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Author
Nero, jA.V.

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Control of Population Densities Surrounding Nuclear Power Plants

A.V. Nero, C.H. Schroeder and W.W.S. Yen

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of

HEALTH AND SAFETY IMPACTS OF

NUCLEAR, GEOTHERMAL, AND FOSSIL-FUEL

ELECTRIC GENERATION IN CALIFORNIA

Energy and Environment Division
Lawrence Berkeley Laboratory
University of California
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Vol. 1: "Health and Safety Impacts of Nuclear, Geothermal, and Fossil-Fuel Electric Generation in California: Overview Report," by the entire staff, Lawrence Berkeley Laboratory Report LBL-5924. Includes "Executive Summary" for the project.

Vol. 2: "Radiological Health and Related Standards for Nuclear Power Plants," by A.V. Nero and Y.C. Wong, Lawrence Berkeley Laboratory Report LBL-5285.

Vol. 3: "A Review of Light-Water Reactor Safety Studies," by A.V. Nero and M.R.K. Farnaam, Lawrence Berkeley Laboratory Report LBL-5286.

Vol. 4: "Radiological Emergency Response Planning for Nuclear Power Plants in California," by W.W.S. Yen, Lawrence Berkeley Laboratory Report LBL-5920.

Vol. 5: "Control of Population Densities Surrounding Nuclear Power Plants," by A.V. Nero, C.H. Schroeder, and W.W.S. Yen, Lawrence Berkeley Laboratory Report LBL-5921.

Vol. 6: "Health Effects and Related Standards for Fossil-Fuel and Geothermal Power Plants," by G.D. Case, T.A. Bertolli, J.C. Bodington, T.A. Choy, and A.V. Nero, Lawrence Berkeley Report LBL-5287.

Vol. 7: "Power Plant Reliability-Availability and State Regulation," by A.V. Nero and I.N.M.N. Bouromand, Lawrence Berkeley Laboratory Report LBL-5922.

Vol. 8: "A Review of Air Quality Modeling Techniques," by L.C. Rosen, Lawrence Berkeley Laboratory Report LBL-5998.

Vol. 9: "Methodologies for Review of the Health and Safety Aspects of Proposed Nuclear, Geothermal, and Fossil-Fuel Sites and Facilities," by A.V. Nero, M.S. Quinby-Hunt, et al., Lawrence Berkeley Laboratory Report LBL-5923.

CONTROL OF POPULATION DENSITIES SURROUNDING NUCLEAR POWER PLANTS

ABSTRACT

In view of the requirement that the California Energy Resources Conservation and Development Commission must specify land-use/population-density control measures to be used in the vicinity of nuclear power plants being granted land use, the possible forms of such measures are examined. Since these measures must maintain population densities below Nuclear Regulatory Commission criteria, if appropriate, NRC criteria for land use and population densities are given particular attention. In addition, a preliminary comparison of the cost of possible control measures with the reduced potential for damage to the public health and safety is made, yielding the result that control measures within approximately one mile of the plant site may be justified, in certain cases, on a strictly cost-benefit basis. However it not clear whether controls over such a limited region would satisfy the legal mandate.

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1. INTRODUCTION: THE BASIC CONSIDERATIONS

The primary impetus to implementation of local controls and planning in the vicinity of nuclear power plants is to minimize potential exposures of members of the general public to radiation resulting from releases of radioactivity from these facilities. To be more precise, possible releases during accidents at these plants are the major concern.

Three basic categories of local measures are usually considered, and these will be treated in this report. They are: land use controls, explicit application of population density criteria, and emergency planning. These measures are directly related to protection of the population surrounding a nuclear plant, and they are strongly interrelated, so much so that it is difficult to consider them separately. Their connection with one another is specified below. However, the primary emphasis of the present discussion will be explicitly land use and population density considerations. Emergency planning around nuclear power plants is considered in detail in a separate report[1], which we will reference freely.

Furthermore, our primary interest is measures to control population exposures, rather than pre-existing conditions or criteria which tend to minimize these exposures. Thus, for example, the existence of relatively low population densities around a site might tend to make it an attractive location for a nuclear plant, but it is the measures that would maintain low densities that are the concern of this report. Of course, the existence of such control measures could itself be one criterion for site selection.

The California Energy Resources Conservation and Development Commission (ERCDC) has broad responsibilities for review of site suitability and of proposed facilities. Land-use/population-density criteria and emergency planning requirements are appropriately considered as part of the site suitability analysis. As discussed in section 3, the legislation constituting the ERCDC explicitly requires that the review procedures require the applicant to demonstrate that adequate density controls exist. To a large extent, the primary referents for "adequacy" are the criteria used by the Nuclear Regulatory Commission (NRC) in Federal licensing procedures. However, the ERCDC must determine whether the NRC criteria take a form appropriate for application by State agencies.

Several aspects of the NRC review procedures pertain directly to the present question: the NRC requires that an "exclusion area," a "low population zone," and a "population center distance," be defined for any proposed nuclear power plant; the NRC applies, in a loosely defined manner, general population density criteria; finally, the NRC reviews the applicant's on-site emergency planning, but only exercises what might be described as "oversight" with respect to emergency planning for surrounding areas. Overall, the NRC does not apply any firm criteria with respect to possible land-use/population-density controls or off-site emergency planning. However, the review contains elements, referred to above and discussed more thoroughly in section 2, which might be utilized by State agencies during their review of proposed sites.

Presuming the regions to be controlled and the densities to be maintained have been determined, a number of control techniques can be applied. They may be divided into three broad categories: public regulatory measures, public acquisition, and private acquisition or covenants. The public regulatory measures include traditional zoning techniques, but may also include newer techniques. Regulatory measures may be implemented by local authorities; they may also be reinforced or directly applied by State authority.

Before examining the NRC procedures and possible State/local options, we note that the NRC review with respect to land use, population densities, and emergency planning is conducted on a rather formal basis. Ideally, the extent of any controls and the details of their implementation would be based explicitly on a comparison of risks posed by potential accidents at a proposed nuclear power plants and of the cost of reducing these risks. This approach would consider the probability and consequences of nuclear plant accidents and would match controls to the potential for harm. Some basis presently exists for such a comparison*, but it is not without controversy. In lieu of such a risk-benefit approach, the NRC review criteria as they presently stand can serve, to a limited extent, as a basis for planning of land use and population densities. The NRC review criteria are based on a more formal accident analysis that is intended, at least in the definition of the exclusion area and the low population zone, to be "conservative."

Some justification should be given for the emphasis on potential <u>accidents</u> as the primary consideration in planning around nuclear power plants. These plants also release radioactivity under normal operating conditions. However, the routine emissions from nuclear power plants are small enough that, based on

*Risk assessment is discussed in a separate review of light-water reactor safety studies.[2]

generally available information, discussed in an accompanying report[3], they do not appear to warrant the attention given to potential accidental releases from these plants. This is particularly true considering the controversy over the risk from nuclear accidents.

The fact that accidental releases are the major concern for nuclear plants,* but routine emissions are most important for fossil-fuel plants[4], leads to important differences in the character of State and local planning for these differing facilities. These differences are also prompted by the intrinsic differences in the types of emissions, i.e., radioactive versus more conventional chemical pollutants. Planning for nuclear plant accidents tends to examine potential exposures on a rather local basis, with an emphasis—historically—on avoiding any massive individual exposures. The effects of fossil-fuel plants, on the other hand, are often considered on a regional basis, which is appropriate because of possible accumulation and transformation of conventional pollutants. Possible transformations have not been as important a consideration for radioactive pollutants.

Furthermore, because of the more regional character of conventional air pollution, any air pollution emergency (or "episode") is likely to be caused by the combined effect of a large array of emitters, so that a particular fossil-fuel power plant would not be solely responsible. A nuclear emergency differs strongly from these episodes, since it would almost certainly be caused by an accidental release from a single facility. For these reasons, the planning around a nuclear plant is typically on a relatively local scale, designed to deal with emergencies, whereas the planning for fossil-fuel related emissions, whether under routine or emergency conditions, will more often attend to regional considerations. This relatively local nature of nuclear planning lends itself to the implementation of land-use/population-density controls and emergency planning as measures to limit exposures should a large accidental release occur.

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*Note that we here treat only the power plant itself. Consideration of the entire fuel cycle may alter this comparison of accidental and routine releases.

2. NUCLEAR REGULATORY COMMISSION REVIEW OF CONTROLS AND PLANNING FOR THE PROTECTION OF LOCAL POPULATIONS

The Nuclear Regulatory Commission requires that the applicant proposing a nuclear power plant define, in its Safety Analysis Report, an exclusion area, a low population zone, and a population center distance. These must meet rather formal conditions based on certain postulated radioactive releases. Furthermore, the NRC staff examines data submitted on surrounding population densities to determine whether they exceed general density criteria. Finally, the NRC reviews provision for on-site emergency response capabilities and examines, but without exercising any regulatory authority, plans for development of off-site capabilities. The details of these NRC reviews, treated in a separate report[1], are specified in the NRC's Standard Review Plan[5] and in supporting materials[6]. The brief discussion below is intended to serve as background for considering how the State might implement controls on land use and population densities, controls which the Nuclear Regulatory Commission does not impose.

2.1 The Exclusion Area and the Low Population Zone; Population Center Distance.

One approach to protecting the public from potential exposures resulting from radioactive releases from a nuclear plant is to depend on a series of population zones surrounding the plant. The selection of two such zones constitutes a formal part of the safety review performed by the Nuclear Regulatory Commission, as specified in Title 10 of the Code of Federal Regulations (10 CFR). One is an exclusion area, for which the applicant must demonstrate that it exercises exclusive control; for practical purposes, this is the power plant site itself, to which the public does not have free access. The second is a low population zone, a region held by the public (and to which it has access); the applicant is expected to provide an emergency response plan, in conjunction with the local authorities, that will adequately provide for the protection of the presumably small population included in this area.

The applicant is constrained from defining these two areas to be inordinately small by formal regulatory requirements, given below, on the radiation doses that would be sustained by individuals at the outer boundaries of these regions should certain postulated accidents occur. The size of these zones is based on a postulated release and a fixed maximum dosage, and is characteristic of the formality of the regulatory approach, a formality that contrasts with actual analysis of accident risks versus regulatory benefits.

This formal approach is most evident in determination of the maximum release to be considered. In the applicant's analysis of the nuclear plant design, a spectrum of "design-basis" accidents is considered. For the design to be acceptable, this analysis must demonstrate that the safety systems at the plant (many of which are referred to as "engineered safety features") are capable of limiting the accident's consequences, preventing, for example, any melting of the fuel in the core. Even with these limited accidents, it is possible that an unusual amount of radioactivity would be emitted, and the applicant is required to consider the means to prevent severe exposures of surrounding populations. In this formal approach, calculated exposures are based on a fission product release that is not directly connected with the accident analysis mentioned above, but which is intended to exceed the release from any "credible" accident. This release is, as a matter of fact, much greater than any that has been observed from any operating power plant.* Based on this release, exposures to individuals in the vicinity of the plant may be calculated.

The NRC requires that two zones be defined for its site evaluation, consistent with the following requirements (10 CFR 100.11):

(1) An exclusion area of such size that an individual located at any point on its boundary for two hours immediately following onset of the postulated fission product release would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

(2) A low population zone of such size that an individual located at any point on its outer boundary who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a total radiation dose to the whole body in excess of 25 rem or a total radiation dose in excess of 300 rem to the thyroid from iodine exposure.

In practice, the exclusion area is the zone immediately surrounding the plant and is purchased outright by the utility+. The low population zone, on the other

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*However, as discussed in section 5 and in reference 2, it is smaller than the releases which appear to constitute most of the risk from nuclear accidents.

+The NRC describes these two zones as follows (10 CFR 100.3): (a) "Exclusion area" means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety. Residence within the exclusion area shall normally be prohibited. In hand, is not owned by the utility and is ordinarily not subject to any population controls as a direct component in the licensing process.* The exclusion area is typically less than a mile in radius (measured with respect to the position of the reactor), and the low population zone typically has a radius exceeding one mile, but no more than several miles. Parameters for nuclear power plants in California are given as examples:

Populations surrounding present California nuclear power plants[a]

Plant	Exclusion Zone Radius (miles)	Low Population Zone (LPZ) Radius (miles)	1972 Population within LPZ	1972 Population within 10 mile rad.	1972 Population within 30 mile rad.
Humboldt	0.13	2.0	2000	49,000	≃90,000
San Onofre	0.1	2.0	0	36,000	644,000
Rancho Seco	0.4	4.7	300	6,000	908,000
Diablo Canyon	0.5	6.0	14*	4,900	135,000

*5 miles

[a]abstracted from reference 1.

A basic criterion associated with the low population zone is that effective evacuation be possible; this criterion is to be applied during consideration of the emergency planning for the facility, a responsibility of the utility and local authorities.

The doses given above (25 rem whole body and 300 rem thyroid) are not intended as acceptable doses, but rather as reference doses for use in licensing evaluation. As such, they constitute a formal, rather than fundamental, approach

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(footnote continued from page 5)

any event, residents shall be subject to ready removal in case of necessity. Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result. (b) "Low population zone" means the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident. These guides do not specify a permissible population density or total population within this zone because the situation may vary from case to case. Whether a specific number of people can, for example be evacuated from a specific area, or instructed to take shelter, on a timely basis will depend on many factors such as location, number and size of highways, scope and extent of advance planning, and actual distribution of residents within the area.

to licensing. The doses are calculated, incidentally, assuming adverse weather conditions for the site being considered.

In addition to the zones defined above, a population center distance is defined with respect to substantial population centers (10 CFR 100.3):

> (c) "Population center distance" means the distance from the reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents.

This distance must be found to be a minimum of 1 1/3 times the low population zone radius (10 CFR 100.11):

> A population center distance of at least one and one-third times the distance from the reactor to the outer boundary of the low population zone. In applying this guide, the boundary of the population center shall be determined upon consideration of population distribution. Political boundaries are not controlling in the application of this guide. Where very large cities are involved, a greater distance may be necessary because of total integrated population dose consideration.

Because this distance is primarily a site criterion, not a control measure, it does not seem probable that this concept can serve as an appropriate device for population density controls in the present context.

On the other hand, the requirements given above lead to definition of a low population zone which may serve as the basis of a program of population density control through the regulation of land use. However, consideration of population density does not enter directly into the definition of the low population zone, except that the available emergency planning should be adequate to protect populations in this zone.

2.2 NRC Density Criteria

The NRC also considers criteria which apply more explicitly to population densities *per se*. However, these actual density criteria apply to a substantially larger region than is considered for the low population zone.

Two NRC guidelines may be considered to be appropriate reference criteria on population densities *per se*. The first uses an unweighted cumulative population versus distance and is the criterion presently used in the evaluation of population distribution in the NRC siting review. It recommends consideration of alternative sites if the population density, projected at the time of initial plant operation, exceeds 500 persons per square mile averaged over any radial distance out to 30 miles, or 1000 per square mile during the lifetime of the facility. As examples, 500 per square mile corresponds to 40,000 for a 5-mile radius, 630,000 for 20 miles, and 2.5 million for 40 miles.

The second guideline is a proposed interim regulatory guide, "Population Distribution Around Nuclear Power Plants," circulated for discussion beginning in April 1974. Sites having actual (or projected) populations exceeding 30,000 within 5 miles, 500,000 within 20 miles, or 2,000,000 within 40 miles would be subject to additional scrutiny and special requirements, such as minimum sizes for the exclusion and low population zones. This criterion is somewhat more strict than that mentioned first. It is, however, not formally issued.

Both of these guidelines are rather crude, giving minimal consideration to the manner in which the population is distributed within the specified radii. This is true despite the fact that the population distribution critically affects both the extent to which surrounding populations could be exposed to radiation and the effectiveness of emergency planning. It is difficult to specify uniformly applicable regulatory guidelines that can effectively reflect the details of emergency conditions. However, some analytical tools have been suggested to weight the population distribution more effectively. (See the "site population factor" discussed in Appendix A of ref. 1.)

It is important to note, though, that the guidelines do require consideration of the projected growth of population around the plant during its operating lifetime. (Methods of projection are given in Appendix B.) However, no controls are required. Moreover, should the population growth exceed the guideline limits, there are no explicit mechanisms for reconsidering or altering the operating license for the plant. Because of this effective lack of control, population densities may eventually rise above the levels presumed in the examination of site suitability.

2.3 Emergency Planning

Although emergency planning is considered more fully elsewhere[1], the relationship of such planning to population densities and to the population zones specified above is very strong. The effectiveness of any planning, whether evacuation, sheltering, or prophylactic measures, clearly depends on the regions to be affected and the number of people involved.

There are more subtle relationships, in addition. The low population zone has a minimum size, in its formal description, that involves—for example—a whole body dose of 25 rem. As noted, this is not intended to be an acceptable dose. As discussed in other reports[1,3], it considerably exceeds the dose levels at which protective actions are suggested, either by the Environmental Protection

Agency or the California Office of Emergency Services.* So, for the postulated releases considered, emergency actions would be required. However, it is a fact that the possible accident spectrum includes accidents with much larger releases[2] than those postulated. This raises questions about the adequacy of the population zones as defined, or of the related emergency planning (which, in any case, is regulated by State or local agencies rather than by the NRC).

Some judgment of the adequacy of the zones, density criteria, and planning discussed in this section may be made by taking the risk-benefit approach discussed in section 5. However, lacking any definitive approach of this type, it is the criteria suggested by the present NRC review procedures that would appear to be the initial basis of controls and planning implemented at the State level. Moreover, the legislation constituting the ERCDC explicitly indicates that the NRC criteria are to be used if possible.

3. CALIFORNIA ERCDC REVIEW RESPONSIBILITIES

The California Energy Commission has a general responsibility to set conditions necessary to protect the public health and safety from damage from any proposed facility. Many of the questions to be considered are listed in section 25511 of AB 1575 (the Warren-Alquist Act), wherein population density controls around nuclear power plants are specifically mentioned. The general authority to consider population densities for any power plant is implied in section 25511, and is made explicit in a section dealing with land use controls alone, section 25528:

> 25528. (a) The commission shall require, as a condition of certification of any site and related facility, that the applicant acquire, by grant or contract, the right to prohibit development of privately owned lands in the area of the proposed site which will result in population densities in excess of the maximum population densities which the commission determines, as to the factors considered by the commission pursuant to Section 25511, are necessary to protect public health and safety. The power of condemnation is hereby granted to the applicant to acquire such development rights and the requirement of the commission that any such rights be acquired is a conclusive finding of the public necessity of such condemnation; provided, however, that nothing in this division grants or extends a right of condemnation to any person or applicant who has not otherwise been granted such right under any other provision of law prior to the effective date of this revision.

*However, such actions guides are still at the development stage.

(b) In the case of an application for a nuclear facility, the area and population density necessary to insure the public's health and safety designated by the commission shall be that as determined from time to time by the United States Atomic Energy Commission, if the commission finds that such determination is sufficiently definitive for valid land use planning requirements

(c) The commission shall waive the requirements of the acquisition of development rights by an applicant to the extent that the commission finds that existing governmental land use restrictions are of a type necessary and sufficient to guarantee the maintenance of population levels and land use development over the lifetime of the facility which will insure the public health and safety requirements set pursuant to this section.

(d) No change in governmental land use restrictions in such areas designated in subdivision (c) of this section by any government agency shall be effective until approved by the commission. Such approval shall certify that the change in land use restrictions is not in conflict with requirements provided for by this section.

(e) It is not the intent of the Legislature by the enactment of this section to take private property for public use without payment of just compensation in violation of the United States Constitution or the Constitution of California.

This section indicates that purchase of developmental rights or restrictive zoning are required by law to assure that population densities do not exceed adopted limits. The section gives general authority to the ERCDC in such matters in order to protect the public health and safety. However, for nuclear facilities, section (b) specifies that criteria for areas and densities shall be those determined by the Atomic Energy Commission, whose regulatory functions have been assumed by the Nuclear Regulatory Commission. As a result, the ERCDC is required to consider first the NRC criteria.

Independently of whether these NRC criteria prove to be sufficiently "definitive," the ERCDC then has the responsibility of insuring that controls exist to limit population densities to the adopted criteria. Ordinarily, actual controls of this type do not exist around currently operating nuclear power plants.

It may also be difficult to institute controls based on the NRC's explicit population density criteria. For these criteria, which examine population densities to a distance of tens of miles, a large area would have to be controlled. It appears unlikely that such controls would be instituted for the specific purpose of insuring ERCDC certification. For criteria applicable to such a large area, a "demonstration of unlikelihood" might be the only practical control mechanism. That is, it might be argued that demonstration that there is no likelihood that density criteria will be exceeded during the life of the plant can be taken to fulfill the legislative requirement. This would then depend on the availability of dependable techniques for predicting population growth. Some approximate techniques, those presently employed by NRC, are given in appendix B.

Ironically, it is unlikely that predictive techniques would be reliable for predicting population growth for the most sensitive population, that very near the plant. Not only is it more difficult to make reliable predictions on a small scale, but the very existence of the plant might considerably alter the predictions. On the other hand, for such a smaller region, explicit density controls might be more workable. In particular, effective controls might be applied to parcels of land the size of the low population zone. This would serve to protect the population most sensitive to accidents and might be construed to fulfill the legislative mandate.

4. TECHNIQUES FOR CONTROL OF POPULATION DENSITIES

The two techniques specifically mentioned in AB 1575 for control of population densities are the purchase of developmental rights and governmental land use restrictions. These are examples of two general classes of density control techniques, private acquisition or covenants and public regulatory measures. A third class is actual public acquisition, which may become an unintended consequence of public regulation.

A preliminary exploration of possible control techniques constitutes appendix A of this report. That discussion will not be repeated here, but it is useful to clarify one point. Appendix A discusses land use control techniques from a rather general point of view, and uses the term "developmental rights" in its usual context, i.e., that of a public regulatory framework, in which such rights can be transferred from one owner to another for actual use in connection with a parcel of land. On the other hand, AB 1575, quoted in section 3, may require that the applicant "acquire, by grant or contract, the right to prohibit development" (emphasis added). This appears to presume acquisition of the development rights through private covenant, not necessarily in the public framework normally associated with the concept of developmental rights. However, as noted in Appendix A, requirement that the applicant have purchased rights in connection with construction of the plant effectively prohibits use of those rights for nearby development. Therefore restriction of local development could be accomplished either by private covenant or by a public framework for developmental rights transfer.

In any case, it is important to note that the applicability of any technique depends critically on the size of the region to be controlled and on the existing land use of the region. For this reason, the choice of what NRC or other criteria are to be applied will have a large influence on the selection of control techniques. Moreover, this selection may depend substantially on the use characteristics and ownership pattern for any particular site being considered.

5. ALTERNATIVE CRITERIA FOR POPULATION DENSITY CONTROLS

Because of the formal basis of the present Nuclear Regulatory Commission population zones, i.e., dependence on reference releases and dose limits, they are subject to the criticism that they do not reflect the actual risk presented by nuclear power plants. Depending on the critic, either more or less severe population density restrictions might be suggested. On the one hand, fission product releases greater than the postulated release are possible. On the other hand, these larger releases are not highly likely as compared with the postulated release, which indeed has never occurred either.

The only study in the United States which gives a quantitative basis for assessment of the importance of large accidents (or, in fact, of smaller ones) is the Reactor Safety Study (WASH-1400), performed for the Nuclear Regulatory Commission during 1972 - 1975. This study, as well as contemporary studies by an American Physical Society study group and by the Electric Power Research Institute, are discussed in a separate report.[2]

The Reactor Safety study indicated that accidents leading to melting of the reactor core are not inconceivable. Rather, they are to be expected, on the average, once per 20,000 years of reactor operation. However, it should be noted that all of the probabilities and consequences resulting from WASH-1400 include substantial uncertainties, typically factors of 10 and 3, respectively.

In some percentage of these accidents, a substantial portion of the radioactive inventory would be released to the atmosphere, exceeding the postulated release. Such large releases, however, are expected to occur substantially less frequently than the core meltdown accidents with more limited releases. Thus although current area and population density criteria might be criticized because they do not postulate the largest possible releases, a less critical view is that they do consider a substantial enough release, in view of the probabilities associated with the various release sizes.

The main point of WASH-1400 was to calculate the probabilities of all accidents which contribute significantly to risk (probability x consequences). The study examined accidents with a wide range of severity. So, presuming the WASH-1400 results have some validity, they may be used to judge the adequacy of current population density criteria.

Table 5-6 of the main report of WASH-1400 states the average societal risks from a system of 100 nuclear power plants due to accidental releases. For purposes of the present discussion, we adapt these results to the case of one average nuclear plant for its lifetime (presumed to be 30 years):

Average risk from a nuclear power plant during its lifetime

(adapted from WASH-1400)

early fatalities	9×10^{-4}
early illness	6×10^{-2}
latent cancer fatalities	6×10^{-1}
thyroid nodules	6
genetic effects	9×10^{-2}
property damage	$\$6 \times 10^{5}$

(The uncertainty in these results is about a factor of 10, according to WASH-1400.) Stating the results in this form, i.e., for the lifetime of the power plant, makes it easier to compare the risks with the costs of implementing land-use/population density control measures.

The calculations of WASH-1400 were based on examination of two plant designs, typical of the largest plants about to begin operation as the study began. The calculations also included, effectively, a particular perception of the adequacy of nuclear plant system design, of the effectiveness of Nuclear Regulatory Commission review, of the extent to which accident consequences can be expected to be mitigated by evacuation, and so on. As discussed in Reference 2, the assumptions of WASH-1400 in these respects and others have been criticized. For the moment, let us presume the results to be accurate, and examine the implications of any error after some preliminary remarks.

In order to make a very crude comparison of costs of population density control measures versus the benefits which may be derived from those measures, we will consider a simple model.

1. We assume that density control will be on the simple basis of utility acquisition, permitting no other use of the land. This is an oversimplification which will be reconsidered below.

2. We neglect the property damage risk in considering how risks might be reduced. This again is an oversimplification. However, the main benefit to be considered in this treatment is the health and safety of the public. Moreover,

it is difficult to predict how property damage risk would be altered by land use control, in particular by utility acquisition.

3. We place an arbitrary valuation of $1 million on prevention of one death, either an early or latent fatality.

We now consider the extent to which risk to life or health, as measured in dollar amount, can be mitigated by controlled (purchased) areas of land of certain radii.

These risks are of several different types, difficult to put on a common basis. However, of the delayed effects (cancer, thyroid nodules, and genetic effects), the one to be most avoided is death. Moreover, the number of delayed fatalities exceeds the number of genetic effects, so that the latter can be eliminated as a primary contributor to the overall risk. As for thyroid nodules, although their number exceeds the number of deaths by a factor of ten, the relative ease of removing such nodules suggests that possible deaths still dominate the risk. For simplicity, we assume this to be true.

For the early effects, we will still presume that we only have to consider deaths, even though in this case illnesses are predicted to exceed deaths by a factor of 70. These may be thought to be comparable, therefore, in terms of any valuation; however, if that is so, then considering either one should serve for our rough estimate.

However, in our simple model, the early and delayed deaths cannot be compared directly, because control of land around a nuclear power plant may affect the risk from these two categories quite differently. The relationship between radiation dose and probability of early death shows a relatively sharp threshold around 500 rem (a unit of dose); the probability is zero below about 200 rem, and is 100% above about 800 rem. Considering the vagaries of plume behavior, the radioactive plume from a large release may or may not cause any early fatalities, and - if it does - they have a tendency to be relatively localized. (Spreading the radioactivity over a larger area would automatically lower the dose which may be received by any particular individual, leading to greater likelihood of no early fatalities at all.) However, the local area subject to most exposure is not necessarily the immediate vicinity of the power plant.

On the other hand, for purposes of assessment of the risk from delayed effects, a linear relationship between dose and effect is often assumed.[3] This leads to the result that a specified summed dose over a population gives the same number of effects, regardless of how the dose is distributed to the individuals in the population. Roughly speaking, 20,000 rem (usually stated as 20,000 man-rem, to avoid ambiguity) is within a factor of two of the summed dose (i.e., population dose) thought to correspond - for assessment purpose - to an increase of one cancer fatality in the irradiated population. Spreading of the plume does not, of itself, reduce the net risk of delayed effects, because the population dose may remain the same, even though individual doses decrease (so that individual risk decreases).

The result of this difference is that delayed effects may be spread among a population covering a very large (almost arbitrarily large) area, whereas early effects would be relatively localized. Localized density controls may affect only a small portion of the delayed effects; they may avoid a large portion of the early effects, if the correct area is controlled.

Let us first consider the early effects. The total number of early deaths to be associated with a plant during its lifetime is only 9×10^{-4}, roughly one thousandth of a death. Valuing prevention of this thousandth of a death at $1000 (consistent with our $1 million per death), we find that - on a cost-benefit basis - we may only expend this amount in the form of preventive measures, surely not enough to control a meaningful area.

A similar judgment may be made about latent effects, this time because of the large area over which they would likely be spread. For example, in a simple "wedge" model of dispersion (such as used by the American Physical Society study group on light-water reactor safety; see reference 2), the released radioactivity spreads out in a wedge, with a roughly constant opening angle and a depth defined by the mixing layer during the release. Under these simplified assumptions, it is easy to show that, except for deposition and decay of the radioactivity, the total population dose calculated is directly proportional to the total distance to which exposures are considered.

Because of deposition and decay, though, this is actually true only to about 100 miles. However it is not possible to expect effective density controls out to 100 miles. The total value of the 0.6 latent deaths expected, on the average, due to the plant's lifetime operation is only $0.6 million. Assuming land valued at $1000 per acre, this could only purchase land out to a distance of roughly 0.5 miles, so that the cost-benefit criterion would not be met. (This purchase would only prevent, on the average, about 1% of the risk.)

These results would indicate that land control measures cannot be justified on a direct health effects cost basis. However, these comparisons are not to be taken seriously as to detail. They completely bury the details of the manner in which effects on health would be distributed geographically. And for both early and latent effects, they ignore the fact that the predictions of WASH-1400 actually assumed some level of evacuation planning and population density controls, thought by some to be overly optimistic. In spite of these gross flaws, the comparisons do indicate very roughly the level at which measures can be justified, presuming the results from WASH-1400 are correct.

However, these results from WASH-1400 are for average plants. For particular sites, impacts could be much more substantial. As a result for any useful consideration of risks and benefits, site-specific analysis is required. Because of the form in which the results were presented in WASH-1400, site-specific results are not immediately available. On the other hand, one can attempt to use simple models incorporating as much as possible the results from WASH-1400. (See ref. 8 for such an attempt.)

A further consideration is that the WASH-1400 results have large uncertainties. There are, moreover, many critics who contend that the stated results are underestimates. If the WASH-1400 impacts are too small by a factor of 10 (which would still be essentially within the quoted uncertainties), and if a particular site has a potential for population exposures that is 10 times the average, then that plant would have impacts which are, on the average, 100 times those quoted above. For example, the cost of latent effects during a plant's lifetime would approach $100 million; the 1% benefit derived by spending $1 million on land would then compare sensibly. Average dollar value of early effects is still substantially less than $1 million, when considered in this context.

Finally, our assumed cost of control may be too high. It is possible that land use controls may be implemented that do not completely deny use of the land. In that case, the cost of control per acre would be somewhat less than the actual value of the land, and - for a given cost - a larger area can be controlled. However, at first blush, it appears unlikely that such controls could be implemented for less than one tenth the value of the land, so that less expensive methods would not alter the cost-benefit balance any more substantially than the considerations of the last paragraph.

On the other hand, an alternative approach to basing overall risk estimates on the results given in WASH-1400 is to use some of the information developed during that study, such as the consequences model, but to modify the estimation of probabilities to take account of suggested faults in the WASH-1400 probabilistic methodology. Reference 8 emphasizes this possibility. However, it is difficult to generalize about the results of such a point of view, because of the variety of views that might be adopted. To some extent, the consideration of the effect of an underestimate of the impacts by a factor of 10, as was considered above, would take account of such criticisms of WASH-1400. This, for example, if applied directly to the core meltdown probability, would yield a probability of one meltdown per 2000 years of reactor operation, a probability that is similar to the limit suggested in WASH-1400 and elsewhere on the basis of operating experience, without meltdowns, of large commercial and military power reactors.

The implication of the above risk-benefit comparisons, however crude, is that control of zones approaching one mile in radius, or slightly more, may provide benefits comparable to cost, especially for certain types of sites. Because such comparisons are extremely site dependent, it would be valuable to formulate a model easily applied to particular sites being considered, for calculating the geographical distribution of both early and latent effects. On this basis, more effective comparisons could be made.

As a final note on these comparisons, we must emphasize that we have neglected to consider two potentially important human factors. One is the potential for sabotage, a factor not treated explicitly in the calculations of WASH-1400. If this neglect (a necessary one, however unfortunate) decreases the calculated risk from power plant accidents, then the comparisons above should actually have been made on the basis of larger values for the risk to health.

The second human factor is that the benefits of visible controls around nuclear power plants may include public peace of mind. Land use control of itself would only have a secondary effect in this matter, because it does not alter the risk to an individual residing at a given site, except secondarily; for example, any evacuation might be more effective. However, the mere involvement of public agencies in planning around a nuclear power plant may serve to reassure the public. This may or may not be perceived to be a benefit.

6. THE FORM, FEASIBILITY, AND EFFECTIVENESS OF CONTROLS

Implementation of any controls on population densities surrounding nuclear power plants will require resolution of several related questions. The ERCDC is clearly given the power to impose such controls, as necessary, around any type of power plant under its jurisdiction. In addition, for the case of nuclear power plants, there appears to be a mandate to control densities within the limits set by Nuclear Regulatory Commission criteria. As a result, what is only a possibility for other types of plants is a requirement for nuclear plants. On the other hand, the suitability of the NRC criteria must first be determined.

As discussed in section 2, the NRC reviews two population-related matters, either or both of which might be construed to serve as the basis for ERCDC imposition of controls. The first is the definition of the low population zone; the second is the consideration of population densities per se within a distance of 30 or 40 miles (depending on which guideline is chosen — see section 2.2) of the plant. We neglect the exclusion area, since it is presumed to be exclusively controlled by the applicant, in any case. We do not consider the population center distance, because it is not a basis for control of land areas.

Because the low population zone is sufficiently small, density control within its area — or a similar area — would appear to be more likely, for either political, administrative, or economic reasons, than control within a 30 mile radius. However, the low-population-zone concept suffers the difficulty, for these purposes, that its definition does not involve population densities. It is more directly related to dosages from postulated releases and to emergency planning.

However, from a more practical point of view, it has been noted in some instances that the population density in the immediate vicinity of a nuclear power plant, such as the low population zone, can sometimes grow much more rapidly than projected for the larger region considered by the NRC in its actual density criteria. Moreover, from the crude comparisons made in the previous section, it would appear that the greatest benefit per dollar cost would accrue from controls within a small area near to the plant. For this reason, serious consideration must be given to the possibility that adoption of controls in an area similar to the low population zone would be the most effective means of complying with the mandate given the ERCDC. For such an area, controls based either on private acquisition of developmental rights or on regulatory tools such as traditional zoning would be practical. In either case, substantial increases in the population density near to a power plant could be prevented by such controls.

For the larger region, with 30-40 miles radius, considered by the NRC in its density criteria, imposition of controls would be more difficult. For practical reasons, the ERCDC could adopt the view that population projections can be used in lieu of controls, which might be justified on the straightforward basis that — for such a large region — projections may be reasonably reliable. For the larger region, use of any of the available density control techniques could prove to be administratively difficult and very costly.

It is,therefore, clear that density controls complying with AB 1575 cannot be formulated easily. It appears that consideration of issues such as those set forth here must be permitted to mature. For the immediate future, it may be important to distinguish, as was done in the previous sections, between density criteria and density controls. In the initial review of possible sites, criteria — such as those used by the NRC — can be used for site selection, without requiring demonstration of adequate controls. Final choice of controls might be postponed until a later stage of review. In principle, then, the ERCDC could satisfy its mandate — at a later date — without either halting the review process or making its choice now. This would also give the ERCDC the opportunity to develop the site-specific analytical tools which might be needed for choosing the form and extent fo controls.

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APPENDIX A TECHNIQUES FOR POPULATION DENSITY CONTROL

This appendix briefly identifies the techniques available to a public entity or a private party, presumably the involved public utility, to control population density in a designated area surrounding a power plant, the area and density having been prescribed to ensure public health and safety by minimizing population exposure to risk as a result of power plant accident. It is purely an introductory exploration. It does not discuss the merits of any specific area or density criteria. Neither does it analyze the propriety of any such action when judged against the effects or consequences of utilization of any specific technique. For example, zoning to low density over a large area may have an important impact on the relevant governmental jurisdiction through erosion of tax base, as well as important economic consequences for the private landowners affected by the zoning. Such impacts must be accounted for in policy formulation; this document does not perform that task. It is intended purely to provide a short topographical map of the land use options in this area.

Density control techniques may be divided into three broad categories: public regulatory measures, public acquisition, and private incidents-of-ownership allocation. Public regulatory measures may be further divided into traditional zoning techniques, modern techniques, and innovative techniques.

A.1 Private Allocation

Agreements between landowners that stipulate that certain limitations will be placed on the use of one parcel of land for the benefit of another are cognizable in law and equity, with converging but different rules governing the enforcement of each.* The power plant site owner theoretically could enter into such arrangements with the landowners within the designated population control area, to limit housing capacity or to retain a certain percentage of open space, or any similar measure which would result in population density

*Such agreements are called restrictive covenants at law and equitable servitudes at equity. This memorandum will not elaborate the distinctions, except to say that the system of servitudes arose in large part to provide more flexible enforcement to provisions affecting the use of land than was permitted by the strictures of covenant doctrine at law.

limits. These agreements once consummated would be placed in the chain of title by recording them in the official records of the county in which the land was located, and thereby notice would be provided to all subsequent purchasers.

Restrictive covenants, or devices like them, are used occasionally in the context of subdivision developments. The developer, at a time when he owns all the subdivision parcels, may incorporate into each deed some requirement, typically one with a community benefit, such as the retention of a certain amount of open space or a prohibition on fences in backyards, which will then bind each property owner. Dallas and Houston, cities without traditional zoning laws, have extensive networks of such restrictive covenants.

Several potential difficulties with this approach as applied to density control around power plants will have to be explored. A modest legal research effort should be undertaken to ascertain whether this type of agreement is within the boundaries of recognized covenants which can bind subsequent owners of parcels within the population control area. Enough nuances and niceties still exist in property law to warrant such inquiry.*

The efficacy of this technique is dependent in large part on ownership patterns within the designated area. Each additional owner raises the transaction costs of securing agreements throughout the area. Current zoning conditions will bear on the present market value of the parcels and hence the values of the covenants. Public utilities generally have powers of eminent domain, and such may have to be used in the event of failure to reach private agreement. (An inquiry should be made to ensure that an agreement of the sort described here is an interest in property amenable to condemnation.) Condemnation is time consuming and expensive, however, and would be a substantial impediment to site approval if acquisition of all needed agreements were a condition precedent to approval. Finally, acquisition of such agreements may have substantial impact on utility rates. Insofar as the price of acquisition accurately reflects a social cost of generating electricity, this may be defensible and perhaps desirable—its consequences should be understood prior to adopting this technique, however.**

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*The starting point should be California Civil Code §§1460-68, which codify the rules respecting some covenants.

**Other private allocation techniques can accomplish the desired result. The utility could acquire the property in the zone outright, and subsequently develop it in accordance with a plan to ensure suitable density. It could buy some of the land and covenant with respect to other parcels. These options are undoubtedly more expensive.

A.2 Public Acquisition

Instead of the utility's agreeing through private arrangement with landowners on the allocation of incidents of ownership, a public body empowered to own land and to condemn land could participate in acquisitions to accomplish population control. This technique has little to recommend it over the private allocation technique as a primary strategy; it merits mention because it could well be an unwelcome but necessary consequence of the public regulation techniques described below.

If regulatory constraints on use of property transgress the judicially defined boundary between regulation and the taking of property without compensation, the result of a suit challenging the regulation may be either invalidation of the constraint or judicial decree that the governmental entity pay just compensation. A decision to impose these constraints initially may imply a commitment to pay such compensation rather than let them lapse. In that case, any decision to proceed via a regulatory strategy should include a decision on how to address the consequences of judicial review.*

A.3 Regulatory Measures

A.3.1 Traditional techniques

Most enabling acts in the United States authorizing localities to zone are modelled on the Standard Zoning Enabling Act (SZEA) formulated in 1926, and premised on a Euclidean zoning scheme, whereby zones of uses, usually coupled with height, area, setback, and other such restrictions, are established. The zones are cumulative, each more permissive zone encompassing the uses of the less permissive ones. The permitted uses are available to private landowners without further review or administrative process.

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*Zoning decisions which result in dimunition of property value, absent discriminatory treatment and absent complete worthlessness of the rezoned property, will most likely not be held to amount to a taking of property. See HFH, Ltd., vs Superior Court, 15 Cal. 3d. 508 (1975). Any detailed analysis of regulatory options should, nevertheless, include a thorough analysis of the regulation vs. taking issue: it is a shifting area and of tremendous potential moment to any such strategy.

Density control can be accomplished using traditional techniques by, for example, zoning areas as single-family residential, 4-plex, or other levels to correspond to whatever density is determined appropriate. This approach lacks flexibility, however, in part because of the requirement of the SZEA that "all such regulations shall be uniform for each class or kind of buildings throughout each district..." (SZEA, §26)* and the judicial due process elaboration that districts or zones be created on the basis of some rational relationship to the public welfare, the land and surrounding neighborhood characteristics. Gradations of zoning districts within the population control area would thus face some test of justifying the differences in treatment. Analysis of the state of the law in California will be necessary to define the limits.

Density control through traditional zoning techniques will require knowledge of lot size, because density will vary according to uses permitted on each lot, and also according to the number of lots in the control area. It may be that certain areas will be too divided already to permit the appropriate level of limitation without denying some lots the right to build residences altogether, or, which can amount to the same thing, without increasing the minimum lot sizes on which development is permitted. Either course of action will face review on grounds of lack of uniformity, and hence discriminatory treatment, arbitrariness (lacking a rational basis), or as a confiscatory taking of property without just compensation.

Traditional zoning will also result in a dispersed pattern of building—one permitted unit of development per lot. It may be that other objectives are also to be reached in the context of population density control. For example, concentrations of population may be more readily evacuated in the event of an accident, thus prompting planners to desire concentration rather than dispersion.

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*See Cal. Govt. Code §65852.

A.3.2 Modern techniques

In response to some of the shortcomings identified above, primarily the lack of flexibility and administrative control over the form and content of development activity, several alternative land use control techniques have been developed in the past 20 years. These include floating zones, contractual zoning, and planned unit developments. They all have the common ingredient of allowing increased governmental control over development, including density conditions and location of development within a site. All have been attempted within the context of SZEA enabling acts, and have generally been upheld as allowable forms of land use control, absent showings of discrimination and the like, as mentioned in the previous section.*

The newer techniques have prompted continued attention on the uniformity requirement of the SZEA and on the requirement that zoning be performed "in accordance with a comprehensive plan," (SZEA, §3). These requirements are potential limitations on the ability of existing plans to be changed without justification, although California courts have been willing to recognize the flexibility a locality must have to utilize new planning techniques (see, e.g., Orinda Homeowners Ass'n vs. Board of Supervisors, 11 Cal. App. 3d. 768 (1970)), as well as the detrimental impacts which would result from enforcement of strict rules against change or the recognition of vested rights in any one plan on the part of property owners. (See, e.g., Selby Realty, vs. City of Buenaventura, 10 Cal. 3d. 110 (1973).) At first glance, health and safety concerns associated with power plant construction would appear to be a clearly satisfactory justification. Again, however, the contours of permissible alterations of existing comprehensive plans should be assessed in the light of particular proposals for density control.

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*See Heyman, "Innovative Land Regulation and Comprehensive Planning," 13 Santa Clara L. 183, 200-08 (1972).

The newer techniques, for example planned unit developments, do allow much greater flexibility in plan design. A locality may permit cluster developments with buffers of open space, thus allowing pockets of concentration while still accomplishing areawide density controls. Utilizing the flexible techniques as to the power plant itself, a locality could insist upon the dedication of a certain amount of buffer space, to be preserved as park or green belt, around the plant as an initial guarantee of low density in the immediate area. California has recognized the propriety of such dedication requirements [Associated Home Buildings vs. City of Walnut Creek, 4 Cal. 3d. 633 (1971)].

A.3.3 Innovative Techniques

Perhaps the most interesting and the most controversial addition to the theoretical literature about land use control techniques to appear in the past decade has been that developing a theory of development rights transfer (DRT). Championed by Costonis,* the essence of the control technique is to create a market place for development rights by recognizing as associated with each parcel of land within a particular district a range of development rights, each correlated with particular uses or intensities of development of the parcel. Control on growth could be accomplished by setting a level of development rights required for power plant development which required the power plant site owner to purchase rights from adjacent landowners until a sufficient number had been assembled. An administrative mechanism would be established to coordinate the transfers and record them. Once rights had been transferred away from a parcel, its development potential would be limited to the level correlative to its remaining rights.

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* See Costonis, "Development Rights Transfer:An Exploratory Essay" 83 Yale L.J. 75(1973) for a discussion of the theory. See, e.g. Berger, "The Accomodation Power in Land Use Controversies: A Reply to Professor Costonis," 76 Colum.L.Rev. 799 (1976), for a summary of the major criticisms.

Professor Costonis originally applied the DRT concept to landmark preservation, and it is not ordinarily considered in the context of density control measures. It appears feasible, however. The appeal of the notion in this application is similar to that of the private allocation technique described above: it provides compensation to adversely affected property owners and appears to charge payment to the proper source — the body seeking to develop.

DRT is a controversial technique, and has as many critics as supporters. Consideration of it, however, would serve a valuable heuristic function in counterpoint to the regulatory options more frequently proposed.

APPENDIX B EVALUATION OF POPULATION PROJECTIONS IN THE NRC LICENSING PROCESS

The applicant for a construction permit to build a nuclear power plant is required to submit information on population distribution within 50 miles of the proposed reactor.[1] The applicant's preliminary Safety Analysis Report should include geographical maps of suitable scale where concentric circles of 1, 2, 3, 4, 5 and 10, 20, 30, 40, 50 miles radius from the proposed reactor have been drawn and divided into 16 equal sectors of 22 $\frac{1}{2}^{o}$ each. Tables appropriately keyed to each area of the map formed by the annular rings and radial lines should provide information on (1) the current residential population, (2) the projected population within each keyed area, both for the expected first year of plant operation and by census decade through the projected plant life. Such information should be based on 1970 census data, and where available, more recent census data. Seasonal and daily variations in population and population distribution resulting from land uses should be generally described.

At the construction permit stage, if the population density projected at the time of initial plant operation exceeds 500 persons per square mile, averaged over any radial distance out to 30 miles, or the projected population over the lifetime of the facility exceeds 1,000 persons per square mile averaged over any radial distance out to 30 miles, special attention will be given by the regulatory staff to the consideration of alternative sites in the environmental review.[2]

Demographic information submitted by applicants is reviewed by the NRC Accident Analysis Branch. The data submitted are analyzed primarily by comparison with independent projections made by other governmental agencies such as the Census Bureau, Bureau of Economic Analysis, Environmental Protection Agency, local and state agencies, and Councils of Government. The preferred reference source for verifying present residential populations is the 1970 census. A programmed census tape is available to the Regulatory Staff to give population distributions in 22 $\frac{1}{2}^{o}$ sectors at the prescribed radii from a proposed reactor site at any given latitude and longitude.[3] Site Analysts also visit the proposed reactor site to discover any special factors which may affect present or future population distributions surrounding the proposed power plant. Population projections for the relevant counties by local or regional planning councils are consulted over other national projections because they tend to be more sensitive to local factors than national forecasts.

Population projections are also evaluated by comparison with "OBERS" projections.[4] OBERS is the descriptive title of a projection program conducted by the U.S. Department of Commerce's former Office of Business Economics (OBE), now renamed the Bureau of Economic Analysis, and the Economic Research Services (ERS) of the U.S. Department of Agriculture. The program was last updated in April 1974 and projects population growth in groupings of economically related counties to 2020. The comparison process is described in Section 2.1.3. "Population Distribution" of the Standard Review Plan as follows:

"1. Determine the Bureau of Economic Analysis (BEA) economic areas which lie entirely or partially within a 50 mile radius of the proposed plant. If only a small part of any such area is within the circle, neglect it.

2. Add the 1970 population figures for all BEA areas determined in the first step, and add the BEA projected population for these areas for each of the years for which population projections are to be compared.

3. Find the growth factor for each projected year by taking the ratio of the total projected population in the BEA areas considered to the total 1970 population in those areas.

4. Tabulate, for various radii from the plant: the applicant's projected population; the projected population using the OBERS growth factors derived above; and the ratio of the OBERS projection to the applicant's projection.

5. If the applicant's projections of population growth within 50 miles are significantly less than the projections made by the above method, a more detailed examination of the bases used by the applicant should be made."[2]

Generally, even if the review guideline value averaged out over 30 miles is exceeded at a proposed reactor site, it is not required that an alternative site be selected. In borderline cases, the Regulatory Staff will give a closer scrutiny to population distribution at the proposed site utilizing the Site Population Factor Index.[5] The fact that large populations are concentrated in a few areas within the 30 miles radius will be balanced against the probability of prevailing winds in those areas.[3]

Regulator experiences have shown that there has not been much variance between population projections submitted by individual applicants and those of independently obtained projections.[3] It should be noted that since the projected lifetime for a nuclear power plant is 40 years, a certain amount of skepticism exists among demographers as to the accuracy of national population projections over that period of time. With respect to national forecasts of regional and local population distributions, the uncertainty is even greater. At the local level, the NRC Regulatory Staff has accepted linear projections of population growth for the prescribed periods where other independent projections are not available.

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