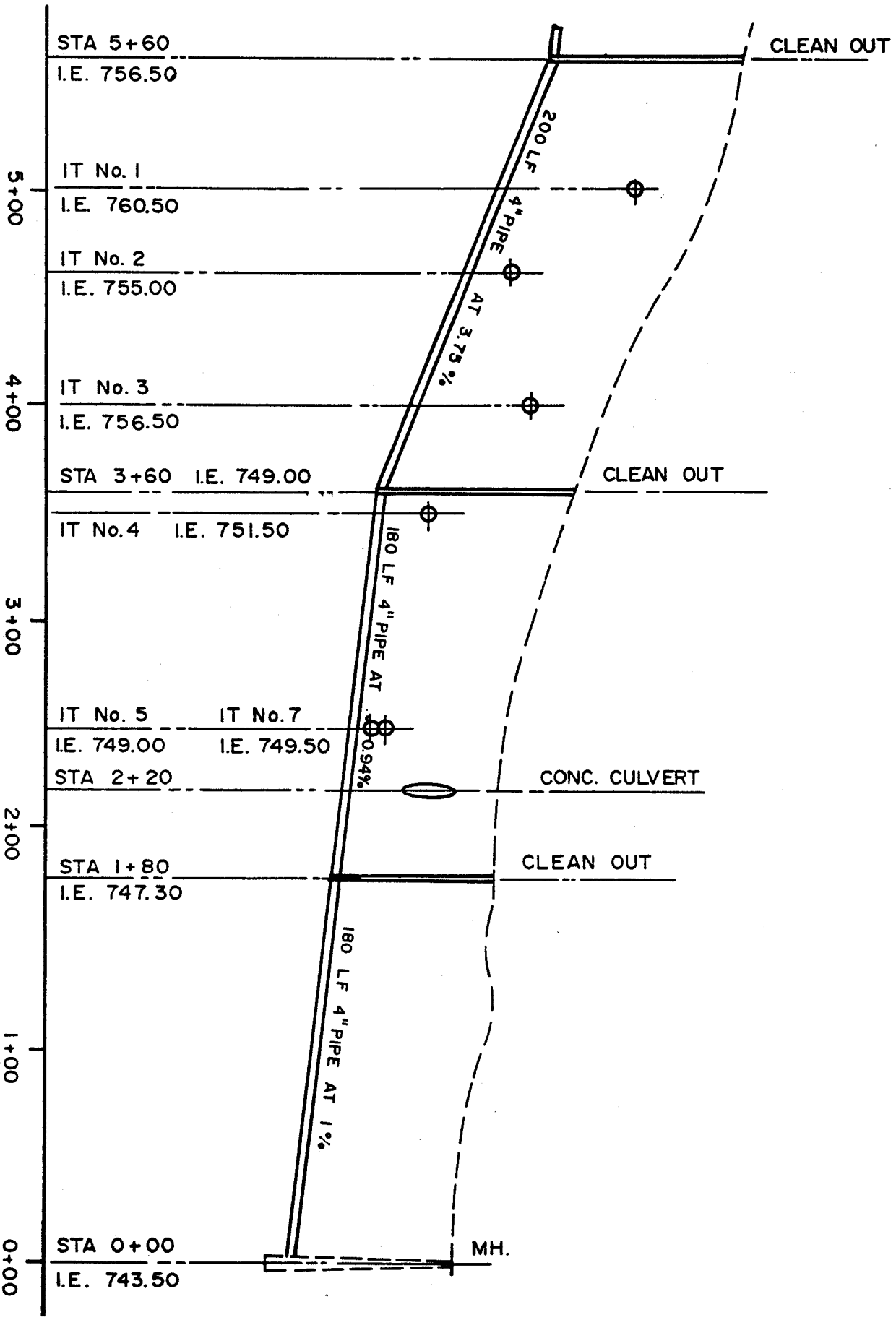


FIG. 6 — PROFILE, TYPICAL SDG SEWER ARRANGEMENT

Since wastewater carried by septic tank effluent sewers has a higher concentration of dissolved hydrogen sulfide due to anaerobic biological processes in the tank, odor and corrosion prevention techniques were incorporated in the system design. Where SDG sewers entered manholes, the manhole interior was coated with a bitumastic waterproofing material to prevent sulfuric acid corrosion of the concrete. Pump station wetwells were also coated to prevent concrete corrosion and were designed with biological soil filter type odor control systems to prevent escape of nusiance odors to adjacent areas.

CONSTRUCTION COSTS

Bids were received by the Towns of Stallings and Indian Trail for both the "conventional" and "non-conventional" collection sewer contracts in August, 1988. Selected unit costs for the project are presented in Table 1 below.

TABLE 1
SELECTED UNIT COSTS BID

"CONVENTIONAL" SEWERS

ITEM	UNIT COST
8-inch diameter sewer	$19.20 - $21.00/L.F.
4-foot diameter manhole	$1000 - $1100 Each

"NON-CONVENTIONAL" SEWERS

ITEM	COST
4-inch diameter sewer	$17.00 / L.F.
6-inch diameter sewer	$18.00 / L.F.
Interceptor Tank	$2000 Each
Manhole Coating	$100 / Manhole
Cleanouts	$120 Each

Unit prices for the 4-inch and 6-inch diameter gravity sewers and interceptor tanks were higher than expected. The apparent cause of the inflated prices seem to be 1) unfamiliarity of area sewer line contractors with the SDG concept and the installation labor requirements for interceptor tanks and other SDG components and 2) the availability of a great deal of conventional sewer construction projects at the time of bidding.

The bid unit price for the interceptor tanks as specified came in at $2,000 each. A modified single compartment tank with one cleanout, and elimination of the reserve capacity was proposed by the contractor for a reduced unit price of $1,765 each. The contractor was able to establish a temporary facility within the area to manufacture the tanks.

SUMMARY

The use of 4-inch and 6-inch small diameter gravity (SDG) sewers with interceptor tanks is a viable alternative for providing sewer service to residential/commercial areas. The cost effectiveness of this approach will be to a great extent dependent on the local availability of sewer line contractors and septic tank manufacturers familiar with non-conventional sewer systems.

Use of small diameter gravity sewers and the available EPA I&A funding for these sewers made possible the implementation of a wastewater collection and treatment system to serve the Towns of