

The Biotope Area Factor as an Ecological Parameter

- Principles for Its Determination and
Identification of the Target -

- Excerpt -

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1 Summary

1.1 Motive and Objective for Developing Standardized Environmental Quality Targets

In accordance with the landscape programme and the targets of ecological urban redevelopment, a basic objective of urban development policy is to reduce existing impacts in the inner city area. Among other things, this is to be achieved by improving the functioning of the ecosystem and promoting the development of biotope areas, whereby the present land utilisation will not be called into question. Instead, requirements shall be formulated for improving the ecological situation while maintaining the current land utilisation.

The considerable ecological damage to the city centre that has resulted from the manifold usage demands in an extremely confined geographic area is exacerbated by the developmental pressure to intensify the use of space both in residential areas as well as on commercial and infrastructure sites. At the same time, the reduction of available site potential sets increasingly restrictive limits on area measures for protecting and developing the ecosystem.

Therefore, it is essential that ecological standards be formulated and stipulated in relation to sites as a requirement for protecting and developing environmental qualities for all of the usage structures in the inner city area. The biotope area factor was developed as such a standard within the scope of landscape planning.

1.2 The Biotope Area Factor – Content and Objective

The biotope area factor (BAF) designates the ratio of areas of a site that have a positive effect on the ecosystem or an effect on the development of the biotope of a site in relation to the entire area of the site with regard to developed sites.¹

$$\text{BAF} = \frac{\text{ecologically effective areas}}{\text{total land area}}$$

Contrary to other parameters, such as the designation of the level of soil sealing or the parts of a site that are to be left unsealed, the BAF takes not only the areas covered solely by vegetation on undisturbed soil into account, even though these naturally have the highest significance for protecting the function of the ecosystem. Instead, a certain factor, which depends on the type of sealing, is also included for paved surfaces as well as for roofs and windowless external walls if they have vegetation on them.

¹ The designation 'biotope area factor' reduces the content of the factor, because apart from its function as a habitat for plants and animals, further aspects relevant for protecting the function of the ecosystem are included in it. However, no use is made of the more comprehensive designation 'factor for ecologically effective areas' due to the difficult concept. Furthermore, the term 'biotope area factor' has already achieved a certain level of awareness among experts.

Therefore, the biotope area factor represents the sum total of the individual ecological function areas of a site in its actual state ("BAF value for existing structures") - the aggregation size, as it were - and serves to formulate the minimum standard to be achieved ("target BAF").

This approach was developed to improve the ecological situation of the existing sites in the inner city. It especially makes allowance for the particular problems in these areas:

- The areas are characterised by a low percentage of public open spaces and, therefore, a lack of areas providing ecological compensation. This situation can only be improved by including areas of private property.
- Generally, within highly developed areas with extremely mixed usage, the percentage of open space is extremely low while, at the same time, considerable usage demands are made on these areas (site development, commercial, playground and storage areas). This makes it necessary to have a certain percentage of sealed areas.
- In the light of this, it becomes particularly important to make full use of the potential for vertical areas and roofs within the developed area, which can include several times the area of non-developed areas.

The biotope area factor designates area quotas, i.e. it is solely a quantitative value, even though it includes qualitative aspects of area characteristics as a benchmark for generating factors indirectly by means of the significance of the areas. Therefore, the biotope area factor does not cover the qualitative demands of landscape planning, e.g. with regard to the layout and usage of areas or the composition of plantation. Similar to urban development parameters in urban development planning, which regulate the kind and measure of usage without making urban development and architectural designing superfluous, the BAF does not release authorities from their obligation to design special open spaces and implement other landscape planning contents.

Since the BAF is an aggregation size made up of parts of different area structures, the corresponding scope for attaining the target BAF already exists. The possibilities for combining different measures (percentage of plantation on the site, selection of surfacings, inclusion of green roofs and exterior walls of different sizes) enable a flexible implementation adjusted to the individual development conditions of the site.

Therefore, the BAF's interference in architectural freedom is relatively low while, however, still setting a benchmark for the necessary minimum standard as an improvement for the environmental situation. The intensity of planning regulation is not increased to an incompatible degree.

In line with urban development parameters, the target BAF must be defined as a value in relation to sites. It should be applicable as an extensively comprehensive instrument within the inner city area, i.e. generally applicable for all built-up areas in the city centre. Apart from residential sites, this also includes commercial and industrial sites as well as public facility and public service sites. Areas that, for the most part, have not been built up, are not included; other regulations must be put in place for such areas.

To simplify the previously standard identification of existing sites (related to individual areas) and measures at the landscape planning level, the BAF is to be used to achieve a standardisation of ecological targets. This means that the target must fulfil the requirements for transferability to other sites that, according to a clear definition, show a comparable building and usage structure and, therefore, requirements for development.

This standardisation, which has already been carried out, is based, on the one hand, on the structuring of existing usages (residential, commercial usages, various usages for public facilities and public services) and, on the other hand, on the typology of a building and open-space structure. Particularly with regard to residential usage, this is a fundamental basis for formulating ecological potential, because of the wide range of land utilisation that exists there.

When identifying BAF targets, especially for existing residential developments and the primary usages of public facilities, linking the BAF to the site occupancy index² has proved significant.

For new housing construction, commercially used areas and public service sites, the target was formulated after the exemplary identification of real possibilities in the light of the urban development model and landscape-planning development concepts. Setting this directly in relation to the site occupancy index, the urban development parameter, proved not to be meaningful. However, as a normative quantity, this parameter was the subject of the strategic discussion.

1.3 Methodical Approach to Deducing BAF Targets

Formulating BAF targets for areas of existing structures lies within the area of conflict between the ecological requirements and the framework set by urban development structures. Therefore, each target BAF represents a mean quantity of the ecological requirements that can subsequently be integrated in urban development. If the BAF is to be applied practically, i.e. if the possibility of implementing it within a reasonable scope is to be ensured, it is even more important that it not be based on purely normative assertion. Apart from the contention with the landscape planning and urban development targets formulated in the superordinate planning, therefore, site-related, projective quantities from existing structures and the actual potential for development must also be derived.

² The site occupancy index is calculated on the basis of the surface area figure in accordance with the regulation on the use of building land 1990. The facilities listed in Section 19(4) such as garages and parking spaces, secondary structures, underground parking and others are not, however, included in the calculation of the site occupancy index.

1.3.1 Underlying Urban Development Model and Landscape-Planning Development Concepts

Formulation of the BAF targets was based on the following principles of development:

- The conservation of established structures of use, including the existing mixture of residential and commercial areas, as formulated in Berlin's Land Use Plan and Landscape Programme including Nature Conservation (LaPro) will always be used as a basis. This means that the scope of necessary greening measures required for achieving the BAF target must not lead to an incompatible restriction or hindrance of commercial use in this mixture.
- With regard to residential areas, the target BAF is oriented to the density of existing buildings, from a more interspersed type of construction to a very compact block construction. The approach for qualifying the density of existing inner-city areas in favour of an overall careful use of areas is applied. However, for a particularly high building coverage ratio within dense block construction areas this requires the fundamental use of roofs and vertical areas. This approach makes allowance for the process of maintaining existing structures and redensification presently taking place in the city centre. However, it contrasts with the objectives of urban development planning to increase the quality of living conditions in inner-city sites by reducing density to some extent. The BAF's methodical approach must allow for an adjustment to changing densities. To rule out, however, a significant change for the worse in the status quo due to the utilisation of the potential for new structures and intensification of development, special quality requirements must be set for new structures. Their dimension must be oriented to the target margins of superordinate urban development planning; they must not be reduced as a result of exemption, even if these margins are considerably exceeded.
- For purely commercial and industrially used areas, a balance must be struck between superordinate landscape-planning models and those for certain areas. A more intensive exploitation of areas already in use for the protection of existing open spaces and land as a resource stands in contrast to a restriction of the effects of the impact from building coverage and sealing within the commercial and industrial area. Therefore, the formulated BAF target values leave scope for a more intensive utilisation within urban development planning objectives provided this is compensated for by a corresponding quantum of compensation measures such as green roofs and vertical areas or rainwater infiltration.
- The very broad range of different infrastructure facilities must be complied with by differentiating the definitions of the target BAF. If typing is unsuccessful, targets should be formulated in relation to individual sites.
- It must be ensured that no land utilisation will fall short of a minimum standard.

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- The measures for achieving the target BAF should primarily be carried out on the site (exception: commercial sites). The target BAF for residential developments should be formulated in such a way that it will generally be possible to achieve this target outside dense block construction areas without additional roof greening. Due to the costly technical set-up and taking into consideration an overall ecological approach, roof greening should be restricted to particularly problematic areas that have only limited on-site qualification options.
 - For urban development purposes and due to the limited development of biomass when formulating the target quantities, façades with windows have not been included.

1.3.2 Determining Projective Values and Formulating Targets

Due to the differing ratios of building coverage and the manifold range of usage with the resultant widespread usage demands made on undeveloped site areas, it is not possible to designate an all-inclusive BAF for the inner city area or parts thereof.

Projective targets must be deduced in relation to a site, whereby the specific building and usage structures must be included in the definition of the target. With regard to the desired transferability, this was achieved by structuring the typology for the predominant range of building and usage. Due to the very wide range of resident usage, it was carried out in detail for this usage. For the other usages, the individual site functions (commercial usage, different usages for public facilities, etc.) were decisive in formulating the target BAF values.

Based on such typification of the building and open space structures and the definite functions of use, on the one hand, as well as an estimation of the specific ecological situation using available basic research and analyses of areas, on the other hand, the measures that were

- required for improving the ecological situation,
 - practicable while maintaining existing structures, and
 - taking into consideration what was reasonable with regard to expenditure
- were designated and the average potential for development was identified.

The implementation of these development targets was played out by the planning department. As a result, a specific distribution pattern of types of areas was apparent for the individual types of structures and the individual functions of usage. Each of these has a different significance for the functional capability of the ecosystem. Generally, the values to be achieved when making full use of the development potential set the reference framework for the BAF target.

For structure-type groups of residential developments, there is a unique correlation between the structure type and its related potential for ecologically effective areas, on the one hand, and the site occupancy index of the existing structures as a common urban development parameter, on the other hand. For most of the public facility sites, a close correlation also emerged between the definite functions of usage and the related potential for ecologically effective areas, dependent on the site occupancy index. This makes it possible to link the majority of the target BAF

values to this quantity. In practice, this allows for improved manageability and comprehension.

The connection to the site occupancy index has also been completed in the fields of new housing construction, commercial sites and public service sites; however, it is oriented here to the urban development target values and not those of the existing structures, taking the dynamics of change into account. Furthermore, the special requirements for usage of parts of sites that are undeveloped must also be considered for commercial sites and public service sites.

For sites for schools providing general education, the site occupancy index parameter is inadequate, as shown by the sample evaluation of several sites. This is mainly due to the very different intensities of usage, depending on the existing open space per student and the possibilities for creating "ecologically effective areas" that are significantly influenced by it. Therefore, it has become clear that a relationship to the existing, undeveloped site per student for school sites is more meaningful.

1.4 Method for Determining the BAF

The BAF is calculated from the ratio of the parts of areas of a site that have a positive effect on the ecosystem or the biotope development to the total area of the site.

$$\text{BAF} = \frac{\text{ecologically effective areas}}{\text{total land area}}$$

Corresponding weighting factors are assigned to the individual partial areas of a site, depending on their "ecological significance". On the one hand, these partial areas form all of the area types on the surface area of a site, from the asphalt to the vegetation surface. On the other hand, those areas are also taken into account that can be included as compensation for surface areas that are "not available". This concerns the green roofs and vertical walls as well as the separate roof areas from which rainwater is filtered off to the ground through vegetation soakaways.

By formulating a target BAF for a site, the following targets are to be achieved:

- improvement of the microclimate and air hygiene quality,
- safeguarding soil function and the efficiency of water management,
- increase in the availability of areas as a habitat for plants and animals.

The following criteria can be derived from the targets for the evaluation of individual types of areas:

- high evapotranspiration efficiency
A high evapotranspiration efficiency comes about as a result of a high rate of evaporation above plants and the soil. This increases humidity, resulting in cooling effects. However, under extreme weather conditions and if yards are narrow, this can also have a negative effect: an increase in the danger of sultriness. By making structural changes and ensuring that cellars and carriage gateways are ventilated, this negative effect can be minimised.

- high capacity for binding dust
Air pollution can be minimised via vegetation: dust is deposited on the surface of leaves. This means that areas that are available as vegetation sites have a high significance. On the other hand, filtering gases through vegetation is relatively insignificant.
- infiltration ability and storage of rainwater
If there is a high rate of infiltration, rainwater does not drain directly into the sewage system or receiving waters. On certain types of areas, rainwater can be drained directly into the ecosystem by enabling the surface water to seep away. Therefore, it serves to replenish groundwater or is stored in the soil, making it available to plants for a longer period of time. In turn, this has positive effects on the efficiency of evapotranspiration.
- long-term guarantee of the conservation or development of soil functions with regard to the filtering, buffering and transformation of hazardous substances
Soil functions (filtering, buffering and transformation of hazardous substances) are, generally speaking, effective if there is a low level of soil sealing, a high percentage of humus and minimum impairment of the natural structure and build-up of the soil. This effect is reduced as sealing and anthropogenic interference increase.
- availability as a habitat for plants and animals
Under this criterion, no exact differences are made regarding the biotope quality (e.g. of individual types of vegetation). Similarly, the volume of green open spaces is not included. The determining factor is whether a site is available as a habitat for plants and animals. Generally, this is the case for open, uncompressed soil that forms a good site for vegetation.

The individual types of areas are assessed on the basis of these criteria. This results in the following weighting factors:

Sealed areas (areas without air and water-permeable surfacings, without plant growth):

Weighting factor 0.0

Examples for types of surfacings:

concrete, asphalt, terrazzo, ceramics, tiles/paving (with a sealing substructure or joint compound), waterproof plastic coatings.

Function for ecosystem and biotope development:

low evapotranspiration efficiency, without infiltration, without soil function, irrelevant as a habitat for plants and animals.

Partially sealed areas (areas with air and water-permeable surfacings that permit infiltration to a certain extent, but generally do not permit plant growth): 0.3

Examples for types of surfacings:

clinker, large and small stone pavement, mosaic paving, wooden pavement, concrete interlocking pavers and tiles (with joints in a sand/crushed stone substructure), sandy areas, crushed stone, water-resistant coating, open, heavily compacted soil, permeable plastic coatings, grass pavers (without a fully developed grass turf due to heavy wear and tear: parking spaces, access roads).

Function for ecosystem and biotope development:

limited effect of evapotranspiration efficiency, low infiltration performance and storage of surface water, limited soil functions as well as low degree of relevance as a habitat for plants and animals (occupants of pavement cracks).

Semi-enclosed areas (areas with air and water-permeable surfacings that permit both infiltration as well as plant growth): 0.5

Examples for types of surfacings:

clinker and crushed stone with grass joints, wooden pavement with a high percentage of joints, pavement with grass joints, grass paver (with a more or less fully developed grass turf due to low intensity of use, e.g. fire brigade access).

Function for ecosystem and biotope development:

medium evapotranspiration efficiency, medium infiltration and storage of rainwater and medium efficiency of soil functions due to biological activity and somewhat increasing significance as a habitat for plants and animals (occupants of pavement cracks).

Vegetation surface not connected to surrounding soil: 0.5

Vegetation surfaces on cellar ceilings/underground garages (less than 80 cm of soil application), raised beds.

Function for ecosystem and biotope development:

medium to high evapotranspiration efficiency, dust bound by vegetation, low infiltration efficiency, limited efficiency of soil functions, medium significance as a habitat for plants and animals. The weighting factor of 0.5 refers to vegetation surfaces. Due to the soil's low capacity for infiltration and storage, semi-enclosed areas are only weighted with a factor of 0.3. 0.3 is still weighted for partly sealed areas, because for this type of area infiltration and storage of surface water in the ground play a subordinate role.

Vegetation surface not connected to surrounding soil: 0.7

Vegetation surfaces on underground garages (more than 80 cm of soil application).

Function for ecosystem and biotope development:

an evapotranspiration efficiency and binding of dust that can increasingly be compared to that of vegetation surfaces connected to the surrounding soil, low to medium infiltration and storage of rainwater, low to medium efficiency of soil function, medium to high significance as a habitat for plants and animals. The higher significance as compared with the category "vegetation surfaces on cellar ceilings/underground garages (less than 80 cm of soil application), raised beds" is justified by the fact that the vegetation, including trees, is able to develop better when more than 80 cm of soil have been applied.

The weighting factor of 0.7 refers to vegetation surfaces. Due to the soil's low capacity for infiltration and storage, semi-enclosed areas are only weighted with a factor of 0.3. 0.3 is still weighted for partly sealed areas, because for this type of area infiltration and storage of surface water in the ground play a subordinate role.

80 cm of applied soil is a mean value, i.e. in certain areas the amount of soil applied may be less than 80 cm while it may be more in other places, e.g. where trees have been planted.

Vegetation surfaces connected to surrounding soil: 1.0

Availability as a site for the development of vegetation without an assessment of the quality.

Function for ecosystem and biotope development:

high to very high evapotranspiration efficiency, potential for binding dust through vegetation, high rate of infiltration and storage capacity of the soil, with a high efficiency of soil functions and high suitability as a habitat for plants and animals.

A differentiation in the quality of vegetation or calculation of the volume of green open spaces is not carried out. Therefore, the quality of this type of area may differentiate considerably with regard to its ecological significance. The availability as a vegetation surface is the primary determining criterion for the assessment with a weighting factor of 1.

Rainwater infiltration: 0.2

Each square metre of roof area on which the surface water is drained off to a vegetation surface that serves as rainwater infiltration can be weighted with a factor of 0.2.

Function for ecosystem and biotope development:

high to very high groundwater replenishment.

Green vertical areas on windowless external walls and walls: 0.5

Weighting is carried out for the site on which there is to be plantation on the walls.

Function for ecosystem and biotope development:

high transpiration efficiency, high binding of dust and high significance as a habitat for animals.

Weighting is carried out for green vertical areas that are mainly on windowless external walls (generally fire walls) and walls. Plantation up to a height of 10 m is weighted; this corresponds approx. to the area that will be covered within 10 years by self-climbing vines. When using a climbing frame for plantation, the area is weighted that is covered by the climbing frame, up to a maximum of 10 m. Weighting is carried out for the site on which the ecological situation improves after these measures are carried out. The plantation of façades is not included in the calculation of the BAF, because the positive effects of unbroken fire walls are far higher than those achieved when designing façades. Furthermore, there are considerably greater impairments in the vitality of the vegetation planted on façades on the street.

Roof greening: 0.7

Function for ecosystem and biotope development:

high evapotranspiration efficiency and capacity to bind dust, limited soil functions, low to medium storage capacity of rainwater, high to very high significance as a habitat for plants and animals (especially when roofs are extensively greened).

No differentiation is made in the significance between intensively and extensively greened roofs. Generally, when roofs are extensively greened, it may be assumed that there is a high significance with regard to the quality of the habitat for plants and animals, while in the case of intensively greened roofs an increase in the ecological effects may be expected due to the increase in the volume of soil.

1.5 Target BAF for Individual Usage

The consideration of real possibilities on the sites in connection with the underlying general urban development model and landscape-planning development concepts results in the following target BAF values as a minimum standard for the scope of ecologically effective areas.

1.5.1 Residential Sites

Existing residential sites:

- | | | |
|----|---|----------|
| 1. | Sites with a site occupancy index ³ of up to 0.37: | BFF 0.60 |
| 2. | Sites with a site occupancy index of 0.38 up to 0.49: | BFF 0.45 |
| 3. | Sites with a site occupancy index of 0.5 and over: | BFF 0.30 |
| 4. | Sites inside key areas on which individual stories of the buildings are used for commercial purposes: | BAF 0.30 |
| 5. | Sites outside key areas on which individual stories of the buildings are used for commercial purposes are to be assigned to nos. 1. to 3. | |

(For the purposes of calculating the BAF target, sites which are primarily residential, but on which individual buildings or parts of buildings are used for commercial purposes, are classified as commercial sites due to the related usage demands on

³ The site occupancy index is calculated on the basis of the surface area figure in accordance with the regulation on the use of building land 1990. The facilities listed in Section 19(4) such as garages and parking spaces, secondary structures, underground parking and others are not, however, included in the calculation of the site occupancy index.

the areas of the site on which buildings have not been erected.)
Residential sites on which changes to the degree of coverage are made:

With respect to residential sites on which the site occupancy index is increased as a result of redensification measures, the BAF is determined in accordance with the BAF values under points 1. to 4. above in compliance with the site occupancy index which applied before the redensification measures. With respect to residential sites on which the site occupancy index is reduced, the BAF subsequent to the reduction of the site occupancy index is determined in accordance with the values indicated under points 1. to 4.

Residential sites on which new structures are built:

With respect to undeveloped sites on which new structures are to be built, the BAF must be at least 0.6. Mixed structures for commercial usage within key areas are an exception to this. In this case, the BAF must be at least 0.3.

Measures to achieve the BAF are to be implemented primarily on the site. Potential for rainwater infiltration from roofs using existing vegetation soakaways should be utilised without interference to the other usage demands on the open space. In the case of building coverage in excess of 0.4, rainwater infiltration through existing vegetation soakaways is generally no longer meaningful.

1.5.2 Businesses and Commercial Premises / Service Providers

For production and processing sites for industrial and service fields with considerable usage demands on open space (e.g. auto repair shops, petrol stations, etc.) and including those sites on which only individual buildings or parts of buildings are used for commercial purposes (partial mixed use of a building; cf. residential sites regarding mixed use of stories) as well as wholesale and retail sites (but not: retail facilities integrated as a mixed storey in residential construction), the BAF must be a minimum of 0.3 for both existing structures as well as new structures.

For sites that are used solely as commercial service sites with no usage demands or only insignificant ones made on open spaces (parking spaces are not regarded here as significant usage demands) or those sites that are used by companies solely as commercial administration sites, the BAF must be defined in accordance with the values of the public facility group, "Public Administration".

On sites that are used solely by production and processing industrial and service fields with considerable usage demands for free space, a minimum of 10 % of the site must be employed as vegetation surface. This applies for existing sites as well as for new structure sites. Storage, parking and developed areas must be set up as completely sealed areas. The only exception is for parking spaces that can be used solely by cars.

On all other sites, measures to achieve the BAF are to be implemented primarily on the site. The possibilities for rainwater infiltration are to be thoroughly exploited.

1.5.3 Public Facility and Public Service Sites

Schools providing general education, centres for education and training

Existing school sites:

Undeveloped space per student*	Target BAF
25 m ² and above	0.5
15 m ² and above 15 m ²	0.4
< 15 m ²	0.3

* The number of students for which the school is designed in each case should be used as a basis.

Amendments to open space per student and new constructions:

With respect to densification of existing structures resulting in the reduction of the available undeveloped site area per student, the BAF values of the existing development prior to the onset of these measures apply.

Sites on which the previous undeveloped site area per student of at least 25 m² is reduced to a value of less than 25 m² are an exception to this. In this case, an adjustment is made to the higher usage density up to a BAF of at least 0.4.

In so far as the open space per student is increased as a result of expansion of that site, the BAF must be adjusted accordingly.

With respect to new development sites, in principle, the value of at least 0.4 is to be applied. In the case of development of sites with open space per student of at least 25 m² a BAF of 0.5 should be allocated.

Nursery Schools and Day Care Centres⁴

Existing sites:

Site occupancy index level	Target BAF
Up to 0.29	0.60
0.30 to 0.49	0.45
0.50 and over	0.30

Adjustments to the site occupancy index and new constructions:

In the case of sites on which the site occupancy index increases as a result of extension to the existing structure, no adjustment of the BAF to the new site occupancy area is made. The status prior to commencement of extension measures to the existing structure is therefore the basis for assigning the BAF.

In the event that the site occupancy index is reduced, in respect of the existing

⁴ The target BAF values only apply to day-care facilities on self-contained sites. More research is necessary in order to deal with integrated child day-care facilities.

impact situation, the newly achieved potential is to be used for protecting and developing the ecosystem. Thus, the reduced site occupancy index forms the basis for assigning the BAF.

With respect to the new development of child day-care facilities, the BAF must be at least 0.6.

Integrated child day-care facilities:

It was not possible to gather and evaluate sufficient data for formulating BAF values in respect of child day-care facilities which are integrated into residential developments. Due to the increasing integration of child day-care facilities into residential buildings, further research into these usage categories is required.

Cultural amenities and other public facilities⁵

(Libraries, youth clubs, community centres, technical schools, community colleges, sports halls on their own sites, indoor swimming pools, etc.)

Existing sites:

Site occupancy index level	Target BAF
Up to 0.34	0.60
0.35 to 0.49	0.45
0.50 and over	0.30

Adjustments to the site occupancy index and new constructions:

In the case of an extension to the existing structure on sites outside centre zones, the site occupancy index of the site prior to commencement of building works is the decisive factor, i.e. no adjustment is made to the new site occupancy index; within key areas an adjustment is foreseen due to the more intensive usage demand.

In the event the site occupancy index is reduced, in respect of the existing ecological impact, the newly achieved potential is to be used for protecting and developing the ecosystem. Thus, the reduced site occupancy index forms the basis for assigning the BAF.

In principle, high demands with regard to ecosystem-friendly areas are to be posed on new developments. Scope for economical designation of parking spaces should be utilised where access to adequate local public transport exists. The BAF is, therefore, to be set at 0.6 outside key areas; within key areas, the BAF is to be assigned in accordance with the site occupancy index levels of the existing structures.

⁵ With the exception of theatres and museums unless they are included under other categories.

Public administration facilities

Existing sites:

Site occupancy index level	Target BAF
Up to 0.29	0.50
0.30 to 0.39	0.40
0.40 and over	0.30

Adjustments to the site occupancy index and new constructions:

With respect to extensions to existing structures on sites outside key areas, the site occupancy index of the site following completion of the construction measures to augment the existing structure is the determining factor in assigning the BAF. Thereby, a BAF should not be assigned below 0.40 unless a value of 0.3 was already to be applied previously, i.e. there is limited adjustment to the new site occupancy index. Within key areas an adjustment is foreseen due to the more intensive usage demand.

In the event the site occupancy index is to be reduced, in relation to the existing ecological impact, the newly achieved potential is to be used for protecting and developing the ecosystem. Thus, the reduced site occupancy index forms the basis for assigning the BAF.

With respect to new constructions, this applies in the same way as to the usage group "Cultural amenities and other public facilities". Outside key areas, the BAF should be assigned at a minimum of 0.40, and at 0.5 up to a site occupancy index of 0.29. In principle, the BAF is to be assigned within key areas in accordance with the site occupancy index levels of the existing structures.

On existing public facility sites, measures to achieve the BAF are to be implemented primarily on the site. The extent to which this includes infiltration of rainwater that falls on roofs through existing vegetation soakaways must be examined from case to case.

Public service sites

A standard BAF target value of 0.3 is specified for public service sites.

No provisions for implementing measures for achieving the BAF have been made for public facility sites. The meaningfulness of the different measures must be determined from case to case.

2. Summary about findings the respective target BAF

2.1 Target BAF for Residential Sites

The assignment of BAF target values for residential sites was carried out using a model oriented on existing structures. This approach will also maintain the future continuity of high building densities and mixed usage.

The current strong demand for additional living space in the inner city requires making full use of the limited potential reasonably viable within urban and landscape planning for redensification within residential areas. Such redensification measures will, however, further intensify these impacts with regard to urban ecology, if comprehensive measures to reduce or compensate for these impacts are not implemented at the same time.

The BAF must, therefore, make allowances for the existing structure and usage of residential sites, i.e. it must be possible to apply the BAF at a later date to the existing structures without calling them into question and, in its calculation of targets, it must also effectively be a method for safeguarding and developing the functionality of the ecosystem in the inner city area. At the same time, the BAF must harmonize with the changes taking place on the sites, i.e. the system must be designed in such a way that it can adapt to changed circumstances on the sites.

The task at hand is based on a number of expert reports in which the open space status of residential sites in inner city areas are assessed and described on the basis of a building and open-space structure typology, and in which the potential for ecological development is presented. To a certain extent, the BAF values for “existing structures” were already provided in these expert reports and the scope for achieving BAF target values was examined.

On the basis of building and open space structures and in the light of the model based on existing structures, specific measures were formulated which

- were required for improving the ecological situation and
- could be adapted while maintaining the existing structures,

and possible development potential demonstrated. These were then transposed into achievable BAF values for the sites.

With the objective of clearly assigning a BAF target to the residential sites and ensuring manageability in practice, the respective development potentials (achievable BAF values) were compared with the building coverage ratios (site occupancy index) of the sites.

BAF target values were determined for individual sites from the comparison between the “achievable BAF value” and the site occupancy index, and taking into account the underlying general urban development model and landscape-planning development concepts. In the process, the following assumptions were applied in addition to the model based on existing structures:

- taking as a basis the existing building and open-space structures and their development potential, under consideration of current usage structures,

- making full use of the existing potential on the sites for the protection and development of the ecosystem within a reasonable framework while allowing for other usage demands,
- safeguarding a minimum, ecologically beneficial area quota as minimum ecological area standard on all residential sites, even in densely developed areas,
- safeguarding the scope of available site potential for development of the ecosystem, even when the building coverage ratio of the sites is increased, or full use of any additional potential when the building coverage ratio on residential sites is reduced,
- providing appropriate, ecologically beneficial area quotas on new development sites in line with the objective to reduce the ecological impact on the inner city.
- With respect to sites on which new building development takes place, it was only possible to assign a normative BAF target value by discussing it in the light of the underlying urban development model and the landscape-planning development concepts, taking into account building legislation principles and the Land Use Plan (FNP).

The discussion on urban development models and landscape-planning development concepts as well as the respective potential for protecting and developing the ecosystem resulted in the formulation of the following target values:

Existing residential sites:

- | | |
|---|---------------------|
| 1. Sites with a site occupancy index of 0.37: | BAF of 0.60 minimum |
| 2. Sites with a site occupancy index of 0.38 up to 0.49: | BAF of 0.45 minimum |
| 3. Sites with a site occupancy index of 0.5 and over: | BAF of 0.30 minimum |
| 4. Sites within key areas on which individual stories of the buildings are used for commercial purposes: | BFF of 0.30 minimum |
| 5. Sites outside key areas on which individual stories of the buildings are used for commercial purposes should be classified as per nos. 1 to 3 above. | |

(For the purposes of calculating the BAF target, sites which are primarily residential, but on which individual buildings or parts of buildings are used for commercial purposes, are classified as commercial sites due to the related usage demands on the areas of the site on which buildings have not been erected.)

Residential sites on which changes to the degree of coverage are made:

With respect to residential sites on which the site occupancy index is increased as a result of redensification measures, the BAF is determined in accordance with the BAF values under points 1. to 4. above in compliance with the site occupancy index which had applied before the redensification measures. With respect to residential sites on which the site occupancy index is reduced, the BAF subsequent to the reduction of the site occupancy index is determined in

accordance with the values indicated under points 1. to 4.

Residential sites on which new structures are built:

With respect to undeveloped sites on which new structures are to be built, the BAF must be at least 0.6. Mixed structures for commercial usage within key areas are an exception to this. In this case, the BAF must be at least 0.3.

The BAF value of 0.3 represents a minimum standard in the light of urban development principles and landscape-planning development concepts, which must also apply in the case of very high-density sites and which is reasonably viable, including, if necessary, compensatory measures.

Measures to achieve the BAF are to be implemented primarily on the site. Potential for rainwater infiltration from roofs using existing vegetation soakaways should be utilised without interference to the other usage demands on the open space. In the case of building coverage in excess of 0.4, rainwater infiltration through existing vegetation soakaways is generally no longer meaningful.

2.2 BAF Target for Businesses and Commercial Premises / Service Providers

The development of the BAF target values for commercial sites including retail businesses and service providers in the inner city is based on a model oriented on existing mixed structures and diverse usage, as well as on the urban development and landscape-planning objective of limited redensification of under-utilised sites.

The existing high environmental impact, however, necessitates urgent measures for improving the ecological situation on commercial sites. In particular, in light of the current trend towards redensification, there is a risk that the impact on the ecosystem in the inner city will be further increased if measures to alleviate the ecosystem are not included.

Sites with **mixed use stories** are characterised by a broad spectrum of site occupancy indexes. The type and scope of commercial use (primarily retail, commercial practices, offices, etc.) makes only limited or no special demands on the open space of the sites (within key areas, allowance must be made for an increased need for private parking spaces). Therefore, the structural and open-space elements of these sites as well as their existing potential for the creation of ecosystem-friendly areas largely correspond with residential sites. The urban development targets and landscape-planning development concepts formulated for the latter apply here accordingly. The BAF should be calculated in line with that of residential sites. Within key areas – taking into consideration required minimum standards for ecosystem-friendly areas – allowance is made for the increased need for parking spaces. The BAF in this case must be at least 0.3.

With respect to sites with **mixed use buildings**, allowance must be made for utilisation rivalry between residents and commercial users in relation to the open spaces. In the inner city area, mixed residential and commercial buildings are generally found on old plots of land with a correspondingly high site occupancy index (GRZ*). The considerable restrictions involved in relation to the protection and development of ecological characteristics are further limited by commercial usage

demands on the open spaces.

On mixed use sites, the BAF must take into account existing residential and commercial usage requirements. In addition, it must also be adequate to ensure a certain minimum standard of ecological quality on these sites. This is, firstly, to make a contribution to the reduction of the ecological impact situation in the relevant blocks, but also to alleviate adverse effects in relation to the quality of living conditions. The BAF for these sites must be at least 0.3.

Sites used exclusively for commercial / industrial purposes must adhere to the objective of the Land Use Plan involving more intensive utilisation of existing commercial areas by making full use of the “inner reserve” aimed at real capacity utilisation of sites with commercial floor levels in diverse usage. This counteracts the extensive expansion of areas used for commercial/industrial purposes (in particular into urban peripheral areas).

The target BAF must, therefore, on the one hand, take into account both the available usage structures of open space on sites and the restricted inner reserves for the purposes of redensification. On the other hand, it must effectively be a method for protecting and developing the ecosystem in these areas.

This complies to some extent with the scope for higher building density within mixed areas and commercial areas defined in accordance with the amended BauNVO. The projected site occupancy index for sites in exclusive commercial usage with considerable usage demands on open space is calculated at 0.6, if inner reserves are exploited in line with the Working Group on Urban Planning’s Expert Report⁶. The associated intensity of land utilisation allows a vegetation area ratio of 10% of the site⁷.

After the limited potential on the site has been exhausted, compensatory measures (greening on vertical walls and roofs) for alleviating the ecological situation should be widely introduced. The potential for changing the surface appropriate to usage demands on commercial usage sites can only be utilised to a very limited extent for soil and groundwater protection reasons, namely only when it can be ensured that no hazardous substances infiltrate the soil (e.g. parking spaces used only for cars).

Nevertheless, it must also be ensured that, in relation to sites used for commercial purposes, a certain percentage of the site area is employed as vegetation surface.

The BAF for these sites must be at least 0.3. In this respect, 10% of the site area must be employed as vegetation surface. The storage and development areas must be completely sealed. This does not apply to surfaces which are used exclusively for cars (nor does it apply to recreation areas for employees or the like).

Commercial service providers without any significant usage demands on open

⁶ Expert report: “Commercial sites in residential and mixed development areas, Working Group on Urban Planning, Berlin 1990”, commissioned by SenStadtUm for the [Berlin] boroughs of Tiergarten, Steglitz and Wilmersdorf.

⁷ Therefore, this estimation remains below the value in the revised regulation on the use of building land which, with a site occupancy index upper limit, envisages scope for 20% vegetation surface on the sites.

space (car parking spaces do not count as a significant usage demand in this case) and administrative buildings of a company on their own grounds are an exception to this. These sites are to be treated as “public administrations” based on their features which correspond to the characteristics of the public facilities group.

2.3 BAF Target for Public Facility and Public Service Sites

The model for inner city areas oriented on existing development calls for sensitive handling of the available potential for protection and development of the ecosystem. Public facilities sites in the inner city area and, in this case, particularly in the overwhelmingly high-density old building quarters, have, to some extent, considerable compensatory functions for absent open spaces.

At the same time, **public facility sites** must assume an important role in providing ecological alleviation for the inner city in otherwise heavily built-up areas of older buildings. Often due to existing building structures and open space layout, the sites have - at least potentially - an important function for air exchange within the blocks, for the infiltration of rainwater, i.e. for the soil and groundwater ecosystem, as vegetation sites and, therefore, also as an interconnecting biotope.

The biotope area factor must, therefore, take existing public facility structures into consideration while sustaining the specific ecological functions of public facility sites.

This means that intensification of site usage must be accompanied by specific quality requirements or, in the event of new public facility sites being developed, a higher significance must be assigned to the specific ecological functions of public facility buildings.

Existing **public service sites** generally already demonstrate intensive exploitation of the site, although further intensification is possible, to some extent, through reorganisation of the usage structures (or also potential for refurbishment). This is why there is extremely limited scope for the development of “more ecosystem-friendly” areas.

In contrast to many years of experience with regard to the potential for “more ecosystem-friendly areas” on residential sites, and also partly on sites with commercial usage, this report has gathered, for the first time, different analyses from public facilities and public services on the subject of “BAF”. However, it was possible, in part, to refer to data which had been collected in the context of other reports.

In addition, further mapping was carried out within the scope of this report.

Categorised according to usage groups, BAF values were determined on the basis of the collected data, taking certain assumptions into account. Benchmarks for quality standards in non-built-up areas in relation to public facilities and public services do not exist from which ecological standards in relation to the type and combination of individual site types could be derived.

These are values which are generally feasible on the sites without involving compensatory measures. The results of these evaluations were contrasted with the

underlying model and the landscape-planning development concepts in addition to existing findings on similar sites, and discussed.

Although it is essentially true for public facilities, as for residential sites, that the scope for creating areas which contribute to the protection and development of the functionality of the ecosystem largely depends on the proportion of available undeveloped areas of a site, considerable differences arise with regard to open space structures, due to varying usage functions, building densities (Floor Area Ratio) and associated open space demands. With regard to assigning BAF values, public facility sites may, therefore, only be separately classified according to individual usage types.

Nevertheless, within public service usage categories, a comparison of projectively determined possible BAF values on existing public facility sites shows, in most cases, a clear correlation to the site occupancy index. Taking into consideration the varying demands on open space, particularly car parking spaces, this allows corresponding BAF value categories to be assigned to the individual site occupancy index classes.

At the same time, schools providing general education (including vocational schools, polytechnical schools and centres for education and training) for which the site occupancy index parameter cannot be regarded as adequately significant for the derivation of ecological value, are an exception to this rule. For this type of usage, the relevant usage density, i.e. the available undeveloped space on the site per student, is of much more decisive significance. Therefore, for schools providing general education, the percentage of open space per student (calculated on the basis of the efficiency of the site) was used as a basis for evaluating the sites with regard to assigning BAF values.

It is not meaningful to link public service sites to the site occupancy index, because of the considerable usage demands on open space on the sites, which requires extensive sealing. The areas at these sites, on which there is, for the most part, very intensive usage, allow very little scope overall for “ecosystem-friendly” site potential.

Nevertheless, even though intensive utilisation of public service sites is to be encouraged for the benefit of overall economical land management in the city, a requirement arises from a site and quarters point of view regarding certain minimum standards in environmental quality. Therefore, the target BAF is primarily normatively set as a “minimum requirement”, although the scope for implementation is tested in individual cases.

In principle, the following guidelines are to be used as a basis for formulating “BAF target values” for public facilities and public service sites:

- taking existing building and open space structures into consideration,
- making full use of the existing potential on the sites for protection and development of the ecosystem while taking into consideration other usage demands and a reasonable framework,
- safeguarding a minimum, ecologically beneficial area quota as minimum

ecological area standard on all public facility and public service sites,

- safeguarding the scope of available site potential for development of the ecosystem, even when the building coverage ratio of public facility sites is increased, or making full use of any additional potential when the building coverage ratio is reduced,
- ensuring appropriate, ecosystem friendly area ratios based on the model devised for new development sites.

Within the context of the work on the expert report, the discussion on urban development models and landscape-planning development concepts, on the one hand, and the relevant scope for protecting and developing the ecosystem on the other, has led to the formulation of the following target values:

Schools providing general education, centres for education and training

Existing school sites:

Undeveloped space per student*	Target BAF
25 m ² and above	0.5
15 m ² and above 15 m ²	0.4
< 15 m ²	0.3

* The number of students for which the school is designed in each case should be used as a basis.

Amendments to open space per student and new constructions:

With respect to densification of existing structures resulting in the reduction of the available undeveloped site area per student, in principle, the BAF values of the existing development prior to the onset of these measures apply.

Sites on which the previous undeveloped site area per student of at least 25 m² is reduced to a value of less than 25 m² are an exception to this. In this case, an adjustment is made to the higher usage density up to a BAF of at least 0.4. In so far as the open space per student is increased as a result of expansion of that site, the BAF must be adjusted accordingly.

With respect to new development sites, in principle, the value of at least 0.4 is to be applied. In the case of development of sites with open space per student of at least 25 m², a BAF of 0.5 should be allocated.

Nursery Schools and Day Care Centres⁸

Existing sites:

Site occupancy index level	Target BAF
Up to 0.29	0.60
0.30 to 0.49	0.45
0.50 and over	0.30

Adjustments to the site occupancy index and new developments:

In the case of sites on which the site occupancy index increases as a result of extension to the existing structure, no adjustment of the BAF to the new site occupancy area is made. The status prior to commencement of extension measures to the existing structure is, therefore, the basis for assigning the BAF.

In the event that the site occupancy index is reduced and in the light of the existing impact situation, the newly achieved potential is to be used for protecting and developing the ecosystem. Therefore, the reduced site occupancy index forms the basis for determining the BAF.

With respect to the new development of child day-care facilities on self-contained sites where the sole provision of open space is through their own site, a BAF of 0.6 is to be assumed in principle. As regards new development sites which are, to some extent, resourced by adjacent green spaces or children's playgrounds, the BAF is to be determined on the basis of the site occupancy index in accordance with the values for existing sites.

Integrated child day-care facilities:

It was not possible to gather and evaluate sufficient data for formulating BAF values with regard to child day-care facilities which are integrated into residential developments. Due to the increasing integration of child day-care facilities into residential buildings, further research into these usage categories is required.

Cultural amenities and other public facilities⁹

(Libraries, youth clubs, community centres, polytechnical schools, community colleges, sports halls on their own sites, indoor swimming pools, etc.)

Existing sites:

Site occupancy index level	Target BAF
Up to 0.34	0.60
0.35 to 0.49	0.45
0.50 and over	0.30

⁸ The target BAF values only apply to day-care facilities on self-contained sites. More research is necessary in order to deal with integrated child day-care facilities

⁹ With the exception of theatres and museums unless they are included under other categories.

Adjustments to the site occupancy index and new constructions:

In the case of an extension to the existing structure on sites outside key areas, the site occupancy index of the site prior to commencement of building works is the decisive factor, i.e. no adjustment is made to the new site occupancy index. Within key areas, an adjustment is foreseen due to the more intensive usage demand.

In the event the site occupancy index is reduced and in the light of the existing ecological impact, the newly achieved potential is to be used for protecting and developing the ecosystem. Therefore, the reduced site occupancy index forms the basis for assigning the BAF.

In principle, high demands with regard to ecosystem-friendly areas are to be posed on new developments. Scope for economical designation of parking spaces should be utilised where access to adequate local public transport exists. The BAF is, therefore, to be set at 0.6 outside key areas. Within key areas, the BAF is to be assigned in accordance with the site occupancy index levels of the existing structure.

Public administration facilities

Existing sites:

Site occupancy index level	Target BAF
Up to 0.29	0.50
0.30 to 0.39	0.40
0.40 and over	0.30

Adjustments to the site occupancy index and new constructions:

With respect to extensions to existing structures on sites outside key areas, the site occupancy index of the site following completion of the construction measures to augment the existing structure is the determining factor in assigning the BAF, whereby a BAF should not be assigned below 0.40 unless a value of 0.3 was already to be applied previously, i.e. there is limited adjustment to the new site occupancy index. Within key areas, an adjustment is foreseen due to the more intensive usage demand.

In the event the site occupancy index is to be reduced and in the light of the existing ecological impact, the newly achieved potential is to be used for protecting and developing the ecosystem. Therefore, the reduced site occupancy index forms the basis for assigning the BAF.

With respect to new constructions, this applies in the same way as to the usage group "Cultural amenities and other public facilities". Therefore, outside key areas, the BAF should be assigned at a minimum of 0.40, and at 0.5 up to a site occupancy index of 0.29. In principle, the BAF is to be assigned within key areas in accordance with the site occupancy index levels of the existing structure.

Public service sites

A standard BAF target value of 0.3 is specified for public service sites.

Mixed usage of public facilities and public services

Within the context of this expert report, it was not possible to conduct sufficient empirical research into sites which comprise a mixture of public facility and public service accommodation and commercial or residential usage. In principle, it may, however, be assumed that, based on the feasible assignment of open space capacity to the usage types, it is possible to define an equivalent BAF in individual cases. More research needs to be carried out for typification and systematic designation of mixed usage.